The Impact of Thought Speed and Variability on Psychological State and Threat Perception

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I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

Signature: ……..

Content

Tables

Literature Review

Empirical Paper

Figures

LITERATURE REVIEW

Systematic Review of Bipolar Disorder and Information Processing: Biases of Attention, Interpretation, and Memory

Benjamin Albert Rosser

University of Exeter

Supervisors

Dr Kim Wright

University of Exeter

Dr Barney Dunn

University of Exeter

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Abstract

Information processing biases are purportedly involved in the development and maintenance of psychological difficulties. Reviews collating bias research are considerable for conditions such as anxiety; however, similar research summary in the field of bipolar disorder was considered absent. Consequently, a systematic review was conducted to investigate information processing biases in different cycle states of bipolar disorder compared to control participants. The review focused on processing bias rather than deficit or impairment. Information processing biases pertaining to attention, interpretation, and memory were included in the review. Of the initial 2476 articles identified, 28 qualified for inclusion in the review based on inclusion/exclusion criteria. Evidence of differences in processing biases between individuals with bipolar and controls was demonstrated; however, manifestation of bias varied considerably and was often conflicting. Although there is evidence of cycle-specific biases, such as negatively biased selective attention in depressive states and positive interpretation bias in manic states, the need for further research to clarify the frequent inconsistencies found is emphasised. Furthermore, cycle-specific bias may also be observable in euthymic individuals, suggesting that this is not necessarily a return to an unaffected state. Processing biases appear present in bipolar disorder; however, currently a clear profile is not forthcoming.

Systematic Review of Bipolar Disorder and Information Processing: Biases of Attention, Interpretation, and Memory

Information Processing Biases and Psychological Disorders

Information processing biases have been proposed to play a role in the development and maintenance of a range of psychological difficulties. These biases trade the accuracy of direct perception with the efficiency of expectation. Their influence may be largely automatic (Teachman, Joormann, Steinman, & Gotlib, 2012), directing attention, interpretation, and recall of information. Biases may provide functional benefits in our ability to make sense of the world; however, the trade in accuracy can lead to maladaptive expectation dominating perception, such as in anxiety and depression (Mogg & Bradley, 2005).

Anxiety has been associated with biases towards threatening information at all stages of processing, through attention (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van, 2007), interpretation (Eysenck, Mogg, May, Richards, & Mathews, 1991), and recall (Coles & Heimberg, 2002). Processing biases have also been observed in other psychological conditions, such as depression (Leppanen, 2006). Critically, specific psychological conditions may relate to specific manifestations of bias – in terms of information content (e.g., negative vs. threatening) and stage of processing at which bias occurs (Mogg & Bradley, 2005). Consideration of specific information processing biases associated with specific psychological conditions may aid insight into the development and maintenance of respective conditions. Research has begun exploring how bias modification may: 1) demonstrate a causal relation between bias and psychological difficulties; and 2) be employed therapeutically (Hertel & Mathews, 2011).

Bipolar Disorder and Information Processing Biases

Bipolar disorder is characterised by fluctuations between clinically elevated and depressed mood states (American Psychiatric Association., 1994). Although less prevalent than anxiety and depression (Kessler, Chiu, Demler, Merikangas, & Walters, 2005; Merikangas et al., 2011), bipolar disorder is associated with difficulties in social functioning (Calabrese et al., 2003), long-term health conditions (McIntyre et al., 2006), and substantially elevated risk of suicide (Chen & Dilsaver, 1996; Jamison, 2000). Processing biases associated with bipolar disorder have, however, received less attention than those of anxiety and depression. Previous reviews have focused largely on functional and neuropsychological differences associated with cognitive impairment. Cognitive impairment may be distinguished from processing bias: Impairment refers to diminished or inability to process information; whereas bias refers to a propensity to process information in a particular way. Recent reviews suggest deficits in memory and executive functioning may be related to depressive and manic states (Murphy & Sahakian, 2001; Robinson & Ferrier, 2006). Variability in impairment is also proposed as potentially dependent on depressive, manic, or euthymic cycle state; however, clear distinction between states was inconclusive based on literature available. Interestingly, there is evidence to suggest that impairment persists even during euthymic periods (Robinson et al., 2006). However, the role of medication in all observed bipolar deficits has been questioned (Holmes et al., 2008).

Research into bipolar information processing biases, rather than deficits, also exists. A review of cognitive vulnerabilities by Alloy, Abramson, Walshaw, and Neeren (2006) considered evidence of similarities between information processing in bipolar disorder and major depression, such as attention towards

negative and self-referent information. Once again there is indication that the current cycle state may be important to bias manifestation. Research suggests that manic states are associated with affective bias towards positive stimuli (Murphy et al., 1999) and decreased recognition of negative facial expressions (Lembke & Ketter, 2002). However, presently systematic review comprehensively summarising information processing biases in bipolar disorder appears absent. The current review was designed to systematically collate literature relating to information processing biases, rather than cognitive deficits, associated with bipolar disorder with consideration of the different cycle states.

Method

Research Questions

A systematic review was conducted to address the following research questions:

1. Compared to controls, do individuals with bipolar disorder demonstrate biases towards processing different types of information in terms of:
    a. Attention,
    b. Interpretation,
    c. Or memory?
2. Do processing biases differ in different cycle states – i.e., manic, depressive, and euthymic?

Literature Review

A systematic review of the literature was conducted utilising a Boolean search strategy based on the key criteria of ‘psychological condition’ (bipolar

disorder) and 'information processing bias' (attentional, interpretative, and memory).[1] The search was conducted the last week of March, 2014 and was employed through OVID SP, PUBMED, and Web of Science databases.

Articles were treated for inclusion in three stages: 1) titles and abstracts were reviewed to ascertain initial relevance, 2) potentially relevant articles were reviewed in full, and 3) data from the relevant qualifying articles were systematically extracted – Figure 1.

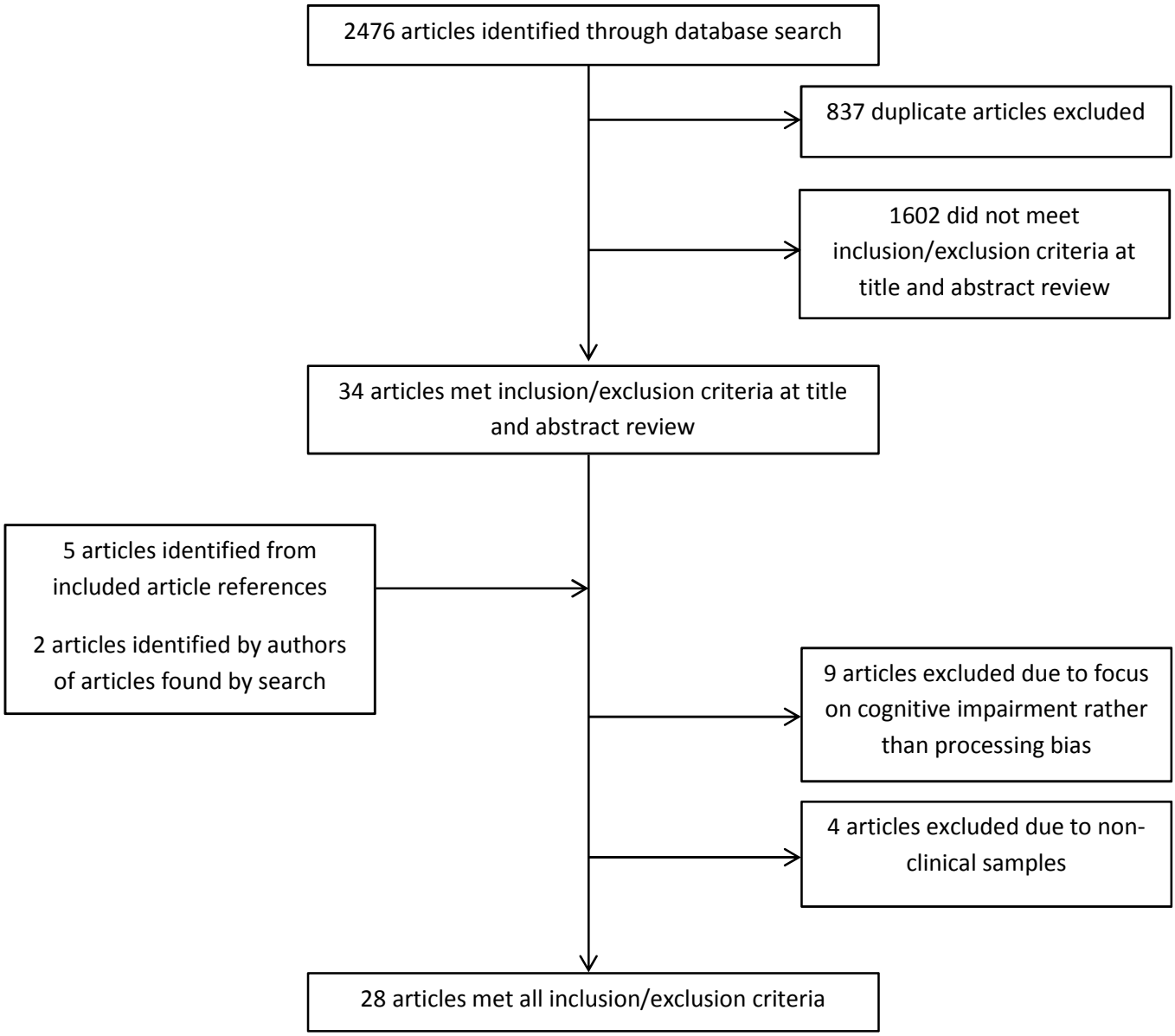

Figure 1. Systematic review application of inclusion/exclusion and article selection.

[1] See Appendix A for full search string.

Inclusion/exclusion Criteria

Inclusion/exclusion criteria were employed at each review stage to ensure relevance to the research questions – Table 1.

Table 1

Inclusion and Exclusion Criteria for Study Qualification in Review of Information Processing Biases in Bipolar Disorder

Criteria category	Inclusion/exclusion criteria
Participant	1. Adult sample only (≥ 18 years or older) 2. Male and female sample included 3. Clinical level of bipolar disorder or mania a. Established either by clinician or diagnostic criteria (e.g., DSM) b. Not unipolar depression only c. Sub-syndromal only samples were excluded 4. Bipolar or mania must be a discernible group differentiated from other mood disorders (i.e., not combined with other disorder like major or unipolar depression) 5. Sample must not have a cognitive impairment (congenital or acquired) unrelated to bipolar or mania condition 6. No case studies (n = 1) 7. Each condition arm must contain n ≥ 10 at beginning of study
Intervention	8. No intervention criteria as this was not the focus of the review
Comparison	9. Studies must include a control comparison group 10. Comparison groups of other psychological conditions will not be included in reviewed data
Outcome	11. Study must include assessment of processing bias in: a. Attention b. Interpretation c. Or memory/recall 12. Outcome must include task performance to provide assessment of processing bias 13. Outcome assessed by brain region activity (e.g. fMRI studies) alone will be excluded
Additional	14. Articles must be published in a peer-reviewed journal 15. English language publications only 16. Conference abstracts and unpublished grey literature will be excluded 17. No restrictions made on publication dates of articles included

Results

Article Details

Twenty-eight articles met inclusion/exclusion criteria. Study results were considered in terms of the three focal types of processing: 1) attention, 2) interpretation, and 3) memory. Results are stratified based on bipolar cycle state (i.e., manic, depressed, euthymic/remitted).

Sample Details

All but two studies (Lomax, Barnard, & Lam, 2009; Lomax & Lam, 2011) reported discrete samples. The total sample consisted of 809 control participants and 934 clinical participants – Table 2. The majority of studies reported a clinical sample of individuals with bipolar I disorder only (53.6%); four studies reported samples including bipolar I and II disorders; and seven did not specify the form of bipolar. One study reported including individuals with bipolar II, bipolar NOS, or cyclothymia (Molz Adams, Shapero, Pendergast, Alloy, & Abramson, 2014); and one study reported a manic or hypomanic sample (David, 1993).

Control participants were commonly defined as having no personal or family history of psychiatric disorder. Four studies, however, did not define what constituted “healthy control” (David, 1993; Kronhaus et al., 2006; Lyon et al., 1999; Thomas et al., 2009).

Table 2

Demographic Information for Reviewed Studies

Study	Location	Control participants			Bipolar participants			
		Number [†]	***Mean age in years (SD)***	***Sex (% female)***	***Total number*** [†]	***Number per condition***	***Mean age in years (SD)*** [n]	***Sex (% female)***
(Bermpohl et al., 2009)	Germany	10	35.8 (12.9)	50%	10	BDM: 10	37.9 (13.2)	50%
(Bermpohl et al., 2010)	Germany	26	38.7 (13.7)	43%	22	BDD: 15 BDE/R: 7[*]		BDM: 47% BDE/R: 57%
(Bertocci et al., 2012)	United States of America	16	32.76 (6.5)	100%	18	BDD: 18	31.94 (8.54)	100%
(David, 1993)	United Kingdom	23	33.9 (6.3)	52%	10	BDM: 10	41.3 (12.9)	67%
(Garcia-Blanco, Perea, & Livianos, 2013a)	Spain	23	41.9 (10.7)	52.2%	80	BDM: 30 BDD: 22 BME/R: 28	BDM: 39.1 (13.7) BDD: 44.1 (10.5) BDE/R: 42.7 (8.9)	BDM: 33.3% BDD: 50% BDE/R: 32.1%
(Garcia-Blanco, Perea, & Salmeron, 2013b)	Spain	28	42.1 (12.4)	46.4% (13)	71	BDM: 25 BDD: 22 BDE/R: 24	BDM: 42.5 (11.4) BDD: 49.1 (10.7) BDE: 40.6 (11.4)	BDM: 44% BDD: 45.5% BDE: 37.5%
(Garcia-Blanco, Salmeron, Perea, & Livianos, 2014)	Spain	20	40.6 (13.4)	50%	66	BDM: 23 BDD: 20 BDE/R: 23	BDM: 42.4 (12.1) BDD: 51.3 (10.2) BDE/R: 40.7 (10.7)	BDM: 39.1% BDD: 45% BDE/R: 34.8%
(Gopin, Burdick, DeRosse, Goldberg, & Malhotra, 2011)	United States of America	144	37.38 (12.88)	41%	59	BDE/R: 59	40.91 (11.98)	43%
(Havermans, Nicolson, & deVries, 2007)	The Netherlands	38	44.94 (11.36)	60.5%	38	BDE/R: 38	46.2 (9.6)	50%
(Holmes et al., 2011)	United Kingdom	23	45.3 (12.2)	43%	23	BDE/R: 23	44.4 (11.8)	43%
(Jabben et al., 2012)	The Netherlands	61	45.3 (8.7)	62.3%	77	BDD: 17 BDE/R: 60	BDD: 46.4 (6.7) BDE/R: 43.9 (8.2)	BDD: 47.1% BDE/R: 55.0%
(Jongen, Smulders, Ranson, Arts, & Krabbendam, 2007)	The Netherlands	29 (CD: 16) (CE: 13)	/ CD: 50 (7) CE: 44 (11)	/ CD: 44% CE: 54%	29	BDD: 16 BDE/R: 13	BDD: 48 (6) BDE/R: 43 (8)	BDD: 44% BDE/R: 54%
(Kronhaus et al., 2006)	United Kingdom	11	36.4 (10.4)	45%	10	BDE/R: 10	40.9 (12.7)	40%
(Kucharska-Pietura & David, 2003)	Poland	30	39.9 (12.2)	/	30	BDM: 30	39.5 (14.1)	53.3%
(Lennox, Jacob, Calder, Lupson, & Bullmore, 2004)	United Kingdom	12	32.6 (10.7)	50%	10	BDM: 10	37.3 (12.8)	20%
(Lex, Meyer, Marquart, & Thau, 2008)	Austria	19	48.1 (15.2)	53%	19	BDE/R: 19	39.7 (10.6)	63%
(Lex, Hautzinger, & Meyer, 2011)[□]	Austria	21	43.43 (12.00)	62%	41	BDM: 15	BDM: 43.33 (12.18)	BDM: 73%

						BDE/R: 26	BDE/R: 49.35 (11.20)	BDE/R: 58%
(Leyman, De Raedt, & Koster, 2009)	Belgium	14	46 (7.33)	43%	14	BDM: 14	46.36 (8.21)	43%
(Lomax et al., 2009)	United Kingdom	30	41.07 (14.98)	63%	30	BDE/R: 30	47.17 (11.67)	60%
(Lomax & Lam, 2011)	United Kingdom	30	41.07 (14.98)	63%	30	BDE/R: 30	47.17 (11.67)	60%
(Lyon, Startup, & Bentall, 1999)	United Kingdom	15	46.47 (14.74)	67%	30	BDM: 15	BDM: 47.87 (18.06)	BDM: 67%
						BDD: 15	BDD: 44.47 (13.16)	BDD: 60%
(Malhi, Lagopoulos, Sachdev, Ivanovski, & Shnier, 2005)	Australia	12	33.7 (12.4)	100%	12	BDE/E: 12	34.9 (9.1)	100%
(Miklowitz, Alatiq, Geddes, Goodwin, & Williams, 2010)	United Kingdom	20	29.6 (16.0)	50%	36	BDE/R: 36	40.8 (13.3)	61%
(Molz Adams et al., 2014)	United States of America	58	19.53 (1.57)	63%	66	BDE/R: 66	19.76 (1.89)	68%
(Roiser et al., 2009)	United Kingdom	19	35.4 (13.6)	19%	15	BDE/R: 15	44.4 (13.4)	67%
(Strakowski et al., 2005)	United States of America	16	30 (9)	44%	16	BDE/R: 16	28 (7)	63%
(Thomas, Bentall, Knowles, & Tai, 2009)	United Arab Emirates	44	37.40 (12.70)	68%	55	BDM: 30	BDM: 45.86 (12.45)	BDM: 67%
						BDD: 14	BDD: 38.28 (7.81)	BDD: 21%
						BDE/R: 11	BDE/R: 44.36 (11.69)	BDE/R: 64%
(Wessa et al., 2007)	France	17	44.94 (11.36)	35%	17	BDE/R: 17	44.94 (12.70)	41%
TOTAL participant numbers	*Control group*		n = 809 (M = 28.9; SD = 25.9) (52.8% female)	*Bipolar group*		n = 934 (M = 33.4; SD = 22.4) (52.6% female)	BDM: n = 227 BDD: n = 144 BDE/R: n = 563	

† Number of participants at start of study; *BDM group only discussed in review results as BDE/R group n < 10; [n] Age data provided for BDM, BDD, and BDE/R conditions where provided by reviewed article; [□] BDM in this study comprised bipolar 1 participants currently experiencing hypomanic episode; BDM: Bipolar disorder – manic; BDD: Bipolar disorder – depressive; BDE/R: Bipolar disorder – euthymic/remitted; CD: Control participants matched to BDD participants; CE: Control participants matched to BDE/R participants.

Assessment of Bipolar and Cycle State

The majority of studies employed DSM-IV criteria in establishing clinical group diagnoses (85.7%). The oldest study employed DSM-III criteria (David, 1993). One study employed the ICD-10 criteria only (Thomas et al., 2009). Diagnostic criteria were commonly assessed via standardised interview process (e.g., SCID-I; First, Spitzer, Gibbon, & Williams, 1996) and/or psychiatrist. One study reported utilising an unspecified 'standardised clinical interview' (Lennox et al., 2004). In addition, most studies also included assessment of current depressive and manic state – Table 3.

Table 3

Commonly Employed Measures of Depression and Mania Level within Reviewed Articles

Mood variable	Measure	Percentage of studies utilising measure
Depression	1. Beck Depression Inventory (I or II) (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961; Beck, Steer, & Brown, 1996)	42.8%
	2. Hamilton Rating Scale for Depression (Hamilton, 1960)	42.9%
Mania	1. Young Mania Rating Scale (Young, Biggs, Ziegler, & Meyer, 1978)	57.1%
	2. Altman Self-Rating Scale for Mania (Altman, Hedeker, Peterson, & Davis, 1997)	10.7%
	3. Bech-Rafaelson Mania Scale (Bech, Rafaelsen, Kramp, & Bolwig, 1978)	7.1%

NB: In evaluation of manic, depressive, and euthymic states, cut-off scores were inconsistent across studies.

Assessment of Processing Bias

All studies reported assessment of attention (*n* = 21), interpretation (*n* = 11), and/or memory biases (*n* = 4) in individuals with bipolar disorder compared to controls – Table 4.

Table 4

Summary of Article Methodologies and Results

Study	Type of processing assessed	Task	Dependent variable	Stimuli	Outcome
(Bermpohl et al., 2009)	Attention Interpretation	Viewing images from International Picture System	Attention Reaction time to photograph presentation Interpretation Interpretation of photograph valence	Valenced photographs (Positive, negative, & neutral)	Attention BDM = CL Interpretation BDM > CL on emotion valence ratings for positive and neutral photographs
(Bermpohl et al., 2010)	Attention	Monetary Incentive Delay Task	Reaction time	Anticipatory cue and neutral target	BDM = BDE/R = CL on reaction time
(Bertocci et al., 2012)	Attention	Emotional face n-back task	Reaction time and response accuracy	Response stimuli = letters; Distractor stimuli = valenced faces (neutral, fearful, happy)	BDD = CL on reaction time and response accuracy
(David, 1993)	Attention	Chimeric faces test; Lateralized Stroop test	Reaction time	Chimeric faces = split sad/happy Stroop = coloured words	BDM = CL on reaction times for chimeric faces and Stroop test
(Garcia-Blanco et al., 2013a)	Attention	Go/no go task	Reaction time and response error	Valenced words (positive & negative)	BDM = BDD = BDE/R = CL on response error CL < BDM, BDD, BDE/R on time taken to respond (i.e. CL faster) BDM < on reaction time to positive than negative words (i.e., faster on positive) BDD < reaction time to negative than positive words (i.e., faster on negative)
(Garcia-Blanco et al., 2013b)	Attention	Prosaccade/ antisaccade task	Eye-tracking; reaction time and response error	Valenced faces (happy, sad & neutral)	Antisaccade: (*viewing away*) BDM, BDD > BDE/R, CL on general response errors BDM > errors to happy faces than neutral or sad BDD approached > errors for sad face then neutral BDE, CL = no diff. in errors within groups BDM, BDD, BDE/R > CL on time taken to respond (i.e., slower than CL) Prosaccade: (*viewing towards*) BDM, BDD > BDE/R, CL on general response errors

(Garcia-Blanco et al., 2014)	Attention	Viewing images from Internation Affective Picture System	Eye-tracking; initial fixation, direction and duration of gaze	Valenced images (happy, sad, neutral & threatening) split into quadrants	BDD < CL on time viewing happy images BDM, BDD, BDE/R > CL on time spent viewing threatening images; and percentage of fixations BDD < CL on percentage of fixations on happy images
(Gopin et al., 2011)	Attention Interpretation	Go/no go task	Reaction time and categorisation accuracy	Valenced words (happy, sad & neutral)	<u>Attention</u> BDE/R > CL response bias for negative words (not positive or neutral) <u>Interpretation</u> BDE/R < CL on accuracy for positive words (not negative or neutral)
(Havermans et al., 2007)	Interpretation	Experience Sampling Method	Appraisal of life events across the day	Appraisal of positive and negative events (pleasantness, stressfulness and importance)	BDE/R = CL for appraisals of positive and negative events
(Holmes et al., 2011)	Interpretation	Homograph Interpretation Task	Valence of interpretations	Valenced homographs (positive/negative)	BDE/R < CL on positive interpretations BDE/R > CL on perceived vividness of positive images
(Jabben et al., 2012)	Attention	Dot-probe task	Reaction time (attentional bias score)	Valenced words (positive, negative & neutral)	BDD > BDE/R, CL attention away from positive words
(Jongen et al., 2007)	Attention	Modified dot-probe task with spatial cueing	Reaction time and response error	Valenced word pairs (depression-neutral, positive-neutral, neutral-neutral)	BDD > BDE/R, CL bias away from both positive and negative word
(Kronhaus et al., 2006)	Attention	Stroop test	Response accuracy	Coloured words	BDE/R = CL on response accuracy
(Kucharska-Pietura & David, 2003)	Attention	Chimeric faces	Number of responses to either side of face	Valenced faces (happy/sad split)	BDM = CL on left-hemisphere bias
(Lennox et al., 2004)	Interpretation	Facial recognition task	Perceived valence intensity	Valenced faces (happy & sad)	BDM = CL for intensity rating of happy faces BDM < CL on intensity rating for the most sad faces
(Lex et al., 2008)	Attention Memory	<u>Attention</u> Emotional Stroop test <u>Memory</u> Incidental recall task	<u>Attention</u> Reaction time <u>Memory</u> Stimuli recall	Valenced coloured words (positive mood, negative mood, neutral & non-words)	<u>Attention</u> BDE/R = CL on response time BDE/R = CL both faster for neutral compared to positive and negative words <u>Memory</u> BDE/R = CL on recall irrespective of word valence

(Lex et al., 2011)	Attention Memory	Attention Emotion Stroop test Memory Emotional Auditory Verbal Learning Test (EMO-AVLT)	Attention Reaction time Memory Stimuli recall	Valenced words (depression-related, mania-related, & neutral)	Attention BDM = BDE/R = CL for response time to words of different valences BDM > CL on response time to all words (i.e., BDM slower) BDE/R = CL on response time to all words Memory BDM < BDE/R, CL for learning (recall) of depression-related word BDE/R < BDM, CL on recognising words, irrespective of word valence
(Leyman et al., 2009)	Attention	Dot-probe task with spatial cueing (200ms or 1000ms)	Reaction time	Valenced faces (happy, angry, neutral)	Sig. effects for 200ms presentation only. BDM > CL on time taken to disengage from angry faces (i.e., BDM slower)
(Lomax et al., 2009)	Attention	Question-answer task	Level of pragmatic implication in response	Ambiguous scenario statements	BDE/R > CL on responses consistent with implication interpretation (i.e., assumed interpretation rather than factual)
(Lomax & Lam, 2011)	Interpretation	Sentence-completion task	Valence of completed sentence	Valence ambiguous sentences (negative/dysfunctional and positive/functional)	BDE/R > CL on negative/dysfunctional sentence completions
(Lyon et al., 1999)	Attention Interpretation Memory	Attention Emotional Stroop test; Interpretation Self-reference incidental recall task (categorisation component) Memory Self-reference incidental recall task (recall component)	Attention Reaction time Interpretation Categorisation of words as self-referential Memory Stimuli recall	Valenced words (positive, negative & neutral)	Attention BDM > CL on response time (i.e., BDM slower) BDM, BDD > interference on negative compared to positive words (CL demonstrate no difference) Interpretation BDM, CL > on endorsement of positive compared to negative words BDD > on endorsement of negative compared to positive words Memory CL > recall of positive than negative words BDM, BDD > recall of negative than positive words
(Malhi et al., 2005)	Attention	Emotional Stroop test	Reaction time and response error	Valenced coloured words (positive, negative & neutral)	BDE/R > CL on time to respond irrespective of word valence (i.e., BDE/R slower) BDE/R = CL on response errors
(Miklowitz et al., 2010)	Interpretation	Scrambled-sentence task	Number of positive/negative rearrangements	Valenced sentences (hyperpositive, negative & neutral)	BDE/R < CL on sentence completion in hyperpositive direction

(Molz Adams et al., 2014)	Interpretation Memory	Interpretation Self-reference information processing task (categorisation component) Memory Self-reference information processing task (recall component)	Interpretation Categorisation of adjectives as self-referent Memory Adjective recall	Valenced words (depression-related and –unrelated adjectives)	Interpretation BDE/R < CL on endorsement of positive adjectives as self-referent BDE/R > CL on endorsement of negative adjectives as self-referent Memory BDE/R < CL on recall of positive adjectives BDE/R > CL on recall of negative adjectives
(Roiser et al., 2009)	Attention	Go/no go task; following positive mood induction	Reaction time and response error	Valenced distractor words (positive and negative)	BDE/R > commission errors to positive than negative distractor words CL did not No differences based on reaction time or omission errors
(Strakowski et al., 2005)	Attention	Counting Stroop test	Response error	Numbers written as words	BDE/R > CL on response error BDE/R < CL on percentage of correct responses
(Thomas et al., 2009)	Interpretation	Sentence-completion task	Valence of completed sentences	Valenced possible sentences (positive and negative)	BDM, BDD, BDE/R > CL on positive sentence completion BDM, BDE/R < CL on negative sentence completion (BDD not sig. different from CL)
(Wessa et al., 2007)	Attention	Go/no go task	Reaction time and response error	Valenced faces (happy, fearful & neutral)	BDE/R = CL on reaction time and response error for all face valences

BDM: Bipolar disorder – manic; BDD: Bipolar disorder – depressive; BDE/R: Bipolar disorder – euthymic/remitted; CL: Control participants.

The studies predominantly employed single-test lab-based designs. Seventy-one percent reported some evidence of processing biases in bipolar participants compared with controls. [2,3]

Attention

Bipolar disorder-manic. Stroop test methodology (Stroop, 1935) demonstrated no significant difference between BDM and control participants in terms of attentional interference to neutral stimuli congruence, using either traditional (Lex et al., 2011) or lateralized[4] presentation (David, 1993). Attentional interference was, however, less consistent with regard to emotional stimuli. Whereas Lex and colleagues (2011) found no evidence of attentional interference to more emotional stimuli (i.e., mania- and depression-related adjectives); elsewhere, slower responses to euphoria-related, compared to depression-related, words were reported in BDM individuals and not controls (Lyon et al., 1999). Accuracy of response-time measurement between these studies may be a factor in the discrepancy; computerised assessment utilised by Lex and colleagues (2011) is a more reliable assessment method than the researcher-controlled stopwatch employed by Lyon and colleagues (1999). These two studies were, however, consistent in finding a general slower response irrespective of stimuli valence in BDM compared to controls. Although one comparable image-response study did not find general slower task responses in BDM compared to controls (Bermpohl et al., 2009), this generic difference seems largely supported, as BDM participants were also found to

[2] Mood induction: Three studies included a mood induction task designed to elevate positive mood (Lomax et al., 2009; Lomax & Lam, 2011; Roiser, Fanner, et al., 2009). Where pre and post assessment was conducted, pre mood induction results only are reported. Roiser et al. (2009) did not provide pre induction assessment; consequently, this is noted in text alongside the results.

[3] Of the nine studies whose main focus was on brain imaging (e.g., fMRI) rather than task performance, only 55.6% reported significant evidence of task performance-based differences compared to 78.9% in studies only focused on task performance. This may demonstrate evidence of publication bias (Fanelli, 2010).

[4] Traditional presentation involves presenting coloured words; Lateralized presentation involves presenting the colour and word separately on separate sides of a screen.

perform generally slower than controls to all stimuli in a go/no-go task (Garcia-Blanco et al., 2013a) and averting gaze from photographs of faces irrespective of expression (Garcia-Blanco et al., 2013b). More specifically, in the go/no-go task, BDM demonstrated faster responses to positive compared to negative words, whereas controls demonstrated no stimuli-based performance differences, which may suggest quicker processing of positive over negative information in BDM. In terms of attentional inhibition, no difference in performance errors in the go/no-go task was found between groups; however, whereas controls demonstrated an expected shift-cost to changing task directions, BDM did not, which may demonstrate general difficulties in directed and inhibited attention control. Elsewhere, BDM individuals did make significantly more errors in averting attention from images of happy faces compared to sad and neutral faces (Garcia-Blanco et al., 2013b), which could suggest that type of stimuli as well as valence is important in specific, over general, attentional inhibition difficulties in BDM.

Although the most commonly utilised methodology for assessing selective attention in the articles included in this review, no dot-probe procedures (MacLeod, Mathews, & Tata, 1986) involved BDM participants. One study did assess selective attention by eye-tracking during simultaneous presentation of differently valenced images (happy, sad, neutral, and threatening) in separate computer screen quadrants (Garcia-Blanco et al., 2014). BDM participants spent more time attending to threatening images than controls, but otherwise demonstrated no valence-specific difference.

Assessment of spatial attention was assessed through the emotional chimeric face test in two studies (David, 1993; Kucharska-Pietura & David, 2003), in which participants categorise half-happy, half-sad faces as *either*

happy or sad. The test is proposed to reveal hemispheric spatial bias – i.e., in right-handed individuals a left-hemispheric bias is expected. No significant differences in spatial bias, or bias towards sad/happy facial expressions, was found between BDM and controls in either study.

One study explored the influence of cued task information prior to performance through the Monetary Incentive Delay Task (Bermpohl et al., 2010). No evidence of performance differences between BDM and control was found that might suggest any altered attention or processing based on prior information.

Finally, some inconsistent evidence of within-group differences[5] was present. Garcia and colleagues (2013a) found faster BDM response times to positive compared to negative words. Whereas Lyon and colleagues (1999) also reported significantly more attentional interference to negative compared to positive words in BDM individuals; no difference between word valence was evident in controls.

Bipolar disorder-depressed. There was relatively consistent evidence of attentional bias in response to valenced stimuli in BDD individuals compared to controls; away from positive stimuli and towards negative stimuli. BDD demonstrated within-group differences of faster task responses to negative compared to positive words (Garcia-Blanco et al., 2013a) and significant attentional interference for depression-related compared to euphoria-related words in a Stroop test (Lyon et al., 1999). Eye-tracking research demonstrated decreased attention towards happy images compared to controls and greater

[5] Within-group difference refers to different performance within the same cycle state (e.g., different response times to different stimuli valences *within* BDM participants, rather than in comparison with another group (i.e., control participants)).

time attending to threatening images (Garcia-Blanco et al., 2014). Relatedly, in a cued dot-probe assessment of attention, BDD participants demonstrated increased responsiveness to pre-probe cues in the form of angry faces (but not positive or neutral) and increased difficulty disengaging from these images, which may suggest increased attention to threat (Leyman et al., 2009). This effect was only present, however, for brief, 200ms presentations of face cues.

Other dot-probe assessment has been less consistent. One study demonstrated increased attentional bias away from positive words in BDD compared to controls (Jabben et al., 2012), suggesting individuals with BDD may advert attention from positive stimuli. Whereas, another found only a general bias away from emotional word-based stimuli (both positive and negative) in BDD compared with controls; and no impact of pre-probe cueing (Jongen et al., 2007).

In terms of attentional control, two studies suggested evidence of a generally impaired performance in BDD compared to controls. Garcia-Blanco and colleagues (2013a; 2013b) found slower tasks responses on the go/no-go task and increased task errors in specifically averting from, or directing attention to, images of faces, irrespective of stimuli valence. In the go/no-go task, BDD participants also demonstrated faster responses to negative compared to positive words; whereas controls did not differ in response. Contrastingly, however, Bertocci and colleagues (2012) found no differences between BDD and controls in inhibiting attention to neutral, fearful, or happy faces acting as distractors in an n-back task.

Bipolar disorder-euthymic/remitted. Little evidence was found of differences between BDE/R and controls in terms of emotion-specific selective

attention or attentional interference. Both dot-probe assessment, utilising positive/negative/neutral word-based stimuli, (Jabben et al., 2012; Jongen et al., 2007) and Stroop assessment, either utilising valenced (Lex et al., 2008; Malhi et al., 2005) or condition-related words (Lex et al., 2011), demonstrated no significant differences between BDE/R and controls. Notably, all studies utilised word, rather than image-based, stimuli; however, eye-tracking technology has also suggested similar gaze fixation in BDE/R and controls for positive, negative and neutral valenced images (Garcia-Blanco et al., 2014) – although, as with BDM and BDD participants, increased attention to threatening images was demonstrated.

Two studies employed neutral Stroop tests, assessing general rather than emotion-specific attentional interference between BDE/R and controls. The results were inconsistent – one study reported no significant differences in response accuracy between groups (Kronhaus et al., 2006) and one reported more errors in BDE/R participants (Strakowski et al., 2005). Relatedly, Malhi and colleagues (2005) did not replicate group difference in terms of errors, but did find generally slower responses rates in BDE/R compared to controls.

In terms of attentional inhibition, go/no-go task results demonstrated inconsistent results. One study found evidence of bias towards negative stimuli; compared to controls, BDE/R demonstrated decreased reaction time to negative words and decreased response accuracy to positive words (Gopin et al., 2011). However, following positive mood induction, Roiser and colleagues (2009) found no difference in reaction time based on stimuli valence, although BDE/R participants did demonstrate significantly more commission errors when presented with positive rather than negative distractor words. Elsewhere differences in attention inhibition failed to be evidenced in either word-based

stimuli (Garcia-Blanco et al., 2013a) or using face distractors (Wessa et al., 2007).

Additionally, Lomax and colleagues (2009) suggested evidence of increased implicational processing in BDE/R compared to controls – i.e., that they were less likely to notice when an answer relied on expected outcome rather than on what could be factually ascertained from the question.

Interpretation

Bipolar disorder-manic. BDM was associated with interpretation biases in multiple forms. Two studies asked participants to interpret the emotional intensity of images, either faces (Lennox et al., 2004) or general images (Bermpohl et al., 2009). Both studies utilised standardised, validated image sets. In interpretation of facial expressions, whereas controls demonstrated good recognition of emotional intensity of both sad and happy faces, BDM participants demonstrated significantly lower ratings of emotional intensity for the most sad faces (Lennox et al., 2004). The authors suggest this may be evidence of reduced perception of sadness in BDM compared to controls. In rating general images rather than faces, this finding was not replicated exactly; instead, compared to controls, BDM gave higher emotional valence ratings for positive and neutral images, but not negative images (Bermpohl et al., 2009).

Thomas and colleagues (2009) employed a sentence-completion task (Teasdale, Taylor, Cooper, Hayhurst, & Paykel, 1995) to assess differences in interpretation of sentences with both potential positive or negative meaning. Compared to controls, BDM participants made significantly more positive, and fewer negative, sentence completions. Relatedly, BDM individuals were found

to endorse more positive than negative words as self-referent; however, this pattern was also found in controls.

Bipolar disorder-depressed. As with BDM individuals, Thomas and colleagues (2009) reported significantly more positive sentence completions in BDD compared to controls; however, unlike BDM, although BDD participants made fewer negative sentence completions than controls, this difference was not significant. No studies explored interpretation of images.

Lyon and colleagues (1999) found that BDD participants endorsed more negative than positive words as self-referential; and that BDD individuals reported higher internalisation scores for negative compared to positive events, whereas BDM and control participants demonstrated the reverse.

Bipolar disorder-euthymic/remitted. As with BDD, stimuli interpretation studies focused on language (word/sentence) interpretation and unfortunately did not include images. Conflicting evidence was found in terms of sentence-completion task interpretation. Despite utilising the same sentence-completion methodology (Teasdale et al., 1995) across studies, BDE/R participants reportedly made significantly more negative interpretations (Lomax & Lam, 2011) *and* significantly more positive interpretations compared to controls (Thomas et al., 2009). The latter difference was found for BDM, BDD, *and* BDE/R; however, only BDM and BDE/R made significantly fewer interpretations of ambiguous stimuli as negative compared to controls. Miklowitz and colleagues (2010) employed a scrambled-sentence task, such that each sentence could be resolved in a hyper-positive or –negative way. Controls made more hyperpositive interpretations compared to BDE/R participants. A further study employing homographs, with both positive and negative meaning,

found significantly fewer positive interpretations in BDE/R compared to controls (Holmes et al., 2011). BDE/R individuals also demonstrated more inaccuracies in correctly categorising emotionally positive words compared to controls, although no difference was found in accuracy of negative or neutral word interpretation (Gopin et al., 2011). BDE/R participants also demonstrated endorsement of significantly fewer positive words and more negative words as self-referent compared to controls (Molz Adams et al., 2014). This relationship was fully mediated by depressive symptoms. Consequently, although there is discrepancy between the sentence-completion studies; the overall evidence is most consistent with Lomax and Lam's (2011) suggestion of a negative interpretational bias.

Only one study incorporated *real-world* assessment. Havermans and colleagues (2007) explored subjective appraisals of life events across the day, but found no difference in perception of un/pleasantness, importance, or stressfulness between BDE/R and controls.

Memory

Bipolar disorder-manic. Two studies assessed memory bias in BDM (Lex et al., 2011; Lyon et al., 1999). In Lyon and colleagues' (1999) study, BDM participants completed a simple recall task following the word endorsement task (see 'interpretation' section). They found BDM participants recalled significantly more negative words compared to controls (Lyon et al., 1999). Elsewhere, a more complex methodology was employed (an Emotional Auditory Verbal Learning Test) to assess ability to learning different valenced information (manic, depressive, and neutral) and the level of interference caused by new information (Lex et al., 2011). This methodology is a variation on standard

cognitive function assessment of immediate and briefly delayed recall, and concludes with a recognition task of included and not included words. Lex and colleagues (2011) reported BDM participants had greater difficulty recalling depression-related words after rehearsal compared to controls; however, no differentiating effects were found on the interference or recognition task.

Bipolar disorder-depressive. Consistent with BDM, BDD was associated with significantly increased recall of negative words compared to controls (Lyon et al., 1999).

Bipolar disorder-euthymic/remitted. Lex and colleagues (2008) found no significant difference in recall of difference valenced stimuli following Stroop test between BDE/R and controls. Similarly, no significant differences were found in recall following rehearsal, or after interference task; however, BDE/R participants recognised significantly fewer words than BDM and controls irrespective of word valence (Lex et al., 2011). Conflictingly, elsewhere, significantly greater recall of negative adjectives and reduced recall of positive adjectives was demonstrated in BDE/R compared to controls following a word endorsement task (Molz Adams et al., 2014). However, this study utilised relative proportion of adjectives as the outcome variable, rather than sum total, which compromises direct comparison with Lex and colleagues (2008).

Discussion

Specific processing biases may be associated with specific psychological difficulties (Mogg & Bradley, 2005). This review demonstrates that in bipolar disorder, however, there is inconsistency, both in terms of the presence and form of bias. A clear profile of processing biases in bipolar disorder is not

currently forthcoming. Instead, the picture painted appears complex and variable – much like the condition itself.

This review found little evidence of selective attention towards, and attentional interference in response to, different valenced stimuli in bipolar disorder in manic and euthymic states. This finding was irrespective of stimulus type (i.e. photograph or word), suggesting that even when processing images, which does not require the same level of semantic processing as words, specific propensities in allocation of attention are not evident in bipolar disorder. In contrast, depressive bipolar states present a more consistent pattern of selective attentional bias away from positive stimuli and towards negative.

Evidence of difficulties employing attentional inhibition specific to valenced information was similarly inconsistent both across, and often within, bipolar states. Predominantly studies exploring attentional inhibition involved BME/R individuals, and it is here that there is most conflicting evidence – both supporting (e.g., Gopin et al., 2011; Roiser et al., 2009) and refuting (Garcia-Blanco et al., 2013a; Wessa et al., 2007) valence-specific inhibition difficulties. Fewer studies exploring valence-specific inhibitions for other bipolar states were found. There was some evidence of speedier processing of valenced stimuli dependent on cycle state – i.e., faster response to positive compared to negative stimuli in manic states; and the converse for depressive states – but no evidence of task error indicative of valence-specific inhibition difficulties (Garcia-Blanco et al., 2013a). It is clear more research is needed across all states in order to more accurately conclude.

More compelling support was found for associations between bipolar disorder and interpretation biases – although, once again, bias manifestation

was not entirely consistent. There is suggestion that manic states are associated with increased positive interpretations and/or diminished negative interpretations of ambiguous stimuli. However, evidence of the opposite negative bias in depressed states was inconsistent (Lyon et al., 1999; Thomas et al., 2009). Similarly, inconsistent biases towards both negative and positive interpretations were found for remitted and euthymic states. Although far from conclusive, it is interesting to observe that euthymic state potentially may not be considered a return to a 'normal' state, as cognitive vulnerabilities may remain. These results may also suggest that research should consider whether participants in euthymic states are stabilised in mood or currently descending or ascending in the bipolar cycle.

Research into potential memory biases associated with bipolar disorder was the most lacking of the information processing biases investigated. Memory is a consistent component of cognitive functioning assessment (e.g., Cavanagh, Van Beck, Muir, & Blackwood, 2002; Hellvin et al., 2012); however, it appears that memory biases, rather than deficits, are under-researched. Consequently, the evidence suggesting a propensity to preferentially recall negative information was limited, as was comparison across cycle states.

Methodological Considerations

Employment of validated diagnostic criteria was good across the majority of studies, enabling comparison of results; however, cycle state classification was less consistent. Although many studies employed validated measures of depression and mania to establish participants' current cycle states, the measures used varied between studies, as did the cut-off criteria differentiating states. This inconsistency compromises comparison between studies.

Sample sizes were typically small. Consequently, statistical analyses will have frequently been underpowered. Once again, this limitation may have contributed to the inconsistent results between studies. More positively, the majority of studies attempted to provide some assessment of equivalence between participant groups on variables outside of bipolar diagnosis (e.g., sex, age).

The majority of studies employed validated tasks to assess bias. However, the potential impact of differences in stimuli and task modifications on outcome between studies must be acknowledged. This review highlights the need for replication of methodologies (Yong, 2012) to support the reliability of findings to refine the currently contradictory body of evidence. Furthermore, more ecologically valid evaluation is required.

Limitations

This review has several limitations. Data for different cycle states of bipolar disorder were aggregated; however, as stated, the studies included did not employ entirely consistent state classification. Although their approaches were typically similar, the slight variation may compromise the unity of the results presented. The division of a disorder arguably considered spectral (Merikangas et al., 2011) may cause issues similar to the reduction of continuous data into categorical. Such reductive separation may be useful but must be considered with caution as the divisions are imposed. Finally, the review is limited to narrative discussion rather than meta-analysis given the heterogeneity of the methodologies and bias variables. Assessment of relative effect-sizes and reliability in future reviews would be expedient.

Conclusions

This review indicates that there may be differences in the way individuals with bipolar disorder process information; however, a consistent profile is currently lacking. The inherent variability of bipolar disorder may mean that processing biases also vary. However, clarification of the inconsistent evidence is essential should consideration be turned to cognitive bias modification and bias-based therapy. Future research may utilise more dimensional conceptions of bipolar symptoms and employ longitudinal assessment of change within individuals throughout the bipolar cycle in order to determine a more coherent picture.

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Appendices

Appendix A: Search String

1. “bipolar”
2. “mania”
3. #1 OR #2
4. “processing bias*”
5. “biased processing”
6. #4 OR #5
7. "attention bias*”
8. “attentional bias*”
9. “biased attention”
10. #7 OR #8 OR #9
11. “interpret* bias*"
12. "biased interpretation"
13. #11 OR #12
14. "memory bias*"
15. "biased memory"
16. "recall bias*"
17. "biased recall"
18. #14 OR #15 OR #16 OR #17
19. #6 OR #10 OR #13 OR #18
20. #3 AND #19

Appendix B: Clinical Psychology Review: Author Submission Guidelines

Guide for Authors

Before You Begin

- **Ethics in publishing**

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EMPIRICAL PAPER

The Impact of Thought Speed and Variability on Psychological State and Threat Perception

Benjamin Albert Rosser

University of Exeter

Supervisors

Dr Kim Wright

University of Exeter

Dr Barney Dunn

University of Exeter

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Target Journal: Cognitive Therapy and Research

Abstract

The speed and variability of thought are purportedly common features of specific psychological states, such as anxiety and mania. The present study explored the proposed independent and combinational influence of these variables upon condition-specific symptoms and affective state. A general population sample was recruited online (*N* = 263). Participants completed a thought speed and variability manipulation task, inducing a combination of fast/slow and varied/repetitive thought. Change in anxiety and mania symptoms was assessed through direct self-reported symptom levels and indirect, processing bias assessment (threat interpretation). Results indicated that both fast and varied thought independently increased self-reported manic symptoms. Affect was significantly less positive and more negative during slow thought. No change in anxiety symptoms or threat interpretation was found between manipulation conditions. Critically, no evidence for the proposed combinational influence of speed and variability was found. Implications for developing understanding of condition-specific mechanisms and avenues for therapeutic intervention are discussed.

The Impact of Thought Speed and Variability on Psychological State and Threat Perception

Cognitive models of psychological difficulties, such as anxiety (Clark, 1999) and mania (Mansell, Morrison, Reid, Lowens, & Tai, 2007), emphasise not only the role of *what we think,* but also *how we think*. Research into the relationship between *how we think* and such difficulties has often focused on the mechanisms and processing biases aligned with disorder-specific thought content (e.g., Alloy, Abramson, Walshaw, & Neeren, 2006; Mogg & Bradley, 2005); however, recently suggestion has been made that characteristics of thinking, previous considered simply symptomatic, may directly contribute to specific difficulties, irrespective of the content of that thought (Pronin & Jacobs, 2008).

Mental Motion: A Theory of Thought Speed and Variability

Mental motion conceptualises characteristics of thinking in terms of the movement-based attributes of thought speed and variability (Pronin & Jacobs, 2008). Thought speed refers to the pace of thinking; whereas thought variability refers to the interconnectivity between thoughts – i.e., their uniqueness or repetitiveness. The mental motion account predicts condition-specific symptoms are causally related to the behaviour of these two characteristics of thought, both individually and in combination. Specific changes in thought speed and variability are proposed to cause changes in affective experience consistent with the conditions of depression, anxiety, and mania – Figure 1. Depressive states are predicted to be the result of slow, repetitive thought; whereas anxiety and mania share an increased thought speed, but are differentiated by thought

variability – anxiety predicted as involving repetitive thought, whereas mania involves varied.

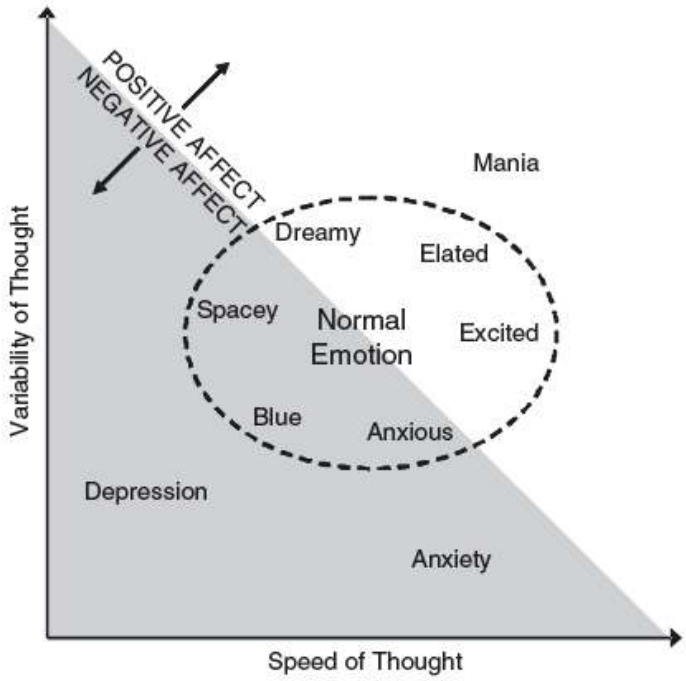

Figure 1. The proposed relationship between variables of mental motion (thought speed and variability) and psychological state. This diagram is taken from Pronin and Jacobs' (2008) article summarising the mental motion account.

The role of thought content in psychological difficulties is acknowledged; however, the characteristics of mention motion are proposed to exert an additional content-independent effect (Pronin & Jacobs, 2008). The proposed effects of mental motion may be theorised as being evolutionarily advantageous: facilitating a state of mobilization and increased propensity towards action in emergency situations that induce quick thinking (Pronin, 2013), and promoting learning and problem-solving through varied thinking by increasing positive affect (Bar, 2009). Conversely, depression, which is associated with slow ruminative thinking, has been hypothesised to encourage inactivity where action is counterproductive (Nesse, 2000).

The existing evidence, outlined below, illustrates that, while there is support for claims of a causal influence of these variables on psychological state, further empirical investigation is required to substantiate the proposed differentiating role of combined thought speed and variability in generating condition-specific symptoms.

Thought speed and psychological state. As stated, the speed at which a person thinks may be related to specific psychological difficulties; for instance, slower thought has been demonstrated in subclinical depression (Sadek & Bona, 2000) and faster thought is a feature of activation demonstrated in mania (Cassidy, Forest, Murry, & Carroll, 1998). Recent experimental designs have begun exploring the proposed causal influence of thought speed on psychological state; employing a wide range of methodologies to artificially manipulate thought speed. Manipulations have including pace-controlled reading, brain-storming, and speed of video presentation (Chandler & Pronin, 2012; Pronin, Jacobs, & Wegner, 2008; Pronin & Wegner, 2006; Yang, Friedman-Wheeler, & Pronin, 2014).

There is consistent evidence from this research that thought speed influences affective state. In a series of six experiments, Pronin and colleagues (2008) employed a selection of manipulation procedures to increase or decrease participant thought speed. Consistently, fast thought was associated with higher levels of positive affect (PA) compared to slow; subscale analysis revealed increased feelings of elation and creativity, and frequently also increased felt energy. This effect on PA has been replicated in larger samples accounting for baseline levels of mood and depression, demonstrating both between and within-group difference for individuals without depression and those with mild-moderate depression; but not severe (Yang et al., 2014).

Interestingly, differences in negative affect (NA) have infrequently demonstrated association with thought speed, even slow thought (Pronin et al., 2008; Yang et al., 2014).

In addition to affective experience, thought speed has been associated with behavioural differences. Participants manipulated to think fast have demonstrated increased pressure of speech and resistance to interruption compared to slow thought conditions (Pronin et al., 2008). Furthermore, in an investigation exploring risk-taking behaviour following thought speed manipulation, fast thought speed was associated with both greater current, and intended future, risk-taking compared to slow thought (Chandler & Pronin, 2012). These behaviours were associated with diminished expectation of negative consequences for the proposed risk-taking, yet no increased anticipated likelihood of positive outcomes.

Limited empirical investigation into anxiety and thought speed exists. Preliminary investigation has demonstrated association between anxiety and thought over-activation (Keizer et al., 2014); however, over-activation encompasses other attributes, such as thought crowdedness, as well as speed. Consequently, the proposition that increased thought speed is associated with anxiety, consistent with a threat-response state of activation, appears predominantly theoretical (Pronin, 2013; Pronin & Jacobs, 2008). Furthermore, as will be discussed, the mental motion account stresses that anxiety may be best understood in relation to combined thought speed and variability, rather than thought speed alone.

Collectively, this evidence suggests that thought speed may influence both affective state and behaviour. Manipulation into fast thought may generate

changes consistent with emotional and behavioural features of manic symptoms (Pronin & Wegner, 2006). Thought speed also influences affective state; however, this influence is most consistently apparent in PA rather than NA. Consequently, although there is evidence that fast thought may change PA in those experiencing mild-moderate depression (Yang et al., 2014), there is not yet confirmation that slow thought is causally related to depression. Furthermore, existing research on thought speed is limited by the relative lack of baseline assessment in methodologies employed. Evidence is predominantly limited to cross-sectional investigation of between-group differences, with few studies attending to within-group change pre/post manipulation (e.g., Pronin et al., 2008 – study six; Yang et al., 2014).

Thought variability and psychological state. Associations between thought variability (or repetitiveness) and psychological state has received considerably more investigation than thought speed – although, as emphasised by Watkins (2008), the literature is fragmented by research fields and terminology.

A thought may bear varying degrees of resemblance and connectivity to prior thoughts, in terms of literal repetition and related conceptual themes. Ruminative thinking is most commonly associated with depression, and has been demonstrated to be elevated in those experiencing dysphoric mood (Riso et al., 2003; Roberts, Gilboa, & Gotlib, 1998), and predictive of depression (Just & Alloy, 1997). However, anxiety is also associated with rumination (Nolen-Hoeksema, 2000), as well another form of repetitive thought – worry. Although rumination and worry appear related (Segerstrom et al., 2000), differentiation in terms of their foci and content has been suggested (Nolen-Hoeksema et al., 2008). Both rumination and worry have demonstrated some evidence of causal

relation with depression and anxiety, respectively. Studies inducing these forms of repetitive thought have found that rumination, compared to distraction, increases depression levels in those with existing depression (Nolen-hoeksema & Morrow, 1993); and worry increases NA (McLaughlin, Borkovec, & Sibrava, 2007).

The concept and form of repetitive thought extends beyond rumination and worry; in an extensive review, Watkins (2008) considered not only the various forms of repetitive thought, but also their potential adaptive functions. In addition to the well-documented unconstructive consequences, repetitive thought may aid problem-solving, focus emergency response, and facilitating emotional processing. Watkins suggested that structural (e.g., content valence) and processing (e.g., concrete vs. abstract) features of repetitive thought may differentiate outcome.

In an experimental manipulation of the breadth of associations between thoughts, Mason and Bar (2012) allocated participants to read either a series of narrowly associated (i.e., revolving around a narrow topic) or broadly progressive words (i.e., related but developing in thematic focus from one to the next). Narrow associative thinking led to decreased PA; whereas, broad progressive thinking led to decreased NA. It has been suggested that changes in affect induced by thought variability may constitute an innate reward system encouraging associative thinking as a means of facilitating learning and survival (Bar, 2009).

Others have suggested that the process of thought repetition may impact on the individual's experience, irrespective of content. In a pace-controlled reading task, Pronin and Jacobs (2008) manipulated both thought speed and

thought variability in 74 participants. The manipulation involved reading a sequence of neutral trivia statements that either did, or did not, repeat. Statements were presented at either half or twice normal reading speed. Compared to the repetitive thought condition, varied thought was associated with significantly higher levels of PA and near significantly higher levels of perceived energy. This study provides the only investigation of the potential interactive properties of thought speed and variability, which the mental motion account proposes play a differentiating role in determining specific psychological states (e.g., anxiety, mania, and depression). Although no interactive effect of thought speed and variability was demonstrated on PA or NA; the results demonstrated that repetitive thought was associated with more feelings of depression than anxiety when slow; and with more feelings of anxiety than depression when fast. The latter thinking style also predicted higher levels of felt energy. These results provide some support for the proposed interactive role of mental motion variables; however, further investigation is warranted for several reasons: 1) the small sample size for the reported analyses, 2) with the exception of assessment of felt energy, differentiation between symptoms of anxiety and mania was largely unexplored, 3) the study did not report using validated measurement of condition symptoms; and 4) the reported significant interaction effects related to differences *between* levels of anxiety and depression rather than *within* each condition – such effects may consequently be largely driven by change in one condition rather than both.

The reviewed evidence provides some support for the mental motion account. Related characteristics of thought have been associated with depression (e.g., Segerstrom et al., 2000), anxiety (e.g., Nolen-Hoeksema,

2000), and mania (e.g., Pronin & Wegner, 2006). Of the two highlighted characteristics of thought, variability/repetition appears to have received the greatest empirical investigation (e.g., see Watkins, 2008). Investigation of thought speed appears largely limited to one research group (i.e., Pronin and colleagues). However, the proposed interactive influence of thought speed and variability has only received limited investigation. In particular, the potential differentiating role of thought variability in generating anxious and manic states is largely untested. It is an interesting proposition as both anxiety and mania can be conceptualised as states of activation. In anxiety, activation is associated with the sympathetic nervous system (Waugh & Grant, 2006) in preparation for 'fight or flight' threat response; whereas in mania, activation is associated with approach towards, and responsiveness to, potential reward (Johnson, Edge, Holmes, & Carver, 2012). Anxiety and mania may, therefore, be related to increased sensitivity of biopsychological systems designed to respond to potential punishment (Behavioural Inhibition System; Gray & McNaughton, 2000) and reward (Behavioural Activation System; see Johnson et al., 2012 for review), respectively. Consequently, the activation states of anxiety and mania may be distinguished by purpose of mobilization – i.e., avoidance or approach. Whether mental motion plays a role in respective system activation is yet to be determined; however, before this question can be addressed, the more fundamental question of whether mental motion demonstrates the predicted causal relation with specific psychological states characterising anxiety and mania requires further attention.

Present Study

The present study aimed to extend previous research into thought speed and thought variability, and their proposed causal relationship with symptoms of

specific psychological states – namely anxiety and mania. In particular, this study was concerned with the independent influence of these variables when controlling for the emotional valence of thought content. As affective experience has frequently been included in previous research and has provided relatively consistent evidence, assessment of changes in affect was also included in the present study to enable comparison with existing evidence. As a nascent area of research, investigation of manipulation effects and symptom variation was limited to the general population, rather than clinical sample. The research was conducted online to facilitate access to a relatively diverse population and recruit a sufficient sample size for well-powered investigation. Online experimental methods are both empirically supported (Germine et al., 2012) and have been previously been utilised for thought speed manipulation (Yang et al., 2014).

The study employed validated clinical self-report measures of condition symptoms. Furthermore, although there have been instances of behavioural assessment of condition symptoms (e.g., Chandler & Pronin, 2012), previous studies have predominantly relied solely on self-report symptom assessment. There is a need for inclusion of more objective symptom assessment as well as self-reported symptoms. Processing biases have been suggested to be instrumental in the maintenance of psychological difficulties (e.g., Clark, 1999) and differentiable between conditions (e.g., Mogg & Bradley, 2005). In anxiety for instance, processing biases commonly present as unconscious, uncontrollable propensities towards threat perception (Teachman, Joormann, Steinman, & Gotlib, 2012), even in its absence. Consequently, this study included assessment of condition-specific threat interpretation bias as an additional more objective assessment of condition symptoms. As there is

discrepant evidence of both decreased sensitivity to threat (Carver & Johnson, 2009) and increased attention towards threat in mania (Garcia-Blanco, Salmeron, Perea, & Livianos, 2014), this study component was exploratory but aimed to provide primarily investigation whether manipulation of mental motion causes differences in perception as well as psychological state.

Finally, whereas previous studies manipulating thought speed have predominantly evaluated cross-sectional between-group differences, this study aimed to extend the limited experimental investigation of change across time points. Based on theory and evidence outlined, the following primary and secondary research questions were developed:

Primary research question. *Do specific combinations of thought speed and variability cause an increase in condition-specific symptoms of anxiety and mania?*

Hypothesis one. Based on the mental motion account, it was predicted that increased thought speed would lead to increased self-reported levels of anxiety symptoms particularly when thought is repetitive and increased self-reported levels of manic symptoms particular when thought is varied.

Furthermore, if specific mental motion, as outlined in hypothesis one, causes increased condition-specific symptoms of anxiety and mania, it was hypothesised that changes in information interpretation consistent with the respective conditions would also be evident.

Hypothesis two. As anxiety is associated with increased threat perception (Mogg & Bradley, 2005), it was predicted that fast, repetitive thought would be associated with increased levels of threat interpretation.

Hypothesis three. Symptoms of mania demonstrate inconsistent association with decreased threat sensitivity (Carver & Johnson, 2009). Consequently, it was tentatively predicted that fast, variable thought would be associated with decreased levels of threat interpretation.

Secondary research question. *Do specific manipulations of thought speed and variability cause changes in affect consistent with previous research findings?*

Hypothesis four. Based on previous research, it was predicted that faster and more variable thought, respectively, would be associated with higher level of positive affect.

Hypothesis five. Based on the mental motion account, it was predicted that slower and more repetitive thought, respectively, would be associated with higher levels of negative affect. However, it was acknowledged that previous research has inconsistently demonstrated significant association between negative affect and these variables.

Materials and Methods

Participants

Participants comprised an opportunity sample from the general population. Participants were only included if aged ≥ 18 years old. Two hundred and sixty-three participants comprised the final sample post data screening.[6] Participants were recruited through online advertising – i.e., study databases, social network websites, forums, and emails were sent to UK universities with ≥ 25,000 students requesting the advert be circulated. A subsection of participants (*n* = 78) were recruited through the university online participant pool and awarded course credit for participation – differences between this subsection and remaining participants is considered in the results section. Participant demographic characteristics are summarised in Table 1.

[6] Sample size exceeded the number required for proposed analyses; see Appendix C1 for power calculation.

Table 1

Participant Demographic Information

Characteristic		**% (unless specified)**
Sex		
	Male	27.4
	Female	72.6
Age		
	Mean (SD)	27.4 years (11.2)
	Range	51.4 years
Marital status		
	Single	52.9
	In a couple, not married	27.0
	Married	16.3
	Divorced	2.7
	Widowed	1.1
Ethnicity		
	White	85.6
	Chinese	4.2
	Other	10.2
Country		
	UK	62.7
	USA	25.1
	Canada	4.2
	Other	8
First language		
	English	89
	Other	29
Employment status		
	Full-time employed	22.4
	Part-time employed	6.8
	Full-time student	58.9
	Part-time student	1.5
	Unemployed	7.6
	Do not work due to disability	1.1
	Retired	1.5
Diagnosis of mental health difficulties		
	No	72.6
	Depression	16
	Anxiety	7.2
	Bipolar disorder	.8
	Other	3.4

Measures[7]

Assessment of manic symptoms. Self-report of manic symptoms was assessed on two levels: 1) trait symptom levels evaluating baseline mania vulnerability for sample descriptive purposes, and 2) state symptom levels evaluating predicted changes in manic symptoms pre/post experimental manipulation.

Hypomanic Personality Scale (HPS; Eckblad & Chapman, 1986). Trait manic symptoms were measured by the HPS. The HPS is a 48-item measure of hypomanic personality; evaluating trait vulnerability towards mania. Items are rated true or false. It has demonstrated good internal (Cronbach's α = .87) and test-rest (α = .81) reliability. In terms of construct validity, Eckblad and Chapman's (1986) original validation study demonstrated association between hypomania vulnerability, assessed by the HPS, and experience of hypomanic episodes. A 13-year follow-up assessment of the same participants further demonstrated that higher HPS scores at initial assessment were associated with increased likelihood of development of bipolar disorder at follow-up (Kwapil et al., 2000).

Internal State Scale (ISS; Bauer, Vojta, Kinosian, Altschuler, Glick, 2000). State manic symptoms were assessed using the ISS. The ISS includes 15-items comprising four subscales: activation, well-being, depression, and perceived conflict. Participants endorse items based on 0-100% agreement scale. All subscales have good internal consistency (α = .81 to .92). This study utilised activation (5 items) and wellbeing (3 items) subscales only. Instructions

[7] The Cognitive Fusion Questionnaire (CFQ; Gillanders et al., 2014) was also employed as a baseline measure; however, it is not reported here as it is intended for report in a separate paper and is not relevant to the specified thesis research questions.

were modified to assess current state, rather than last 24 hours – this modification has been employed elsewhere (e.g., Taylor & Mansell, 2008).

ISS: activation was selected as a measurement of state manic symptoms as activation has been proposed to be a common and core factor underpinning the range of manic symptoms (see Mansell and Pedley (2008) for discussion); and the subscale correlates positively with clinical assessment of mania.[8] Additionally, in combination with the wellbeing subscale, the activation subscale provides dichotomous categorisation of mood state for (hypo)manic, mixed state, euthymic, and depressive states, respectively (Bauer et al., 2000).

Assessment of anxiety symptoms. Self-report assessment of anxiety symptoms was also measured at trait and state levels, respectively assessing: 1) descriptive information regarding sample vulnerability, and 2) predicted change in anxiety symptoms across experimental manipulation.

State-Trait Inventory for Cognitive and Somatic Anxiety (STICSA; Grös, Antony, Simms, & McCabe, 2007).[9] Trait anxiety symptoms were measured by the STICSA. The STICSA is a 21-item measure of anxiety, capable of assessing state and trait anxiety, respectively – the trait assessment was used in this study. It incorporates cognitive and somatic anxiety subscales, and a composite total. Participants endorse likert-scale items based on level of agreement with each statement (1 = *not at all*; 4 = *very much so*). The STICSA-trait measure reportedly demonstrates good internal consistency (Cronbach's α = .87 for both subscales); convergent validity through strong positive correlation with other anxiety measures (Grös et al., 2007); and greater discriminating

[8] r = .60 with the Young Mania Rating Scale (Young, Biggs, Ziegler, & Meyer, 1978) – reported in Bauer et al., 2000.

[9] Original STICSA validation published in conference presentation (Ree, MacLeod, French, & Locke, 2000 as cited in Grös et al., 2007, p. 370.)

validity than Spielberger State-Trait Anxiety Inventory (Elwood, Wolitzky-Taylor, & Olatunji, 2012).

Spielberger State-Trait Anxiety Inventory – short-form (STAI-sf; Marteau & Bekker, 1992). State anxiety symptoms were assessed using the STAI-sf. The STAI-sf is a six-item short-form of the original STAI (Spielberg, Gorsuch, Lushene, Vagg, & Jacobs, 1983). Participants endorse item (e.g., I feel calm) on a 4-point likert-scale (1 = *not at all*; 4 = *very much*). Authors report good internal consistency (Cronbach's α = .82) and comparability to the full STAI. Compared to alternative short-form versions, the selected measure demonstrates the best reliability and validity in correlation with the full STAI (Tluczek, Henriques, & Brown, 2009).

Assessment of affective state. State PA and NA were assessed to explore predicted changes in affect across experimental manipulations. Standardised measurement was utilised at baseline for descriptive information about the sample; however, brief single-item assessments were preferred for repeated measurement pre/post manipulation to reduce task burden whilst assessing predicted change.

Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988). The PANAS is a 20-item measure of PA and NA. Item are endorsed on the extent they relate to present mood on a 5-point likert-scale (1 = *very slight or not at all*; 5 = *extremely*). Authors report good internal consistency (PA, α = .89; NA, α = .85) and construct validity through correlation with depression and anxiety measures.

Brief mood items. Single-item assessments of PA and NA, respectively, were included for brief mood assessment. Participants rated an item on the

positivity and negativity of current mood, respectively, on a 0-100% scale. Items were correlated with PANAS assessment to evaluate their validity as mood assessments (Table 2).

Table 2

Measure Internal Reliability Statistics for Current Study

Assessment focus	Measure	Measure purpose	Cronbach's α (present study)
Manic symptoms	HPS	Trait mania vulnerability; Baseline assessment	α = .89
	ISS: activation	State manic symptoms; Pre/post manipulation change	α = .82
Anxiety symptoms	STICSA	Trait anxiety vulnerability; Baseline assessment	α =. 92
	STIA-sf	State anxiety symptoms; Pre/post manipulation change	α = .86
Affect	PANAS	PA and NA; Validated baseline assessment	PA: α = .9 NA: α = .87
	Single mood items	PA and NA; Pre/post manipulation change	PA correlated with PANAS-PA, r (261) = .43, p < .001, NA correlated with PANAS-NA, r (261) = .54, p < .001

STICSA: cognitive subscale Cronbach's α = .88, somatic subscale Cronbach's α = .85; ISS: wellbeing Cronbach's α = .78 for the present study; PANAS correlations one-tailed.

Assessment of threat interpretation. Threat interpretation was assessed pre/post experimental manipulation to evaluate predicted changes following experimental manipulation.

Ambiguous Scenarios Test (AST; Mathews & Mackintosh, 2000). The AST was employed to assess the predicted changes in threat interpretation. The test consists of 20 short threat-ambiguous scenarios – 10 pre and 10 post manipulation. For each scenario, participants are presented with two sentences providing differing interpretation of the scenario – one threatening and one neutral interpretation. Participants then rated both

interpretations on a 4-point likert scale in terms of how similar to the meaning of the scenario they thought each statement was (1 = *very different in meaning*; 4 = *very similar in meaning*). Within this study only the threat ratings are employed in the analyses as this data relates most specifically to the research question. Consistent with previous AST methodology, scenarios in each set of 10 were presented in the same order and the sets counterbalanced between participants (Hoppitt, Mathews, Yiend, & Mackintosh, 2010).

Engagement and technical difficulties questions. Items evaluating participant engagement and any technical difficulty during completion were included for data screening purposes.

Manipulation

The thought speed and thought variability manipulations replicated Pronin and colleagues' methodology (Pronin & Jacobs, 2008; Pronin & Wegner, 2006). A 2x2 factorial design was employed; thought speed (fast/slow) X thought variability (varied/repetitive). Participants were allocated to one of these four manipulation conditions. In each condition, participants read 63 neutral statements presented in a video produced using Microsoft Powerpoint. Thought speed was manipulated by speed of statement presentation; either fast (40ms per letter) or slow (170ms per letter).[10] The interval between statements was 320ms in the fast condition and 4,000ms in the slow condition. Thought variability was manipulated by presenting either a non-repeating sequence of 63 neutral statements (varied thought) or presenting the same three statements 21 times (repetitive thought). Multiple versions of the repetitive condition, with

[10] Pronin & Wegner (2006) report the fast thought speed manipulation as approximately twice the normal rate of reading; and the slow thought speed manipulation as approximately half the normal rate.

different sets of three statements, were employed across participants to prevent content effects.[11]

Thought speed manipulation check. To assess change in perceived thought speed resultant from the experimental manipulation, a single-item utilised by Pronin and Wegner (2006) was employed. The item requested participants rate their current speed of thought on a 9-point likert-scale (1 = *very slow*; 9 = *very fast*) – wording was modified to enable repeated employment pre/post manipulation.

Procedure

Ethical approval was awarded by the departmental ethics committee. Participants completed the study online. Following informed consent, participants completed demographic details and baseline questionnaires – the order of the latter was randomised. Participants then completed the pre-manipulation AST before being allocated to one of four manipulation conditions. Allocation to manipulation condition was determined by the pseudorandom number generator[12] function of the online study software (qualtrics.com), which guarantees relatively equal numbers between conditions. Post-manipulation questionnaires and AST were then administered. Thought speed was assessed at four points across the course of the study – Figure 2.

[11] Full details on manipulation statements and control of presentation order effects is detailed in Appendix B12.
[12] This randomisation algorithm is the Mersenne Twister.

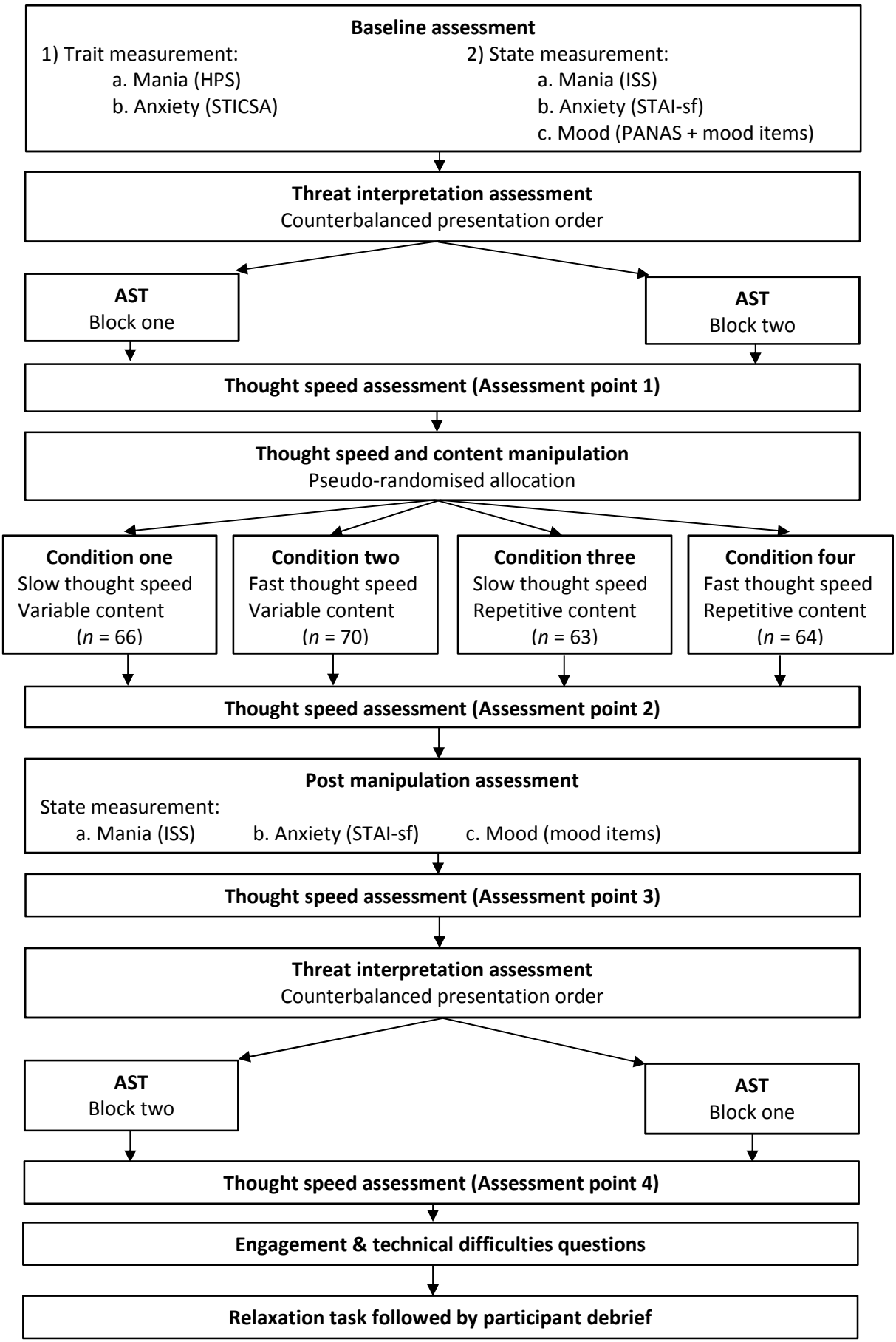

Figure 2. Experimental design and procedural flow.

The study concluded with engagement and technical difficulties questions and a relaxation video aimed to counter any residual effects of the manipulation. Participants were then provided with a full study debrief. A pilot study (N = 10) conducted prior to the main study confirmed the acceptability of this design.[13]

Data Screening and Reduction

Online research typically increases the potential for large quantities of incomplete data, technical difficulties, and potential noise. However, these considerations do not have to compromise the quality of the final data set or findings (Germine et al., 2012) and can be accounted for by strict data screening. Consequently, the original data set (N = 603) was screened and reduced to include participants who completed all study components within specific time parameters (e.g., no longer than 1 ½ hours; and remained on the manipulation video webpage for a set minimum time period).[14] To reduce the influence of extreme data points, dependent variables were assessed for outliers, which were replaced using the Winsorising approach.[15]

Statistical Analyses

Data were analysed using SPSS statistics 20. Parametric analyses were conducted as assumptions of normality were met according to central limit theorem (each group $N \geq 30$); alongside chi-square tests and logistic regression for categorical variables. For the purposes of analyses, effects coding[16] was employed for both thought speed (slow = -1; fast = 1) and thought variability

[13] Full details of pilot study and participant responses are detailed in Appendix C2.
[14] Full data screening and reduction methods are detailed in Appendix C3.
[15] Outliers were defined as data points ≥ 75 percentile + 1.5xInterquartile range; and ≤ 25 percentile – 1.5xInterquartile range. Outliers were replaced with the nearest acceptable non-outlying data point.
[16] Effects coding (i.e., -1, 1) was preferred over dummy coding (i.e., 0, 1) as there was no control condition as appropriate contrast.

(repetitive = -1; varied = 1). Model assumptions and fit were assessed for all analyses (e.g., Levene's test); where evidence of poor fit was detected and could not be rectified through data transformation, this is reported alongside the results. With the exception of sample descriptive information, all means reported are estimated means.

Results

Baseline Descriptive Information and Comparisons[17]

Sample descriptive information for all measures was compiled – Table 3**.**

Table 3

Baseline Raw Data Descriptive Information for Total Sample and Stratified by Manipulation Condition

	Manipulation condition: *Thought Speed X Thought Variability*				
Mean variable score (SD)	**Slow, repetitive**	**Slow, varied**	**Fast, repetitive**	**Fast, varied**	***TOTAL SAMPLE***
HPS	16.35 (9.50)	15.76 (8.23)	16.58 (8.53)	16.59 (7.60)	16.32 (8.42)
STICSA	39.24 (10.98)	38.09 (11.77)	38.98 (10.12)	39.34 (11.25)	38.92 (11.01)
STAI-sf	12.21 (3.92)	11.36 (4.02)	11.63 (4.10)	12.80 (4.05)	12.01 (4.04)
ISS: activation	127.84 (103.23)	122.02 (86.35)	142.06 (104.44)	116.16 (88.04)	126.73 (95.55)
ISS: wellbeing	146.19 (67.46)	157.26 (60.80)	167.59 (64.72)	148.11 (57.18)	154.69 (62.72)
PANAS PA	24.32 (8.50)	26.67 (8.74)	25.72 (8.12)	24.26 (7.27)	25.23 (8.18)
PANAS NA	15.10 (4.66)	15.61 (5.24)	15.53 (5.29)	15.87 (5.26)	15.54 (5.10)
Single-item PA	61.27 (21.57)	67.23 (23.53)	65.84 (22.38)	59.29 (22.87)	63.35 (22.73)
Single-item NA	29.76 (23.75)	25.26 (22.67)*	30.94 (22.44)	37.36 (26.09)*	30.94 (24.10)
AST Threat	20.76 (5.41)	21.59 (5.92)	21.22 (5.85)	21.51 (6.47)	21.28 (5.91)

* Tukey's post-hoc analysis revealed that variable slow and variable fast manipulation conditions significantly differed at baseline on single-item NA, M = 12.10 95% CIs [1.53, 22.67], SE = 4.09, p = .018.

[17] Baseline comparisons of study completers versus non-completers are detailed in Appendix D1.

To assess the equivalence of participants between conditions, baseline comparisons were conducted between the manipulation conditions outline in Table 1. Between-groups univariate ANOVAs were employed to investigate baseline differences between the four conditions. A separate ANOVA was conducted for the each of the following continuous demographic and dependent variables: age, self-reported thought speed, trait anxiety symptoms (STICSA) and mania vulnerability (HPS), state anxiety symptoms (STAI-sf), mood (PANAS and single mood items), state mania symptoms (ISS: activation), state wellbeing (ISS: wellbeing), and level of threat interpretation (AST).[18] Univariate tests demonstrated no difference between experimental conditions on these measures (*Fs* ≤ 1.84, *ps* ≥ .141), with the exception of single-item NA, $F(3, 259)$, $p = .031$, $\eta_p^2 = .03$ – Table 3. However, baseline scores were accounted for in all subsequent analyses of these dependent variables, including NA, either as covariate or repeated-measures design; consequently, this finding did not compromise the following results.

Comparison between experimental conditions on categorical baseline variables (Table 1) was explored through chi-squared tests. Only variables of participant sex and whether participant's first language was English fulfilled the test requirements.[19] No difference was demonstrated in participant sex, $X^2(3) = .70$, $p = .874$; difference in English as first language was near threshold, $X^2(3) = 7.48$, $p = .058$, but not statistically significant.

[18] Model fit was good for all variables except age, PANAS NA, and single-item PA. Square-root transformation resolved poor fit for age and Log transformation resolved fit for PANAS NA; in both cases transformed data did not alter outcome of analyses. Model fit for single-item PA was not improved by either transformation; however, since histogram of standardised residuals for untransformed data was considered acceptable, untransformed data were used.

[19] I.e., ≤ 20% of expected values were less than 5.

In addition, participants recruited through the university participant pool were compared with those recruited outside the pool. Univariate ANOVAs outlined above were repeated, this time with recruitment group as the between-subjects factor; these two groups were compared on same baseline measures as the previous ANOVAs. Levene's test was significant for three measures – PANAS NA, and single-item PA and NA. This violation was resolvable by square-root transformation for single item NA only; however, standardised residuals for all models of transformed demonstrated good fit and therefore the results were considered reliable. Univariate tests demonstrated no differences between groups on baseline variables ($Fs \leq 1.74$*; ps* $\geq .188$), with the exception of level of threat interpretation, $F(1, 261) = 7.19$, $p = .008$. Consequently, the sample was collapsed for analysis; however, potential differences between the participant pool subgroup and full sample were considered when analysing threat interpretation data.

Manipulation Check

The impact of the experimental manipulation on perceived thought speed was assessed through mixed-model 4x2x2 ANOVA. The ANOVA explored change in self-reported thought speed (across assessment points 1-4) X thought speed (fast/slow) X thought variability (varied/repetitive).[20] The manipulation appeared successful; significant difference in thought speed across assessment points was found between fast and slow thought speed manipulation conditions, $F(2.37, 613.76) = 35.727$, $p < .001$, $\eta_p^2 = .12$, with

[20] Mauchly's test indicated violation of assumption of sphericity for both the 4x2x2 ANOVA ($X^2(5) = 123.03$, $p < .001$) and repeated-measures ANOVAs (slow thought speed: $X^2(5) = 114.68$, $p < .001$; fast thought speed: $X^2(5) = 31.84$, $p < .001$). Therefore, Greenhouse-Geisser estimates of sphericity are reported as the corrected degrees of freedom. In addition, contrasts were only explored if multivariate test statistic was significant.
Model fit was good for 4x2x2 ANOVA and subsequent repeated-measures ANOVA below. Of the four dependent variables, only 'thought speed at assessment point 3' demonstrated slightly poorer fit but consultation of standardised residuals histograms suggested adequate fit.

faster self-reported thought speed in the fast (*M* = 5.65, 95% CIs [5.42, 5.88], *SE* = .12) compared to slow condition (*M* = 4.76, 95% CIs [4.52, 4.99], *SE* = .12) – Figure 3.

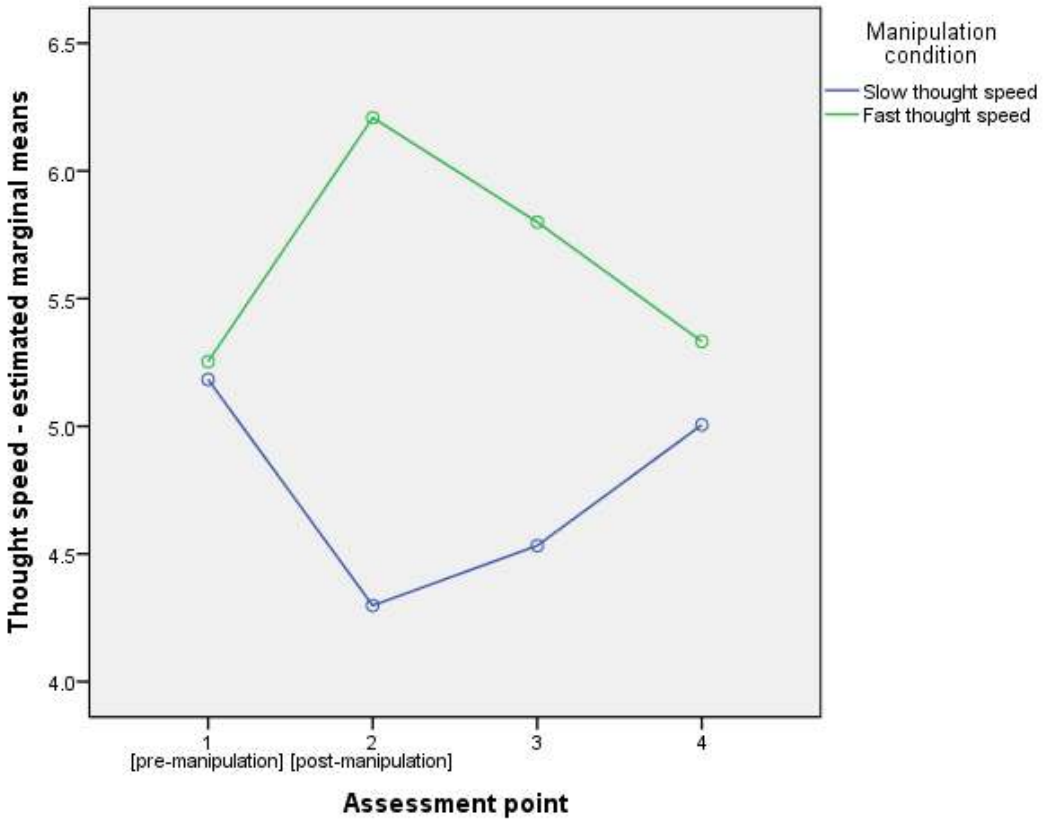

Figure 3. Graph illustrating estimated means of self-reported speed thought at assessment points 1-4 for slow and fast thought speed manipulation conditions.

Simple contrasts indicated that the significant changes in thought speed lay between assessment points 1-2 and 1-3 (*Fs* ≤ 56.87, *ps* < .001). As would be expected, no significant difference in thought speed was found between varied versus repetitive thought conditions across assessment points, *F*(2.37, 613.76) = 2.62, *p* = .064, η_p^2 = .01.

Expanding the analysis above, two repeated-measures ANOVAs were conducted for slow and fast thought conditions, respectively, to investigate change in thought speed across the four assessment points *within* manipulation conditions. Analyses demonstrated significantly decreased thought speed in the

slow manipulation, $F(1.96, 250.59) = 15.09$, $p < .001$, $\eta_p^2 = .11$, and increased thought speed in the fast manipulation, $F(23.67, 354.66) = 21.87$, $p < .001$, $\eta_p^2 = .14$. Simple contrasts revealed that the initial effect size, between assessment 1-2, was large for the slow manipulation ($\eta_p^2 = .14$), and larger still for the fast manipulation ($\eta_p^2 = .24$). In both conditions, the manipulation effect remained significant ($p < .001$), but decreased in effect size at assessment points 3; returning to the pre-manipulation state at assessment point 4 ($Fs \leq 1.22$, $ps \geq .272$).

Primary Research Question: The Effects of Change in Thought Speed and Variability on Symptoms of Anxiety and Mania

The study was concerned with whether manipulation of thought speed and variability influenced psychological state consistent with predictions based on the mental motion account. Of primary interest were changes in symptoms of anxiety and mania assessed via self-reported symptoms and threat interpretation. To explore the primary predictions, a series of 2x2 ANCOVAs were conducted – thought speed (fast/slow) X thought variability (varied/repetitive). The post-manipulation score (assessment point 2) on symptom of interest was entered as the dependent variable; and pre-manipulation score (assessment point 1) entered as a covariate to account for baseline symptom level. ANCOVA was preferred over alternative tests as it is a powerful test well suited to the study design (Vickers & Altman, 2001). Where Levene's test demonstrated violation of homogeneity assumptions, square-root data transformation was applied. This action was taken for ISS: activation and AST threat interpretation data. Transformation exacerbated rather than resolved the violation for threat interpretation. Standardised residuals, however,

demonstrated adequate model fit for untransformed threat interpretation data.[21] Finally, although Levene's test was not significant for anxiety scores, as measured by the STAI-sf, model fit was improved by square-root transformation – consequently, transformed data for this variable were employed in analyses. Table 4 summarises ANCOVA output.

These analyses provided assessment of differences *between* manipulation conditions. Where significant between-group effects were found, these results were explored further through repeated-measures ANOVA to establish the direction and effect size *within* respective manipulation conditions pre-to-post manipulation. For example, if ANCOVA demonstrated significant difference between fast and slow thought speed conditions for an assessed dependent variable, then dependent variable change across assessment points 1-2 was subsequently assessed *within* fast and slow conditions, respectively, by conducting separate repeated-measures ANOVAs for each condition.

Hypothesis one: Self-report symptoms of mania and anxiety.

ANCOVA supported the predicted association between manic symptoms, measured by ISS: activation, and increased thought speed and variability. As predicted, activation level was significantly higher in the fast thought condition (M = 12.6, SE = .34), compared to slow (M = 10.0, SE = .34), $F(1, 258) = 30.20$, $p < .001$, $\eta_p^2 = .11$; and significantly higher in the variable thought condition (M = 11.9, SE = .34), compared to repetitive (M = 10.6, SE = .35), $F(1, 258) = 7.41$, $p = .007$, $\eta_p^2 = .03$.

[21] ≥ 95% of standardised residuals within -/+2.

Table 4

Summary of Estimated Means with 95% Confidence Intervals from ANCOVA Relating to Symptoms of Anxiety, Mania, and Affective State

Dependent variable (post-manipulation)	**Thought speed**			**Thought variability**		
Estimated Mean [95% CI]	**Slow**	**Fast**	***Sig.***	**Repetitive**	**Varied**	***Sig.***
State anxiety symptoms[n] (STAI-sf)	3.50 *[3.44, 3.57]*	3.55 *[3.49, 3.62]*	.314	3.52 *[3.45, 3.59]*	3.54 *[3.47, 3.61]*	.636
State mania symptoms[n] (ISS: activation)	9.97 *[9.29, 10.64]*	12.61 *[11.95, 13.28]*	<.001	10.63 *[9.95, 11.32]*	11.95 *[11.29, 12.61]*	.007
Positive affect	56.54 *[53.63, 59.46]*	61.43 *[58.57, 64.29]*	.019	59.80 *[26.87, 62.74]*	58.17 *[55.33, 61.01]*	.432
Negative affect	33.69 *[30.57, 36.82]*	29.05 *[25.99, 32.12]*	.038	31.05 *[27.92, 34.17]*	31.70 *[28.68, 34.73]*	.766
ISS: wellbeing	135.73 *[128.41, 143.05]*	146.68 *[139.50, 153.87]*	.037	140.29 *[132.92, 147.66]*	142.12 *[135.00, 149.25]*	.725
Threat interpretation (AST score)	21.45 *[20.69, 22.21]*	20.81 *[20.06, 21.55]*	.234	21.45 *[20.68, 22.21]*	20.81 *[20.07, 21.55]*	.241

	Interaction				
Estimated Mean [95% CI]	**Slow, repetitive**	**Slow, varied**	**Fast, repetitive**	**Fast, varied**	***Sig.***
State anxiety symptoms[n] (STAI-sf)	3.50 *[3.40, 3.60]*	3.51 *[3.41, 3.61]*	3.54 *[3.44, 3.63]*	3.57 *[3.48, 3.66]*	.836
State mania symptoms[n] (ISS: activation)	9.56 *[8.60, 10.53]*	10.37 *[9.43, 11.32]*	11.71 *[10.74, 12.67]*	13.52 *[12.60, 14.44]*	.300
Positive affect	56.73 *[52.56, 60.90]*	56.35 *[52.27, 60.44]*	62.87 *[58.73, 67.01]*	60.00 *[56.02, 63.96]*	.551
Negative affect	34.12 *[29.68, 38.56]*	33.27 *[28.90, 37.64]*	27.97 *[23.56, 32.37]*	30.14 *[25.89, 34.39]*	.497
ISS: wellbeing	133.44 *[122.95, 143.93]*	138.02 *[127.79, 148.25]*	147.14 *[136.70, 157.58]*	146.23 *[136.28, 156.17]*	.601
Threat interpretation (AST score)	21.89 *[20.80, 22.97]*	21.01 *[19.95, 22.07]*	21.01 *[19.93, 22.08]*	20.61 *[19.58, 21.64]*	.658

[n] = Square-root transformed data; Estimated means = Adjusted group means accounting for dependent variable pre-manipulation score as covariate.

Assessment of symptom change pre-to-post manipulation within fast and slow thought speed conditions, respectively, clarified these findings. The repeated-measures ANOVAs demonstrated that activation level significant increased when manipulation induced fast thought speed, $F(1, 133), 36.32, p < .001, \eta_p^2 = .21$; but did not significantly change when thought speed was slowed, $F(1, 128) = .79, p = .375, \eta_p^2 = .01$. Similarly, within the thought variability conditions, only variable thought demonstrated within-group change.

Activation increased when variable thought was induced, $F(1, 135) = 19.62, p < .001, \eta_p^2 = .13$; but not when thought was repetitive, $F(1, 126) = .50, p = .482, \eta_p^2 < .01$.

Contrary to prediction, ANCOVA demonstrated no differences in anxiety symptoms, measured by STAI-sf, between manipulation conditions. No significant main effects were demonstrated between thought speed, $F(1, 258) = 1.02, p = .314, \eta_p^2 < .001$, or thought variability conditions, $F(1, 258) = .23, p = .636, \eta_p^2 < .01$.

The mental motion account emphasises combinational role of thought speed and variability in differentiating anxious and manic states; however, no evidence was found for the predicted interaction for either symptoms of mania, $F(1, 258) = 1.08, p = .3, \eta_p^2 < .01.$, or anxiety, $F(1, 258) = .05, p = .826, \eta_p^2 < .01$.

Hypotheses two and three: Objective symptoms of mania and anxiety. Contrary to prediction, no evidence of condition-specific differences in threat interpretation, as measure by AST, was found between manipulation conditions. ANCOVA main effects were non-significant for thought speed, $F(1$

258) = 1.43, p = .234, η_p^2 = .01, and thought variability, F(1 258) = 1.40, p = .238, η_p^2 = .01. The interaction term (Speed X Variability) was also non-significant, F(1 258) = .19, p = .660, η_p^2 < .01.

As significant difference in baseline threat interpretation scores were found between participants recruited through the university participant pool and those not, the ANCOVA outlined above was repeated with these two groups included as a covariate. The results remained non-significant, $Fs \leq 1.42$, $ps \geq .241$.

Secondary Research Question: Effects of Thought Speed and Variability on Affective State

Of secondary interest were the predicted differences in affective state dependent on thought speed and variability manipulation. The analytic approach employed for the primary research question was repeated, with single-item PA and NA as dependent variables: 1) ANCOVA assessing between condition differences, and 2) repeated-measures ANOVA to assess within condition change pre-to-post manipulation.

Where Levene's test was significant in ANCOVA, square-root data transformation was applied. This action was taken for single-item PA. Transformation exacerbated rather than resolved the violation for PA and did not improve model fit. Consequently, untransformed data were utilised in this instance. Furthermore, the single-item NA ANCOVA and repeated-measures ANOVA for slow thought conditions demonstrated evidence of poorer model fit,[22] which was not resolvable by transformation. Consequently, to improve reliability, PA and NA results should be considered with reference to related

[22] NA ANCOVA: 93.9% of standardised residuals within +/-2; NA ANOVA: 94.6% within +/-2.

study findings (e.g., Pronin & Jacobs, 2008; Yang et al., 2014). ANCOVA output is summarised in Table 4**.**

Hypotheses four and five: Affective state. Consistent with prediction, ANCOVA demonstrated significant differences between thought speed conditions for both positive, $F(1, 258) = 5.56$, $p = .019$, $\eta_p^2 = .02$, and negative affect, $F(1, 258) = 4.33$, $p = .038$, $\eta_p^2 = .02$. Participants engaged in fast thought reported significantly higher levels of PA ($M = 61.43$, $SE = 1.45$) and lower levels of NA ($M = 29.05$, $SE = 1.56$), compared to the slow condition ($M_{\text{positive affect}} = 56.54$, $SE = 1.48$; $M_{\text{negative affect}} = 33.69$, $SE = 1.58$).

Repeated-measures ANOVAs assessing within-group change pre-to-post manipulation demonstrated significant decrease in PA, $F(1, 128) = 20.23$, $p < .001$, $\eta_p^2 = .14$, and increase in NA, $F(1, 128) = 4.81$, $p = .030$, $\eta_p^2 = .04$, within the slow thought condition. No significant changes were demonstrated in the fast thought condition for in either positive, $F(1, 133) = 1.22$, $p = .271$, $\eta_p^2 = .01$, or negative affect, $F(1, 133) = 3.26$, $p = .073$, $\eta_p^2 = .02$.

Contrary to prediction, no differences were found between the thought variability conditions for either PA, $F(1, 258) = .62$, $p = .432$, $\eta_p^2 < .01$, or NA, $F(1, 258) = .09$, $p = .766$, $\eta_p^2 < .01$. Furthermore, no significant interactions (Speed X Variability) were demonstrated (*Fs ≤ .46, ps ≥ .497*).

Mood State Classification

In addition to the results outlined, ISS subscales were employed to generate mood state classifications; participants were dichotomously categorised as meeting criteria for each of the following categories,

respectively: (hypo)mania, depression, euthymia, and mixed-state.[23] Participants were categorised pre and post manipulation. As categorisation included manic and depressive states, the subsequent analyse were relevant to both primary (manic symptoms) and secondary (affective state) research questions.

Four logistic regressions were conducted – one for each mood state category. Participant mood state post-manipulation was entered as the dependent variable. To account for baseline mood, pre-manipulation mood state was entered in the first step as a covariate. Thought speed, thought variability, and their interaction term (Speed X Variability), were entered as predictive variables in the second step. Model fit was good for prediction of (hypo)mania only, consequently the poorer fit of the remaining models should be borne in mind.[24]

Thought speed significantly improved the predictive power of the model, above baseline mood state predictor, for the mood state categories of (hypo)mania and depression only. Table 5 summarises the significant model results.

Consistent with prediction and the mental motion account, regression results demonstrated that, post-manipulation, more individuals met criteria for (hypo)mania in the fast thought speed condition compared to slow; and more individuals met criteria for depression in the slow thought speed condition compared to fast – Figures 4 and 5. However, thought variability did not predict association with either (hypo)mania or depression.

[23] Participants were coded (0 = not meeting ISS mood state criteria; 1 = meeting ISS mood state criteria) for each mood state category, respectively.

[24] Removing outlier standardised residuals solely on basis of their lack of fit with model is considered bad practice (Field, 2005); rather, in the absence of explanation for such outliers, the limitations of the model must be acknowledged and future research may aim to clarify.

Table 5

Logistic Regression Exploring Mood State Predicted by Thought Speed and Variability

Dependent variable	**Predictors**		**95% CI for exp *b***		
		B (SE)	**Lower CI**	**exp *b***	**Upper CI**
(Hypo)mania	*Constant*	-1.84*** (.35)		.16	
	Baseline ISS mania classification	2.22*** (.35)	4.66	9.19	18.11
	Thought speed	1.07* (.44)	1.23	2.90	6.83
	Thought variability	.21 (.46)	.50	1.23	3.01
	Speed X Variability	-.07 (.60)	.29	.93	3.01
R^2 = .18 (Hosmer & Lemeshow); .21 (Cox & Snell); .29 (Nagelkerke). Model $X^2(4) = 61.71$					
Depression	*Constant*	-1.21 (.32)		.30	
	Baseline ISS depression classification	-2.70*** (.38)	7.13	14.93	31.30
	Thought speed	-.94* (.48)	.15	.39	.99
	Thought variability	-.09 (.43)	.39	.92	2.13
	Speed X Variability	-.42 (.68)	.17	.66	2.48
R^2 = .23 (Hosmer & Lemeshow); .24 (Cox & Snell); .35 (Nagelkerke); Model $X^2(4) = 71.77$					

*** p < .001; ** p < .01; *p < .05

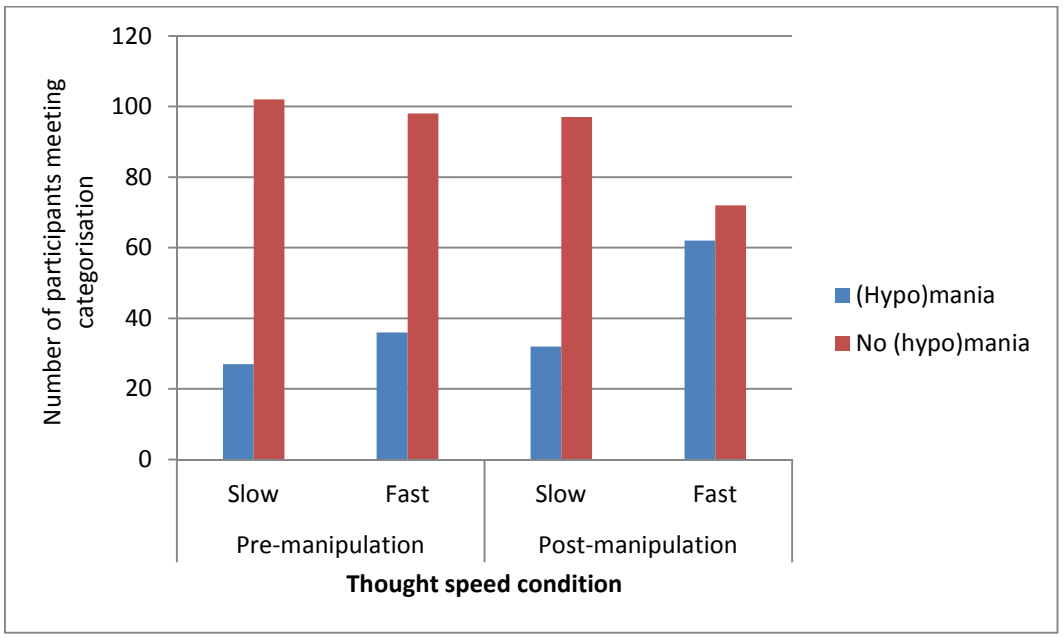

Figure 4. Number of participants meeting threshold for ISS (hypo)mania categorisation for slow and fast thought speed conditions (pre and post manipulation).

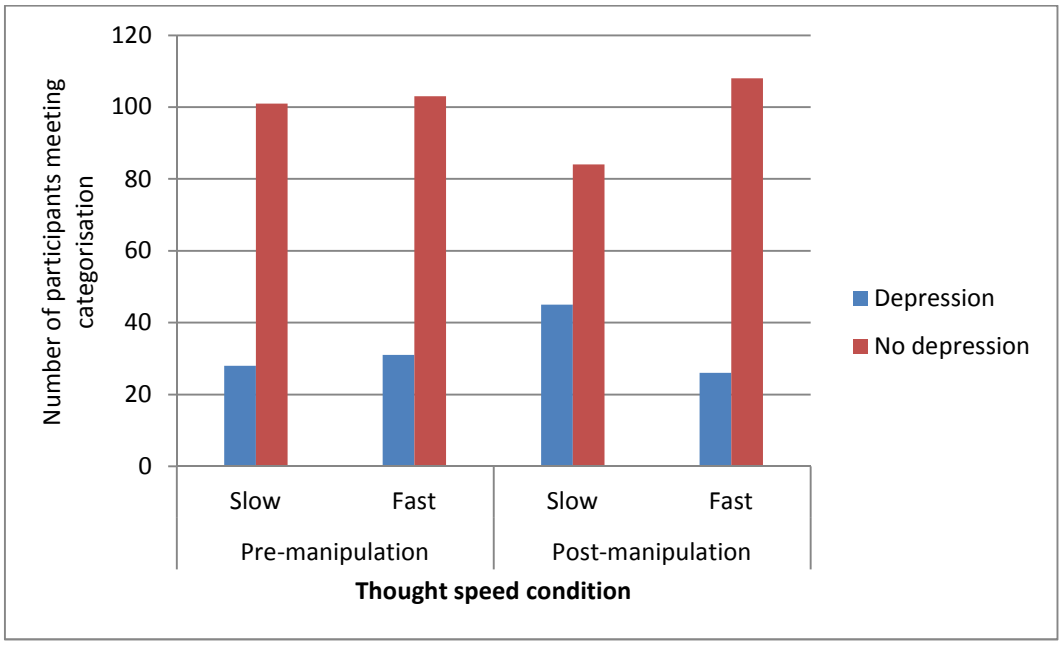

Figure 5. Number of participants meeting threshold for ISS depression categorisation for slow and fast thought speed conditions (pre and post manipulation).

Discussion

The present study explored the impact of thought speed and variability on psychological state. The mental motion account predicts that these variables are causally related to specific psychological states, such as anxiety and mania, rather than simply being symptomatic of those states. This study extended previous research by further investigating whether condition-specific symptoms of anxiety and mania are induced by speed and variability of thought. Based on the theoretical account, increases in anxiety and manic symptoms were predicted to be associated with fast thought, but differentiable by the variability of that thought. These characteristics of *how we think* have been proposed to exert both individual and combinational effects. Critically, the combinational effects have been suggested to play a differentiating role between the specific psychological states of anxiety and mania (Pronin & Jacobs, 2008). Changes symptom levels were assessed by both self-reported level and threat interpretation. Additionally, as affective state has been a consistent focus within the existing literature (e.g., Pronin et al., 2008), change in PA and NA was also included to evaluate the reliability of the present study findings. This study found supportive evidence that thought speed and variability do influence psychological state. The findings most consistently support the mental motion account of manic and affective state; relationship between mental motion and anxiety was unsupported suggesting the theory requires further development.

Mental Motion and Symptoms of Anxiety and Mania

Based on the mental motion account it was predicted that specific changes in thought speed and variability would be associated with increases in anxiety and manic symptoms, respectively (hypotheses one-three). The

predictions were partially supported. Predominantly the mental motion account of manic thinking was supported; both fast and variable thought were independently associated with increased self-reported activation levels, a core symptom of mania (Mansell & Pedley, 2008). However, change in anxiety symptoms dependent on mental motion, and the predicted differentiation between anxiety and mania symptoms based on specific combinations of thought speed and variability, was not demonstrated.

Consistent with hypothesis one, manic symptoms differed significantly both between experimental manipulation conditions and within. Individuals in the fast thought speed condition exhibited higher levels of activation compared to those in the slow condition. Change in activation level within fast and slow thought speed conditions, respectively, suggested that the observed difference in activation level was largely driven by increases attributable to fast thinking, rather than decreases attributable to slow. Furthermore, ISS mood state categorisation demonstrated that thought speed predicts (hypo)manic state.

Thought variability was also associated with manic symptoms; varied thought was associated with higher levels of activation compared to repetitive thought. Again, this difference appeared largely attributable to significant change on one level of thought manipulation; increased activation was only evident within the varied thought condition, and not the repetitive condition. However, it is acknowledged that inclusion of an active control group with *normal* pace and variability of thought for comparison is necessary to further clarify the reported effects.

Collectively, these findings are consistent with previous evidence of increased manic symptoms (e.g., felt levels of energy, power, creativity, and

risk-taking) in fast compared to slow thought manipulations (Chanlder & Pronin, 2012; Pronin & Wegner, 2006). They support a causal, as well as symptomatic, conception of the thought speed and variability associated with mania. A generic impact of mental motion on manic symptoms appears evident. However, increased speed and variability does not necessitate clinical levels of mania. Consequently, further factors, potentially such as differences in reactivity to affective change (Gruber, 2011) and appraisal of internal states (Mansell et al., 2007), require consideration to clarify what determines subsequent outcome.

Additionally, it was predicted that changes in threat perception consistent with decreased threat sensitivity may be evident alongside increased self-reported manic symptoms. However, no evidence of change in threat interpretation was found. This study component was acknowledged as exploratory given the mixed evidence of threat sensitivity in mania (Carver & Johnson, 2009; Garcia-Blanco et al., 2014) and that existing interpretation bias research has predominantly focused on valence, not threat (e.g., Lex, Hautzinger, & Meyer, 2011; Thomas, Bentall, Knowles, & Tai, 2009). Consequently, the study results cannot be considered conclusive evidence that mania-consistent processing biases are not induced by manipulated changes in thought speed and variability. Further investigation is required.

In contrast to results pertaining to manic symptoms and contrary to prediction, anxiety symptoms (both self-report symptom level and threat interpretation) were not related to either differences in thought speed or variability. While the pace of worried thinking in anxiety has been suggested to demonstrate similarities with manic thinking (Pronin & Jacobs, 2008), anxiety frequently demonstrates co-morbidity with depression (Hirschfeld, 2001), a

condition characterised by slower, ruminative thinking. It has been suggested that anxious worried thought has differently themed content to depressed rumination (Nolen-Hoeksema et al., 2008); it may be that association between mental motion and anxious psychological states cannot be accurately observed or understood without the consideration of thought content.

Critically, no evidence was found to support the predicted differentiating role of combined thought speed and variability. This combinational effect has been proposed to be potentially involved in clarifying similarities between some features of anxious and manic thinking styles (Pronin, 2013; Pronin & Jacobs, 2008). However, this study demonstrated no significant interactions between thought speed and variability.

Mental Motion and Affective State

As predicted in hypothesis four and five, affective experience was influenced by changes in thought speed. Consistent with multiple previous studies (e.g., Chandler & Pronin, 2012; Pronin et al., 2008; Pronin & Wegner, 2006; Yang et al., 2014), individuals engaging in fast, compared to slow, thought reported higher levels of PA and lower levels of NA. Although within-group change pre-to-post manipulation was consistent with previous results that slow thought may cause decreased PA, this study did not replicate previous findings that fast thought causes significantly increased PA (Pronin et al., 2008 – study six; Yang et al., 2014). However, a recent study that stratified results by depression level only found significant PA change in individuals with mild-moderate depression, whereas change did not meet the threshold of statistical significance in those with minimal or no depression (Yang et al., 2014). Consequently, these findings may suggest that the affective influence of thought

speed partially depends on current affective experience (e.g., depression level); and that in the general population, slow thought speed demonstrates the strongest influence over mood, decreasing PA and increasing NA. Furthermore, slow thought, compared to fast, predicted ISS categorisation of depression. This finding provides further support of a possible relationship between thought speed and depression.

Contrary to predictions (hypotheses four-five), affective state did not appear influenced by thought variability. Previous research has found affective influence of thought variability but has often included consideration of thought content (e.g., worry and rumination: Nolen-Hoeksema & Morrow, 1993; McLaughlin et al., 2007) or conceptual interrelationship between thoughts (Mason & Bar, 2011). The study results may further indicate the need to include thought content when investigating the impact of thought variability (Watkins, 2008).

Clinical Implications and Future Research

This research adds to emergent recommendations that psychological intervention may benefit from inclusion of components assessing and manipulating thought speed and variability (e.g., Bar, 2009; Pronin, 2013; Pronin & Jacobs, 2008). A body of literature is demonstrating that *how we think* our thoughts can causally influence psychological experience. This influence may broaden our understanding of the mechanisms of psychological difficulties, such as mania (Pronin & Wegner, 2006) and depression (Yang et al., 2014). This study also extends a developing field considering the value of experimental manipulations as interventions, as well as research methodologies (Hertel & Mathews, 2011).

Inclusion of therapeutic components targeting mental motion associated with specific psychological difficulties may broaden established cognitive-behavioural intervention (Hofmann, Asnaani, Vonk, Sawyer, & Fang, 2012), such as by increasing thought speed to improve mood in mild-moderate depression (Yang et al., 2014); and potentially by inducing slower, more repetitive thought to reduce activation reinforcing factors in individuals with mania.

Furthermore, as these thought processes appear potentially causally related to the manifestation of manic symptoms, self-monitoring of thought speed and variability may enhance individuals' awareness of current vulnerability to relapse and facilitate early intervention (Morriss et al., 2007). Indeed, thought speed (e.g., racing thoughts) is a common symptom of prodromal state in bipolar disorder (Lam & Wong, 2005). Regular, brief assessment of thought speed and variability may enable an individual to be aware of increasing risk factors for relapse and also to engage in brief targeted intervention to revert thinking to a more balance speed and level of variability. This advancement is consistent with NICE guidance for relapse prevention in mania (NICE, 2006), and may potentially provide additional avenues for supporting individuals, where currently the psychosocial recommendations are limited.

It is stressed, however, that further research is required before intervention development. In particular, investigation in clinical populations is necessary to ascertain where and when manipulation of mental motion provides effective therapeutic change. Existing research suggests that in severe difficulties, manipulating mental motion may not have the same outcome as for moderate difficulties (Yang et al., 2014).

Limitations

The present study has a number of limitations. First, the study was conducted online rather than in a laboratory. Online research raises a number of concerns regarding the level of experimental control and comparability to existing lab-based evidence. However, comparability of lab-based and online experiments has demonstrated equivalence (Germine et al., 2012); and a variation on this study's methodology has been successfully employed online (Yang et al., 2014).

Second, a control condition was not included. Although within-group change potentially provides some indication of the impact of deviation of thought speed and variability from *normal* levels, further investigation including a non-manipulated comparison control would extend understanding of typical thought speed and variability.

Third, consistent with previous protocols, this study included self-reported thought speed as a manipulation check. However, in replicating previous methods (Pronin & Jacobs, 2008), similar thought variability measure was not included, which compromises evaluation of the effectiveness of this manipulation. Positively, the significant differences found between, and within, thought variability conditions suggest that the manipulation was effective. However, future research should include a specific, repeated measurement to ascertain manipulation effect size and duration. Furthermore, the manipulation check within this study was limited to self-report, which is vulnerable to social desirability effects. Inclusion of objective assessment of manipulations (e.g., assessing thought speed through response-time in neutral decision-making tasks) would improve future research.

Fourth, in replicating the previously published manipulation procedure, manipulation tasks varied in length. Consequently, the factor of time elapsing may also have influenced the results. Furthermore, additional extraneous variables potentially influenced by the manipulation, such as irritation or boredom associated with repetitive or unstimulating tasks, were not assessed. Consequently, their potential contribution to effects cannot be discounted. However, relative consistency between present findings and investigation utilising alternative manipulation tasks of varying method and duration (e.g., Pronin et al., 2008) affords confidence that mental motion variables are contributing to the observed effects.

Finally, comparison analysis of completers and non-completers revealed little between-groups difference – potentially limiting understanding of the observed attrition and generalizability of the sample. Again, consistency with previous research tempers this limitation. However, as the present study did not employ a clinical sample, generalizability to a clinical population cannot be assumed.

Conclusion

The present study extends understanding of the independent effects of thought speed and variability on psychological state, specifically focusing of symptoms of anxiety and mania. The study findings suggest that the mental motion account, incorporating these attributes, may be most relevant to understanding changes in manic and affective states, rather than anxiety. Faster and more varied thought both independently contributed to increases in activation; whereas, affect was most significantly impacted on by slow, rather than fast, thought speed. Threat interpretation did not differ based on thought

speed and/or variability and no evidence was found of the proposed combinational effect of mental motion variables in differentiating anxious and manic states. Consequently, the theory requires further development if anxiety is to be incorporated. Future research may aim to generate a more comprehensive theoretical account, incorporating other features of thought, such as content and relationship with that content (e.g., Gillanders et al., 2014; Hayes, Luoma, Bond, Masuda, & Lillis, 2006).

In conclusion, the specificity of the influence exerted by thought speed and variability on internal state may prove useful for assessment and therapeutic intervention. However, understanding of the specific influence of these variables requires further confirmation and clarification, particularly in clinical populations.

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Appendices

Appendix A: Ethical Documentation, Information and Consent

Appendix A1: Ethical Approval

Ethical Approval system

Your application (2013/318) entitled THE IMPACT OF THOUGHT SPEED AND VARIATION OF THOUGHT CONTENT ON THREAT INTERPRETATION: ANXIOUS VS. MANIC THINKING has been conditionally accepted

Please visit http://www.exeter.ac.uk/staff/ethicalapproval/

Please click on the link above and select the relevant application from the list. The conditions are as follows:

> This application is approved with the following conditions:1. The debriefing information sheet should provide greater detail (explaining design, hypotheses, etc.).2. Given the inclusion of mood scales and measures relevant to psychopathology, there should be some information in the debriefing information sheet about relevant sources of help if the procedure has raised any issues relating to psychological well-being. This can be very brief (about seeing health professionals), given the potential for responses from all over the world, though web-based sources of information may be helpful.Please ensure that you have addressed these issues prior to commencing data collection. You should email a single document that explains how you have addressed the issues to the Chair, Psychology REC (C.N.W.Burgess@ex.ac.uk), who can then take Chair's Action in providing final approval for your research.

To: Rosser, Benjamin;

- You replied on 25/06/2013 14:24.

Hi Ben,

Sincere apologies for the delay in replying to your message. I have now had a chance to read through your response to our review and your proposed amendments. I am happy with these and so you are free to commence data collection. I wish you all the best with your research.

Cheers,
Cris.

Dr Cris Burgess
Senior Lecturer in Psychology

Education Manager – Undergraduate Psychology
Programme Director, BSc in Psychology
Programme Director, BSc in Applied Psychology
Chair, Psychology Research Ethics Committee

Psychology, College of Life & Environmental Sciences
University of Exeter

Hi Cris,

I've completed my pilot study now, which was included in the ethics application along with the full study design. In the original application I included the activation subscale of the internal state scale (ISS), which was approved; following the pilot, I'd like to add three more items from the ISS (participants rate 0-100% agreement for each statement) to the full study:

1. Right now I feel like a capable person
2. Right now I actually feel great inside
3. Right now I feel energized

I hope that's ok, they are part of the same measure but in combination with the activation subscale allow for standardised grouping of participants for analysis based on response.

All the best

Ben

Trainee Clinical Psychologist

Hi Ben,

Thanks for letting me know about your amendment. I am happy for you to proceed on this basis. I wish you all the best with your ongoing research.

Best regards,
Cris.

Dr Cris Burgess
Senior Lecturer in Psychology

Education Manager – Undergraduate Psychology
Programme Director, BSc in Psychology
Programme Director, BSc in Applied Psychology
Chair, Psychology Research Ethics Committee

Psychology, College of Life & Environmental Sciences
University of Exeter

Appendix A2: Participant Information Sheet

The impact of thought speed and content on perception

Purpose of Study
The purpose of this study is to examine how the way people think influences the way they view and experience the world. The study aim is to explore how the speed and content of our thoughts may impact on how we interpret information and how we feel. It may be that specific psychological difficulties, like anxiety and mania, relate to these thought processes which are associated with tendencies to view the world in a particular, perhaps unhelpful, way. By understanding the impact of these processes we may better understand how to intervene to help people experiencing certain psychological difficulties.

Procedures
You must be aged eighteen years or older to participate in this study. Participating in this study involves watching a short video which requires reading a series of statements. The statements may be presented at a particular rate to affect the speed at which you read them. You will also be asked to complete a selection of questionnaires before and after watching the video. The first questionnaire asks questions about your background, such as your age, gender and education. The second set of questionnaires explores psychological variables, such as mood and anxiety. You will also be provided with a selection of stories before and after the video and asked to rate your experience of these stories.
All information collected from your participation in this study will be stored in accordance with the ethical standards of confidentiality that govern psychologists. All identifying information will be separated from questionnaire responses. The data will be destroyed within seven years of completion of the study.

Remuneration
Your participation in this research is of great help and much appreciated. Unfortunately, no remuneration is offered for participation. *[INCLUDED FOR PARTICIPANT POOL RECRUITMENT] At the very end of the study you will be provide with instructions about meeting with the researcher to gain your credit. [INCLUDED FOR PARTICIPANT POOL RECRUITMENT]*

Potential Risks and Ethical Consideration
We would expect that for some people, watching the video may affect the way that they feel – they may feel anxious or activated/energised. These affects are, however, expected to be short lasting and there will be relaxation exercise at the end of the study to counteract these affects. We recommend that you complete the whole study, including relaxation exercise. In addition, it is possible some people may experience some discomfort while answering some of the person questions. If you feel you have any ongoing adverse reaction you can contact one of the study team. No other risks are known to the investigator at this time.

Benefits
We don't expect there to be any direct benefits to participants but by taking part you are helping us explore and understand how the way people think affects them.

Confidentiality
All information collected in this study is done so in confidence. Your data will be kept strictly confidential. We will anonymise your data by allocating you a participant identification number. All identifying information will be kept separate to your questionnaire responses. Data will be downloaded and stored on a password protected computer. All data will be deleted seven years after study completion.

What will happen to the results of the research?
The results will be written up in a doctorate thesis and made available to the University marking system. We also hope to publish the study results in a peer-reviewed journal and present them at relevant conferences. Confidentiality will be ensured and no identifying information will be included in any of these activities.

Withdrawal/Premature Completion
Your participation is entirely voluntary and you may cease your involvement at any time without providing a reason. If you would like to withdraw your data you may do so by contacting the researcher below. Please note that if you have not requested for your data to be removed at the time of study completion your data may be included in write ups of the study, as stated above.

Invitation to ask further questions
If you have any further questions regarding this study before providing your consent to participation please contact the research using the contact information below.

Contact Information
Ben Rosser, Trainee Clinical Psychologist, University of Exeter
br250@exeter.ac.uk

Supervised by:
Dr. Kim Wright, Senior Lecturer, University of Exeter
K.A.Wright@exeter.ac.uk

Dr. Barney Dunn, Associate Professor, University of Exeter
B.D.Dunn@exeter.ac.uk

This research has been reviewed and approved by the University of Exeter Ethics Committee.

If you have any concerns about the study you may contact the Chair of Ethics at the University of Exeter: Dr. Cris Burgess C.N.W.Burgess@exeter.ac.uk

Appendix A3: Participant Consent Form

Consent
Please check the tick boxes to show your understanding and agreement to the following statements:

- ☐ I have read the information and understand what the study entails.
- ☐ I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason.
- ☐ I confirm that I am of eighteen years of age or older.
- ☐ I understand the results of this study may be presented and/or published, but that my identity will be kept confidential at all times.
- ☐ I give my informed consent to participate in this study.

Username

To ensure your data is stored confidentially we ask that you create an anonymous username by entering the requested details below.

You will be asked for this username should you contact the researcher to have your data removed.

The last three digits of your phone number

The last three letters/digits of your postcode or zipcode

Appendix A4: Participant Debrief Information

Participant debrief form

Thank you for participating in this research. Without your input we could not complete this research.

As stated at the beginning of the study, this research is interested in how the way people think influences the way they view and experience the world. The study is exploring the relation between the speed at which a person thinks and how they interpret ambiguous information. The statements you watched in the video were designed to temporarily influence the speed you were thinking at. The speed and the variety of the statements are different for different participants.

This study is helping us explore the following research questions:
1. Does thinking varied thoughts quickly cause a decreased perception of threat?
2. Does thinking repetitive thoughts quickly cause an increased perception of threat?

In particular, we are interested in how these 'ways' of thinking might be related to specific psychological difficulties like anxiety and mania. It is hoped that by understanding these processes and their relationship to psychological difficulties we may inform more effective treatments in the future.

We do not anticipate any lasting effects of taking part in the study. The relaxation exercise at the end of the study should have left you feeling calm. However, if you continue to feel highly activated or anxious at a level that worries you, or this procedure has raised any issues relating to your psychological wellbeing, please contact one of the research team on the contact details listed below. Alternatively or additionally, you may wish to contact a local health professional, such as your doctor.

Once again thank you for your help in this research. If you would like any further information about the study or if you would like to withdraw your data please contact us using the details below:

Contact details
Ben Rosser, Trainee Clinical Psychologist, University of Exeter
br250@exeter.ac.uk

Supervised by:
Dr. Kim Wright, Senior Lecturer, University of Exeter
K.A.Wright@exeter.ac.uk

Dr. Barney Dunn, Associate Professor, University of Exeter
B.D.Dunn@exeter.ac.uk

This research has been reviewed and approved by the University of Exeter Ethics Committee.
If you have any concerns about the study you may contact the Chair of Ethics at the University of Exeter: Dr. Cris Burgess C.N.W.Burgess@exeter.ac.uk

Appendix B: Measures and Materials

Appendix B1: Demographic Information Questionnaire

Participant Details

Please answer the following questions about yourself:

1. Please enter your date of birth
    a. DD/MM/YYYY
2. What is your sex?
    a. Male/Female
3. What is your marital status?
    a. Single
    b. In a couple, no married
    c. Married
    d. Divorced
    e. Widowed
4. Is English you first language?
    a. Yes
    b. No, if no please state your first language
5. In which country do you reside?
6. What is your ethnicity?
    a. White
    b. Mixed – White and Black Caribbean
    c. Mixed – White and Black African
    d. Mixed – White and Asian
    e. Any other mixed background, please specify
    f. Indian
    g. Pakistani
    h. Bangladeshi
    i. Any other Asian background, please specify
    j. Black Caribbean
    k. Any other Black background, please specify
    l. Chinese
    m. Any other ethnic group, please specify
7. Employment status
    a. Full-time employed
    b. Part-time employed
    c. Unemployed
    d. Full-time student
    e. Part-time student
    f. Do not work due to disability
    g. Retired
8. Any diagnosis of mental health difficulties
    a. No

b. Depression
c. Anxiety
d. Mania
e. Bipolar disorder
f. Other, please specify

Appendix B2: Hypomanic Personality Scale (HPS; Eckblad & Chapman, 1986)

Instructions:

Please answer each item true or false. Please do not skip any items. It is important that you answer every item, even if you are not quite certain which is the best answer. An occasional item may refer to experiences that you have had only when taking drugs. Unless you have had the experience at other times (when not under the influence of drugs), mark it as if you have not had that experience.

Some items may sound like others, but all of them are slightly different. Answer each item individually, and don't worry about how you answered a somewhat similar previous item.

	True	False
1. I consider myself to be pretty much an average kind of person.	○	○
2. It would make me nervous to play the clown in front of other people.	○	○
3. I am frequently so "hyper" that my friends kiddingly ask me what drug I'm taking.	○	○
4. I think I would make a good nightclub comedian.	○	○
5. Sometimes ideas and insights come to me so fast that I cannot express them all.	○	○
6. When with groups of people, I usually prefer to let someone else be the center of attention.	○	○
7. In unfamiliar surroundings, I am often so assertive and sociable that I surprise myself.	○	○
8. There are often times when I am so restless that it is impossible for me to sit still.	○	○
9. Many people consider me to be amusing but kind of eccentric.	○	○
10. When I feel an emotion, I usually feel it with extreme intensity.	○	○
11. I am frequently in such high spirits that I can't concentrate on any one thing for too long.	○	○
12. I sometimes have felt that nothing can happen to me until I do what I am meant to do in life.	○	○
13. People often come to me when they need a clever idea.	○	○
14. I am no more self-aware than the majority of people.	○	○
15. I often feel excited and happy for no apparent reason.	○	○
16. I can't imagine that anyone would ever write a book about my life.	○	○
17. I am usually in an average sort of mood, not too high and not too low.	○	○
18. I often have moods where I feel so energetic and optimistic that I feel I could outperform almost anyone at anything.	○	○
19. I have such a wide range of interests that I often don't know what to do next.	○	○
20. There have often been times when I had such an excess of energy that I felt little need to sleep at night.	○	○

21. My moods do not seem to fluctuate any more than most people's do.	○	○
22. I very frequently get into moods where I wish I could be everywhere and do everything at once.	○	○
23. I expect that someday I will succeed in several different professions.	○	○
24. When I feel very excited and happy, I almost always know the reason why.	○	○
25. When I go to a gathering where I don't know anyone, it usually takes me a while to feel comfortable.	○	○
26. I think I would make a good actor, because I can play many roles convincingly.	○	○
27. I like to have others think of me as a normal kind of person.	○	○
28. I frequently write down the thoughts and insights that come to me when I am thinking especially creatively.	○	○
29. I have often persuaded groups of friends to do something really adventurous or crazy.	○	○
30. I would really enjoy being a politician and hitting the campaign trail.	○	○
31. I can usually slow myself down when I want to.	○	○
32. I am considered to be kind of a "hyper" person.	○	○
33. I often get so happy and energetic that I am almost giddy.	○	○
34. There are so many fields I could succeed in that it seems a shame to have to pick one.	○	○
35. I often get into moods where I feel like many of the rules of life don't apply to me.	○	○
36. I find it easy to get others to become sexually interested in me.	○	○
37. I seem to be a person whose mood goes up and down easily.	○	○
38. I frequently find that my thoughts are racing.	○	○
39. I am so good at controlling others that it sometimes scares me.	○	○
40. At social gatherings, I am usually the "life of the party".	○	○
41. I do most of my best work during brief periods of intense inspiration.	○	○
42. I seem to have an uncommon ability to persuade and inspire others.	○	○
43. I have often been so excited about an involving project that I didn't care about eating or sleeping.	○	○
44. I frequently get into moods where I feel very speeded-up and irritable.	○	○
45. I have often felt happy and irritable at the same time.	○	○
46. I often get into excited moods where it's almost impossible for me to stop talking.	○	○
47. I would rather be an ordinary success in life than a spectacular failure.	○	○
48. A hundred years after I'm dead, my achievements will probably have been forgotten.	○	○

Appendix B3: State-Trait Inventory for Cognitive and Somatic Anxiety (STICSA; Ree, MacLeod, French, & Locke, 2000; Grös, Antony, Simms, & McCabe, 2007)

STICSA: Your General Mood State

Instructions:

Below is a list of statements which can be used to describe how people feel. Beside each statement are four options which indicate the degree with which each statement is true of you (e.g., "*not at all",* up to *"very much so"*). Please read each statement carefully and select the option which best indicates how often, ***IN GENERAL***, the statement is true of you.

	Not at all	A little	Moderately	Very much so
1. My heart beats fast	○	○	○	○
2. My muscles are tense.	○	○	○	○
3. I feel agonized over my problems.	○	○	○	○
4. I think that others won't approve of me.	○	○	○	○
5. I feel like I'm missing out on things because I can't make up my mind soon enough.	○	○	○	○
6. I feel dizzy.	○	○	○	○
7. My muscles feel weak.	○	○	○	○
8. I feel trembly and shaky.	○	○	○	○
9. I picture some future misfortune.	○	○	○	○
10. I can't get some thought out of my mind.	○	○	○	○
11. I have trouble remembering things.	○	○	○	○
12. My face feels hot.	○	○	○	○
13. I think that the worst will happen.	○	○	○	○
14. My arms and legs feel stiff.	○	○	○	○
15. My throat feels dry.	○	○	○	○
16. I keep busy to avoid uncomfortable thoughts.	○	○	○	○
17. I cannot concentrate without irrelevant thoughts intruding.	○	○	○	○
18. My breathing is fast and shallow.	○	○	○	○
19. I worry that I cannot control my thoughts as well as I would like to.	○	○	○	○
20. I have butterflies in the stomach.	○	○	○	○
21. My palms feel clammy.	○	○	○	○

Appendix B4: Spielberger State-Trait Anxiety Inventory – short-form (STAI-sf; Marteau & Bekker, 1992)

STAI - STATE

Directions:

A number of statements which people have used to describe themselves are given below. Read each statement and then blacken in the appropriate circle to the right of the statement to indicate how you feel ***RIGHT NOW***, that is, ***AT THIS MOMENT***. There are no right or wrong answers.

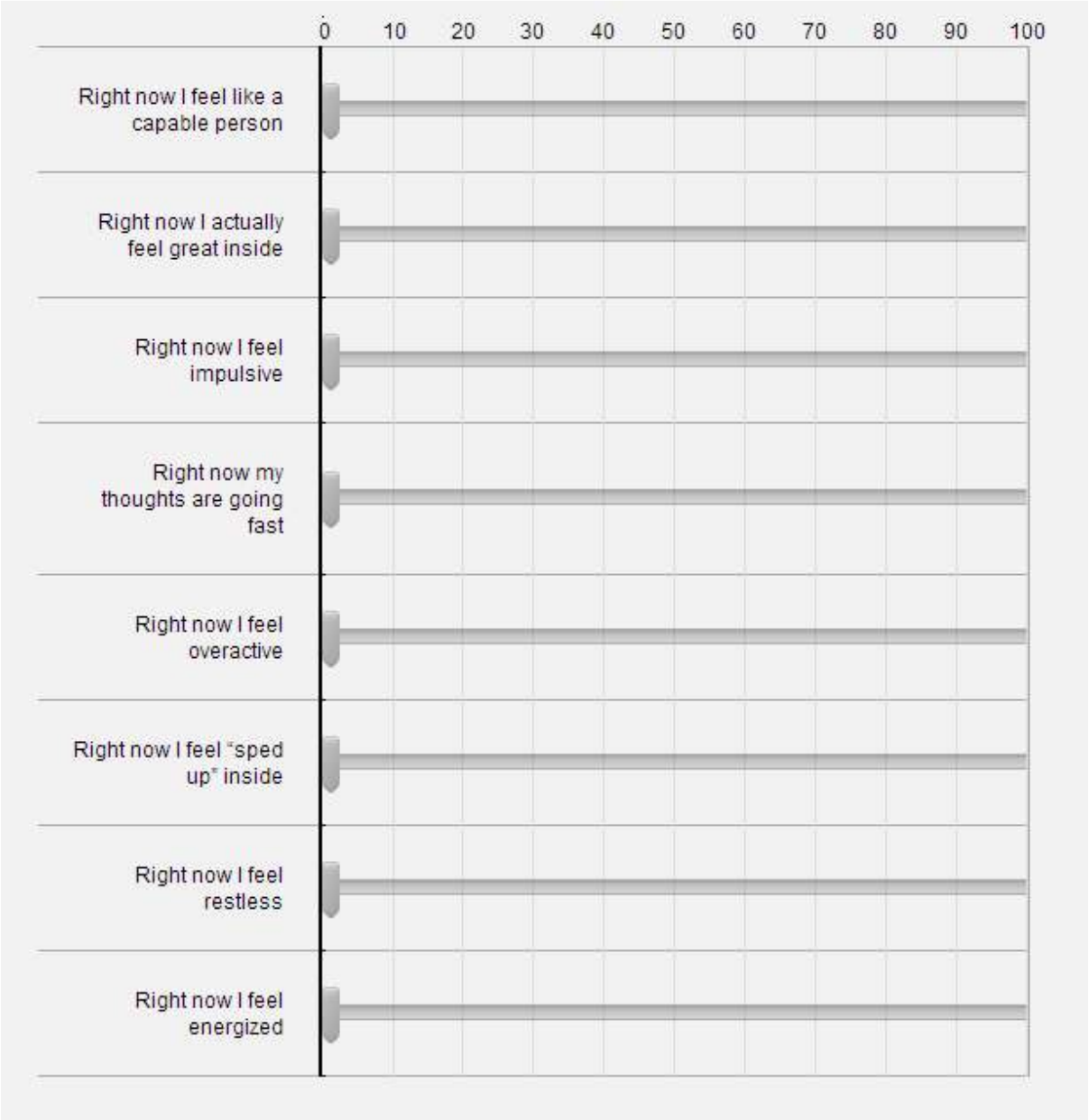
Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

	NOT AT ALL	SOMEWHAT	MODERATELY SO	VERY MUCH SO
I feel calm	○	○	○	○
I am tense	○	○	○	○
I feel upset	○	○	○	○
I am relaxed	○	○	○	○
I feel content	○	○	○	○
I am worried	○	○	○	○

Appendix B5: Internal State Scale (ISS; Bauer, Vojta, Kinosian, Altschuler, Glick, 2000)

ISS

For each of the following statements, please rate from 0-100% how well each statement describes the way you feel ***RIGHT NOW***.



Appendix B6: Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988)

PANAS

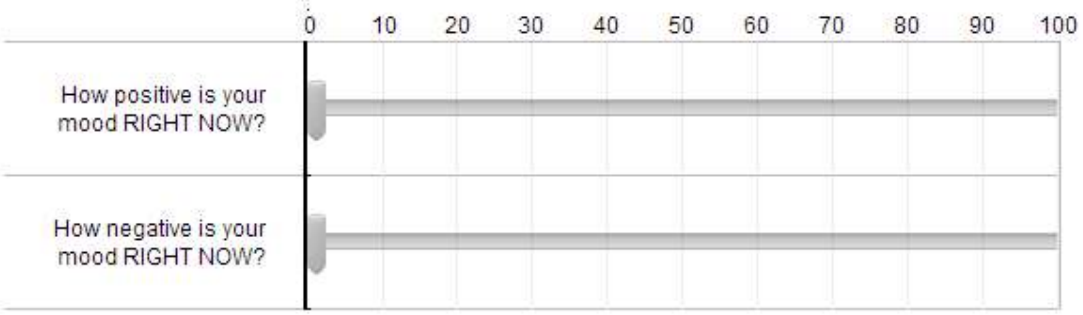
This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you feel this way ***RIGHT NOW***, that is, at the present moment.

	Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
Interested	○	○	○	○	○
Disinterested	○	○	○	○	○
Excited	○	○	○	○	○
Upset	○	○	○	○	○
Strong	○	○	○	○	○
Guilty	○	○	○	○	○
Scared	○	○	○	○	○
Hostile	○	○	○	○	○
Enthusiastic	○	○	○	○	○
Proud	○	○	○	○	○
Irritable	○	○	○	○	○
Alert	○	○	○	○	○
Ashamed	○	○	○	○	○
Inspired	○	○	○	○	○
Nervous	○	○	○	○	○
Determined	○	○	○	○	○
Attentive	○	○	○	○	○
Jittery	○	○	○	○	○
Active	○	○	○	○	○
Afraid	○	○	○	○	○

Appendix B6: Brief mood items

Mood state:

Please answer the questions below. Rate them on a scale from 0-100%.



Appendix B7: Self-Report Thought Speed Item

Sometimes people have the feeling that their thoughts are coming slowly, and other times people feel that their thoughts are 'racing'.

What do you feel is the speed of your thought ***RIGHT NOW***?

	Very slow 1	2	3	4	Moderate 5	6	7	8	Very fast 9
The speed of your thought	○	○	○	○	○	○	○	○	○

Appendix B8: Cognitive Fusion Questionnaire (Gillanders et al., 2014)

Included in measures; related to additional question but not reported in the thesis as not related to thesis research question)

CFQ13

Below you will find a list of statements. Please rate how true each statement is for you by selecting a number next to it using the scale below to make your choice.

	1 never true	2 very seldom true	3 seldom true	4 sometimes true	5 frequently true	6 almost always true	7 always true
My thoughts cause me distress or emotional pain	○	○	○	○	○	○	○
I get so caught up in my thoughts that I am unable to do the things that I most want to do.	○	○	○	○	○	○	○
Even when I am having distressing thoughts, I know that they may become less important eventually	○	○	○	○	○	○	○
I over-analyse situations to the point where it's unhelpful to me	○	○	○	○	○	○	○
I struggle with my thoughts	○	○	○	○	○	○	○
Even when I'm having upsetting thoughts, I can see that those thoughts may not be literally true	○	○	○	○	○	○	○
I get upset with myself for having certain thoughts	○	○	○	○	○	○	○
I need to control the thoughts that come into my head	○	○	○	○	○	○	○
I find it easy to view my thoughts from a different perspective	○	○	○	○	○	○	○
I tend to get very entangled in my thoughts	○	○	○	○	○	○	○
I tend to react very strongly to my thoughts	○	○	○	○	○	○	○
It's possible for me to have negative thoughts about myself and still know that I am an OK person	○	○	○	○	○	○	○
It's such a struggle to let go of upsetting thoughts even when I know that letting go would be helpful	○	○	○	○	○	○	○

Appendix B9: Ambiguous Scenario Test (AST; Mathews & Mackintosh, 2000)

You will be presented with a series of short stories.

After each story you will be presented with two statements that correspond to the story. Neither statement is worded identically to the story - please just rate each statement on how similar in meaning they are to the story.

Please now read the following short stories. When reading the story, please imagine that you are the person being described.

[AST SET 1 (1-10)]

The wedding reception.

Your friend asks you to give a speech at her wedding reception. You prepare some remarks and when the time comes, get to your feet. As you speak, you notice some people in the audience start to laugh.

Please rate the statements below on how similar in meaning they are to the story you have just read. Rate them on the scale from 1-4, where 1= very different in meaning and 4 = very similar in meaning.

As you speak, people in the audience laugh appreciatively.

As you speak, people in the audience find your efforts laughable.

The local club.

You are invited for a night out at a local club, although you don't know any of the members very well. As you approach the door you can hear loud music and noisy conversation, but as you enter the room it is quiet for a moment.

Please rate the statements below on how similar in meaning they are to the story you have just read. Rate them on the scale from 1-4, where 1= very different in meaning and 4 = very similar in meaning.

As you enter the room the music stops for a moment.

As you enter the room everyone stops and stares at you.

The bus ride.

You get on a bus and find an empty seat next to one that has a rip in it. At the next stop several people get on that you vaguely recognise, but they sit together and the seat next to you remains vacant.

Please rate the statements below on how similar in meaning they are to the story you have just read. Rate them on the scale from 1-4, where 1= very different in meaning and 4 = very similar in meaning.

The seat next to you remains empty because it looks damaged.

The seat next to you is empty because no one wants to sit with you.

The job interview.

You applied for a job in a company you'd really like to work in. You are invited to an interview, where you answer the questions as well as you can. Reflecting later, you think that the quality of your answers decided the outcome.

Please rate the statements below on how similar in meaning they are to the story you have just read. Rate them on the scale from 1-4, where 1= very different in meaning and 4 = very similar in meaning.

You think that your astute answers led to you being offered the job.

You think that your poor answers lost you the job.

Meeting a friend.

In the street, you bump into an old friend you haven't seen for a long time. She is too busy to stop, so you arrange to meet later in a bar. You arrive a little late but the bar is empty and a few minutes later she is still not there.

You arrange to meet a friend in a bar but your friend is late.

You arrange to meet in a bar but your friend stands you up.

Your birthday.

It is your birthday and you wake up looking forward to your day. You wonder how many friends will send you a birthday card. However, you have to go to work as usual, and by the time you leave, no cards have arrived.

You have to leave for work before the postman brings your mail.

You leave for work realising that no one has sent you a card.

Your first painting.

You've taken up painting as a hobby, and have just finished your first picture. You hang it on the wall when a group of friends visit. Later you overhear your friends making remarks that make clear their opinion of your ability.

You overhear some friends saying how much they liked your painting.

You overhear some friends making critical remarks about your picture.

The private view.

Your neighbour invites you to a private exhibition of his art. You arrive to find many other guests whom you do not know. You try talking to some of them, and can see how interested they are in your conversation.

You talk to some guests and can tell that they find you interesting.

You talk to some guests but they think what you say is boring.

The first aid refresher.

You participate on a first aid refresher course at work. The instructor asks a question and no one in the group volunteers an answer, so he looks directly at you. You offer a reply, thinking about how your answer must be sounding to the others.

You answer the question, thinking that the others may be quite impressed.

You answer the question, thinking how ignorant you may seem.

The joke.

You are with a group of new friends, on your way to an open air concert. You decide to tell a joke you heard recently. Everyone looks at you as you start telling the joke, and you see their expressions change when you get to the punchline.

When you get to the end you see everyone starting to laugh.

When you get to the punch line everyone looks confused.

[AST SET 2 (11-20)]

Visiting the doctor.

You have been feeling dizzy occasionally, and decide to get a check-up. You make an appointment right away. Your doctor takes your blood pressure and listens to your chest, and then tells you to relax while giving you his opinion.

The doctor tells you all is normal and you are in good health.

The doctor tells you bad news about your health.

Late return home.

Your partner is working late this evening but now it is well past the time you were expecting them home. You are thinking about a crash you saw on the route your partner drives, when the phone rings. You pick it up and find out what had happened.

The phone rings and it is your partner telling you they are nearly home.

The phone rings and you are informed your partner is hurt in an accident.

Your eye operation.

You're finding that your sight is worse than it was and despite the risks you decide to try an experimental laser surgery you've read about. Afterwards as the bandages are taken off your eyes, you realise your life will be affected radically by the result.

You realise that this operation has made your vision perfect.

You realise that the operation has made your vision much worse.

The evening stroll.

You are taking a stroll on a quiet street near where you live. As you round the corner you see someone coming towards you on the same side of the road. As you meet, he stares straight at you and moves closer while raising his hand.

As you meet he waves in recognition and gives you a friendly greeting.

As you meet he moves closer and raises his fist menacingly.

A flight abroad.

You are on your way on holiday abroad. You have been in the air for an hour when you hear a change in the sound of the engine next to you. The fasten seat-belt sign flashes, and you hear the captain begin to make an announcement.

The seat belt light comes on and the captain says there will be turbulence.

The seat belt light comes on and the captain tells you one engine is failing.

At home one night.

You are at home alone late one night. You have just finished reading and turn out the light to go to sleep. While lying in the dark you hear a soft rustling sound coming from just outside your window.

Lying in bed you hear the sound of a small animal outside your window.

Lying in bed you hear the sound of someone trying to get in at your window.

The screening clinic.

You have been offered a routine cancer screening appointment at your local health centre. You have an X-ray and some samples are taken for tests. While waiting you see the doctor point out something on the X-ray plate to the nurse.

You notice the Doctor pointing out to the nurse that your X-ray is normal.

You notice the Doctor pointing out a tumour on your X-ray to the nurse.

Walking home.

You have been visiting some friends in the centre of town, when you realise it is getting late. They offer you a lift but you set off on foot. Walking through a street that you don't know at all well, you can hear someone running up from behind.

In the unfamiliar street your friend runs up from behind to walk with you.

In the unfamiliar street a mugger runs up from behind and threatens you.

The exercise regime.

You decide that you must start to exercise more. For the next week you take a little more exercise each day. After several weeks, you are running further and decide to see how far you can push yourself, when you notice your breathing is laboured.

Running further than usual you have to breath harder and deeper.

Pushing yourself too hard you cannot get enough air and feel dizzy.

The car park.

It is late at night and you are in a multi-storey car park trying to find your car. You have been looking for about ten minutes and still cannot find it. You hear a noise behind you and see a shadow of something.

You see a security person approaching to help you.

You see someone coming towards you looking threatening.

Appendix B10: Engagement and Technical Difficulties Questions

The following questions relate to your experience of completing this study. Please answer all questions honestly.

1. Did you experience any technical difficulties whilst completing the study – e.g., the video stuttering or not playing?
    a. No
    b. Yes, please specify
2. Have you completed this study before?
    a. Yes/No
3. Did you stop at any point and then come back to finish this study later?
4. Did you watch the entire video and try to read all the words presented?
    a. Yes/No

Appendix B11: Manipulation Materials: Thought Speed Trivia Statements (provided by E. Pronin)

Instructions:

Shortly, a series of sentences will be presented on the screen one at a time.

Please read every sentence as it appears, even if you have read that sentence before.

Full list (used in the varied thought manipulation)

1. Oranges contain Vitamin C.
2. Pandas Bears are endangered animals.
3. Coffee contains the stimulant caffeine.
4. Donald Trump recently married Melania Knauss.
5. The Hawaiian alphabet has 13 letters.
6. A “fortnight” lasts for fourteen nights.
7. English is the official language of Australia.
8. A ghost writer pens an anonymous book.
9. Europe is the only continent without deserts.
10. The dessert Cranberry Jello-O contains real cranberries.
11. Currently, domestic postage stamps cost forty-four cents.
12. The national language of Brazil is Portuguese.
13. Seven is the square root of forty-nine.
14. Nova Scotia is Latin for New Scotland.
15. Slang is a constantly changing part of language.
16. Stretching is not likely to involve aerobic exercise.
17. A sprinkler system protects a building against fire.
18. You sign a contract “on the dotted line.”
19. In most countries, UPS drivers wear brown uniforms.
20. The planet Venus is known to rotate clockwise.
21. The Easter holiday is always on a Sunday.
22. America’s best selling ice cream flavor is vanilla.
23. Most cars have either two or four doors.
24. The equator separates the Northern and Southern hemispheres.
25. Grabbing a quick rest is called “taking a catnap”.
26. A drill is not commonly considered a gardening tool.
27. The world’s largest alphabet is Cambodian, with 74 letters.
28. The ancient Egyptians slept on pillows made of stone.
29. The Empire State Building is in New York City.
30. Walt Disney created the popular cartoon character, Mickey Mouse.
31. The blue whale is the largest mammal on Earth.
32. The four seasons are Winter, Spring, Summer, and Fall.
33. The Hope Diamond was shipped from South Africa to London

34. A pilot light continually remains lit in a gas stove.
35. In Ring Toss, players throw a loop over a peg.
36. The TV series “Seinfeld” is set in New York City.
37. A structure for keeping pigs in is called a sty.
38. Australia is the only country that is also a continent.
39. The planet Mars is named after the god of War.
40. The city of Austin is the state capital of Texas.
41. There are seven points on the Statue of Liberty’s crown.
42. Water molecules contain two hydrogen atoms and one oxygen atom.
43. The Super Bowl game is always held on a Sunday.
44. People say, one should not “bite the hand that feeds them.”
45. There is no twelve of diamonds in a deck of cards.
46. Some say, “the road to hell is paved with good intentions.”
47. A proverb says, the pot should not call the kettle black.
48. When a fish dies, it is said to “go belly up.”
49. Columbus left for his first voyage across the Atlantic in 1492.
50. The Capitol of the United States is located in Washington, DC.
51. The Mona Lisa is one of the most famous portrait paintings.
52. Neil Armstrong stepped on the moon with his left foot first.
53. In England, people drive on the left side of the road.
54. ABC’s schedule of TV shows is associated with the start of Fall.
55. If something is really cheap, people say it’s “a dime a dozen.”
56. The first airplane was flown at Kitty Hawk by the Wright Brothers.
57. About one-tenth of the earth’s surface is permanently covered with ice.
58. The Atlantic Ocean has more salt in it than the Pacific Ocean.
59. An old saying claims that, “An apple a day keeps the doctor away.”
60. Los Angeles is a city on the West Coast of the United States.
61. New York City has more people than any other city in the United States.
62. In lowercase, I and J are the only letters to have a dot on top.
63. In the game of bowling, one must knock down 10 pins to get a strike.

Sets of three statements (used in the repetitive thought manipulation)

Participants were randomly allocated to one of the following six statement sets:

Set 1:

1. Stretching is not likely to involve aerobic exercise
2. Slang is a constantly changing part of language.
3. A sprinkler system protects a building against fire.

Set 2:

1. The planet Venus is known to rotate clockwise.
2. You sign a contract “on the dotted line”.
3. In most countries, UPS drives wear brown uniforms.

Set 3:

1. Grabbing a quick rest is called “taking a catnap.”
2. The world’s largest alphabet is Cambodian, with 74 letters.
3. A drill is not commonly considered a gardening tool.

Set 4:

1. The Empire State Building is in New York City.
2. The ancient Egyptians slept on pillows made of stone.
3. Walt Disney created the popular cartoon character, Mickey Mouse.

Set 5:

1. In Ring Toss, players throw a loop over a peg.
2. The Hope Diamond was shipped from South Africa to London.
3. A pilot light continually remains lit in a gas stove.

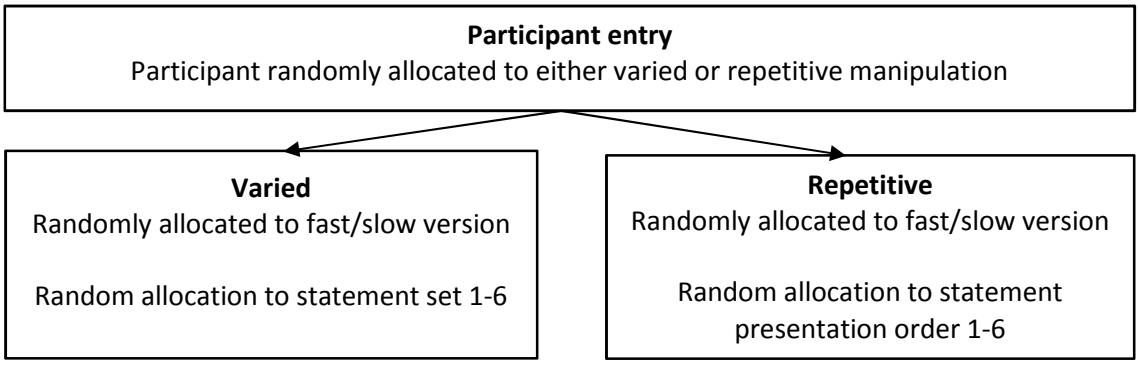
Set 6:

1. The TV series “Seinfeld” is set in New York City.
2. Australia is the only country that is also a continent.
3. A structure for keeping pigs in is called a sty.

Appendix B12: Varied/Repetitive Manipulation Conditions Procedural Flow

To prevent presentation order effects with the presentation of trivia statements the following steps were taken:

1. In the varied thought manipulation: participants were randomly allocated to one of six variations of the presentation order of the full 63 statements.
2. In the repetitive thought manipulation: participants were randomly allocated to one of six statement sets (each with three statements – see Appendix B11)



Appendix B13: Relaxation Task (Progressive Muscle Relaxation)

Relaxation exercise

You have almost completed the study. Before the study ends please take part in this brief relaxation exercise. The purpose of the exercise is to leave you in a calm state at the end of the study. Please press play on the video and follow the instructions.

[VIDEO GUIDING INSTRUCTED RELAXATION]

Follow the instructions as they are presented on screen.
Find a comfortable sitting position.
Slow down your breathing
In your head, slowly say ‘one thousand’ as you inhale
And ‘two thousand’ as you exhale.
Relax the following areas of your body for as long as the words of the body part appear on the screen
Focus on your right arm,
Allow it to become loose and relaxed
Focus on your left arm,
Allow it to become loose and relaxed
Focus on your face,
Allow it to become relaxed and neutral in expression
Focus on your jaw,
Allow it to become loose and relaxed
Focus on your shoulders,
Allow them to drop comfortably and become relaxed
Focus on your chest,
Allow it to fill and empty with air slowly
Focus on your right leg,
Allow it to become loose and relaxed
Focus on your left leg,
Allow it to become loose and relaxed
Bring your attention back to your breathing,
Allow it to be slow and comfortable
Allow yourself to rest for a few moments before continuing.
When you are ready please continue into the final part of the study.

Appendix C: Expanded Methods

Appendix C1: Power Analysis

Power calculations were performed using G*Power 3.1.7. Power analyses were calculated for the 2x2 ANCOVA (Thought Speed X Thought Variability) as this was the main method of analysis – Table C1. Required sample size was based on the interaction effect as this requires larger numbers than the main effect alone.

Table C1

Summary of Power Analysis and Sample Size Calculation

	Number of levels	**Numerator df**	**Number of covariates**	**α**	**Effect size**	**Power**	**Sample size required**
Thought speed (A)	2	1 (A-1)	1	.05	.25	.8	128
Thought variability (B)	2	1 (B-1)	1	.05	.25	.8	128
Speed X Variability (A*B)	4	2 (A-1*B-1)	1	.05	.25	.8	158

Appendix C2: Pilot Study

Prior to the main study, a small pilot study was conducted, with the researcher physically present, to ascertain the acceptability of the research before it was made widely accessible online. The study was completed on PC or laptop, either in a university computer-lab or participant home. Participants were asked 10-point likert items on level of acceptability of the study (0 = *not at all acceptable*; 10 = *very acceptable*), and level of distress caused by participation (0 = *not distressing at all*; 10 = *very distressing*). Participants were also asked their opinions on study length and the usefulness of the relaxation task – results are summarised in Table C2.

Table C2

Summary of Pilot Study Demographic Details and Acceptability Results

Demographic details			
Sex	***Mean age (SD)***	***Marital status***	***Employment***
80% female	29.84 years (2.62)	50% married 40% couple, not married 10% single	90% full-time employment 10% student
Acceptability responses; mean (SD)			
Acceptability	***Distress***	***Study length****	***Relaxation task***
8.80 (.79)	.89 (1.69)	2.3 (.48)	1.9 (.32)

N = 10; Participants took on average 36.4 minutes to complete the study. * how did you find the study length? 1 = too short; 2 = about right; 3 = too long.

The opportunity sample rated the study as highly acceptable and not distressing. Seventy-percent of participants reported the study length as “about right”. The relaxation task was found useful (60%) and of appropriate length (90%). Consequently, the research procedure remained unchanged for the main study.

Appendix C3: Data Screening and Reduction

Study completion and technical difficulties. Data were screened based on study completion and technical difficulties. Of the full sample (*N* = 603), data were included if the participant had completed all questionnaire components (*n* = 348), and had not completed the study previously or found the manipulation video had failed to play (*n* = 332).

Completion of manipulation task. Participants were also screened on time spent on the manipulation video webpage. This variable was used as an indicator of level of participation in manipulation task. It was possible to screen by level of participation using either a condition specific cut-off (i.e., percentage of video watched; the duration of which varied across fast and slow presentation conditions) or standard cut-off across all conditions (i.e., a set minimum duration of video watched irrespective of condition). Screening criteria for both methods were generated and compared.

Two comparison data sets were generated based on the following criteria: 1) participants time on video webpage was ≥ 90% of the shortest video congruent with their condition (i.e., ≥ 138.6secs for participants in the fast presentation condition; ≥ 627.2secs for slow presentation condition) (*n* = 245); and 2) participant time on webpage ≥ 138.6secs (i.e., 90% of the shortest video out of all the conditions) (*n* = 287). For both data sets an additional high cut-off point was applied; time watching video no more than 1min longer than the duration of the longest video dependent on participant condition (i.e., ≤ 232secs for fast presentation condition; ≤ 836secs for slow presentation condition).

The effect of the manipulation on participant thought speed, assessed by the self-report item, was comparable across the two data sets. In both instances ANOVA demonstrated significant effects in the same direction and of comparable effect size. Therefore, as the standardised duration screening method provided the largest sample with the most balanced numbers across conditions, this screening method was selected (*n* = 285).

Finally, participants were excluded if the total time to complete the entire study was greater than 1 ½ hrs (*N* = 263).

Outliers in dependent variables. To reduce the influence of extreme data points, dependent variables were assessed for outliers. Outliers were defined as data points ≥ 75 percentile + 1.5xInterquartile range; and ≤ 25 percentile – 1.5xInterquartile range. The Winsorising approach to outliers was employed – i.e., replacement of outliers with the nearest acceptable non-outlying data point.

Appendix D: Expanded Results

Appendix D1: Comparison Analyses of Study Completers versus Non-completers

Multivariate test demonstrated no significant difference between completers and non-completers, Pillai's Trace = .038, $F(13, 362) = 1.09$, $p = .365$, for continuous demographic and dependent variables at baseline. Assumptions of homogeneity was support by Levene's test for all variables (*all ps* > .1) and Box's test ($p = .588$).

Standardised residuals in the Chi-square tests did not reveal a significant difference between completers and non-completers in terms of their marital status, $X^2(4) = 1.59$, $p = .810$, first language as English, $X^2(1) = .38$, $p = .535$, and diagnosed mental health difficulties, $X^2(4) = 3.43$, $p = .489$. Non-completers were, however, significantly different to completers in terms of sex, $X^2(1) = 5.87$, $p = .015$, with less of a discrepancy between numbers of men and women (ratio: 1:1.64) in non-completers compared to completers (ratio: 1:2.55). Non-completers also differed on employment status, $X^2(6) = 21.0$, $p = .002$; non-completers were more frequently part-time employed or not working due to disability, and less frequently a full-time student. Chi-square tests were not appropriate for the variables of country or ethnicity as the number of expected counts with a value less than five exceeded 25%; however, descriptive statistics show that, as with completers, in the non-completer group then most frequently reported their country of residence as the UK (36.9%) and USA (33.7%); and ethnicity as white (66.7%).

Appendix D2: Assumptions and Model Fit

Normality

The sample size entailed (N > 30 for each group) that assumptions of normality were met according to Central Limit Theorem.

Homogeneity of Variance

Levene's test was consulted to assess homogeneity of variance in between-groups analyses. Violations were noted in thesis text. Data were treated with square-root or log transformations to resolve violation; where violation could not be resolved, this was acknowledged in thesis text in reference to the model fit – see Appendix E3 for full details of where Levene's test was violated, standardised residuals evaluating model fit, and action taken.

Sphericity

Mauchly's test was consulted for the repeated-measure ANOVAs with repeated-measures with two or more levels – see Results: 'manipulation check' section. As Mauchly's test indicated violation of assumption of sphericity for both the 4x2x2 ANOVA, $X^2(5) = 123.03$, $p < .001$, and repeated-measures ANOVAs (slow thought speed: $X^2(5) = 114.68$, $p < .001$; fast thought speed: $X^2(5)= 31.84$, $p < .001$, Greenhouse-Geisser estimates of sphericity (slow condition: $\mathcal{E} = .65$; fast condition: $\mathcal{E} = .89$) are reported as the corrected degrees of freedom.

Appendix D3: Assessment of Model Fit

Model fit for all linear model analyses was evaluated through consulting Levene's test and the standardised residuals for each model. Table D3 summarises the standardised residuals for all analysis models; model fit was evaluated (percentage of standardised residuals within +/-2 and +/-3 respectively), and what course of action was taken to resolve poor fit is also outlined. In addition, violations of homogeneity as assessed by Levene's test are also noted; Levene's test is only reported when significant.

Table D3

Summary of Standardised Residuals, Evaluation of Model Fit, and Action Taken

SECTION:	**Baseline comparisons (all DVs are baseline; assessment point 1)**							
Analysis	***IV***	***DV***	***Covariate***	***Std. Resid. within +/- 2***	***Std. Resid. within +/- 3***	***Adequate fit***	***Action taken***	***Outcome of action***
Univariate ANOVA	Between subjects: Participant pool vs. non-pool	Thought speed	N/A	95.8%	100%	YES	N/A	N/A
Univariate ANOVA	Between subjects: Participant pool vs. non-pool	HPS	N/A	97.3%	100%	YES	N/A	N/A
Univariate ANOVA	Between subjects: Participant pool vs. non-pool	STICSA	N/A	97%	100%	YES	N/A	N/A
Univariate ANOVA	Between subjects: Participant pool vs. non-pool	STAI-sf	N/A	96.6%	99.6%	YES	N/A	N/A
Univariate ANOVA	Between subjects: Participant pool vs. non-pool	ISS: activation	N/A	95.8%	100%	YES	N/A	N/A
Univariate ANOVA	Between subjects: Participant pool vs. non-pool	ISS: wellbeing	N/A	95.9%	100%	YES	N/A	N/A
Univariate ANOVA	Between subjects: Participant pool vs. non-pool	PANAS: PA	N/A	97.7%	100%	YES	N/A	N/A

Univariate ANOVA	Between subjects: Participant pool vs. non-pool	PANAS: NA	N/A	89.7%	100%	NO Levene's test sig.	SQRT transformation	Levene's remained sig. BUT: 100% within +/- 2 Transformed data used.
Univariate ANOVA	Between subjects: Participant pool vs. non-pool	Single-item PA	N/A	95.1%	100%	YES Levene's test sig.	SQRT transformation LOG transformation	SQRT did not resolve levene's LOG did not resolve levene's As model fit was adequate, untransformed data were used
Univariate ANOVA	Between subjects: Participant pool vs. non-pool	Single-item NA	N/A	93.9%	100%	NO Levene's test sig.	SQRT transformation	Levene's non-sig. 95.4% +/-2 100% +/-3
Univariate ANOVA	Between subjects: Participant pool vs. non-pool	AST Threat	N/A	96.2%	100%	YES	N/A	N/A
Univariate ANOVA	Between subjects: RF/RS/VF/VS	Age	N/A	93.5%	97.7%	NO	SQRT transformation LOG transformation	SQRT did not improve fit LOG = 93.5% +/- 2; 100% +/-3
Univariate ANOVA	Between subjects: RF/RS/VF/VS	Thought speed	N/A	96.2%	100%	YES	N/A	N/A
Univariate ANOVA	Between subjects: RF/RS/VF/VS	HPS	N/A	97%	100%	YES	N/A	N/A
Univariate ANOVA	Between subjects: RF/RS/VF/VS	STICSA	N/A	95.8%	100%	YES	N/A	N/A
Univariate ANOVA	Between subjects: RF/RS/VF/VS	STAI	N/A	95.4%	100%	YES	N/A	N/A
Univariate ANOVA	Between subjects: RF/RS/VF/VS	ISS: activation	N/A	95.8%	100%	YES	N/A	N/A
Univariate ANOVA	Between subjects: RF/RS/VF/VS	ISS: wellbeing	N/A	96.5%	100%	YES	N/A	N/A
Univariate ANOVA	Between subjects: RF/RS/VF/VS	PANAS PA	N/A	96.9%	100%	YES	N/A	N/A
Univariate ANOVA	Between subjects: RF/RS/VF/VS	PANAS NA	N/A	92.8%	100%	NO	SQRT transformation	Adequate fit: 98.1% +/- 2; 100% +/-3
Univariate ANOVA	Between subjects: RF/RS/VF/VS	Single-item PA	N/A	93.9%	100%	NO	SQRT transformation LOG transformation Histogram consulted	Both transformations made fit worse, so untransformed data used – untransformed data histogram of std. residuals was very slightly negatively skew but generally acceptable.

Univariate ANOVA	Between subjects: RF/RS/VF/VS	Single-item NA	N/A	95.8%	99.6%	YES	N/A	N/A
Univariate ANOVA	Between subjects: RF/RS/VF/VS	AST threat	N/A	97.3%	100%	YES	N/A	N/A
SECTION:	**Manipulation check (DV at assessment points 1-4)**							
Analysis	***IV***	***DV***	***Covariate***	***Std. Resid. within +/- 2***	***Std. Resid. within +/- 3***	***Adequate fit***	***Action taken***	***Outcome of action***
4x2x2 ANOVA	Repeated measures: Assessment point (1-4) Between subjects: 1.speed (fast/slow) 2.variability (varied/rep.)	Thought speed 1	N/A	96.2%	100%	YES	N/A	N/A
		Thought speed 2	N/A	97%	100%	YES	N/A	N/A
		Thought speed 3	N/A	94.3%	100%	NO	Histogram consulted SQRT transformation LOG transformation (applied to thought speed 1-4)	Both transformations worsened fit and Levene's Untransformed data was very close to good fit; histogram of std. residuals was acceptable. Untransformed data used.
		Thought speed 4	N/A	95.5%	100%	YES	N/A	N/A
Repeated measures ANOVA	Repeated measures: Assessment point (1-4) Fast thought speed conditions only	Thought speed 1	N/A	95.6%	100%	YES	N/A	N/A
		Thought speed 2	N/A	97%	100%	YES	N/A	N/A
		Thought speed 3	N/A	93.3%	99.3%	NO	Histogram consulted SQRT transformation LOG transformation (applied to thought speed 1-4)	Both transformations worsen model fit. Untransformed data histogram was acceptable. Untransformed data used as provides best fit.

		Thought speed 4	N/A	94%	100%	NO	N/A	N/A
Repeated measures ANOVA	<u>Repeated measures:</u> Assessment point (1-4) Slow thought speed conditions only	Thought speed 1	N/A	96.1%	100%	YES	N/A	N/A
		Thought speed 2	N/A	99.2%	100%	YES	N/A	N/A
		Thought speed 3	N/A	98.4%	100%	YES	N/A	N/A
		Thought speed 4	N/A	96.8%	100%	YES	N/A	N/A
SECTION:	**H1: Self-report symptoms of mania and anxiety**							
Analysis	***IV***	***DV***	***Covariate***	***Std. Resid. within +/- 2***	***Std. Resid. within +/- 3***	***Adequate fit***	***Action taken***	***Outcome of action***
ANCOVA	Thought speed x variability	ISS: activation (post)	ISS: activation (pre)	94.7%	100%	NO Levene's test sig.	SQRT transformation	Does not improve residuals (94.7% +/-2) But levene's not sig. SQRT data used
ANCOVA	Thought speed x variability	STAI-sf (post)	STAI-sf (pre)	93.9%	100%	NO	SQRT transformation	Resolved fit 95.1% +/-2 100% +/-3 Transformed data used
Repeated measures ANOVA	<u>Repeated measures:</u> Assessment point (1-2) Fast thought speed conditions only	ISS: activation (pre) SQRT data	N/A	96.3%	100%	YES	N/A	N/A
		ISS: activation (post) SQRT data	N/A	95.5%	100%	YES	N/A	N/A

Repeated measures ANOVA	Repeated measures: Assessment point (1-2) Slow thought speed conditions only	ISS: activation (pre) SQRT data	N/A	94.5%	100%	NO	Compared to untransformed data AND consulted histograms between data sets	Untransformed data = 95.3% +/-2 BUT better normal distribution in SQRT data Consequently, SQRT data used NB: ANOVA results were comparable between data sets
		ISS: activation (post) SQRT data	N/A	94.6%	100%	NO	Compared to untransformed data AND consulted histograms between data sets	Untransformed data = 95.3% +/-2 BUT better normal distribution in SQRT data Consequently, SQRT data used NB: ANOVA results were comparable between data sets
Repeated measures ANOVA	Repeated measures: Assessment point (1-2) Varied thought speed conditions only	ISS: activation (pre) SQRT data	N/A	94.1%	100%	NO	Compared to untransformed data AND consulted histograms between data sets	Untransformed data = 94.9% +/-2 BUT better normal distribution in SQRT SQRT data used NB: ANOVA results were comparable between data sets
		ISS: activation (post) SQRT data	N/A	95.6%	100%	YES	Compared to untransformed data (due to pre score violation) AND consulted histograms between data sets	Better residuals and distribution found in transformed data SQRT data used. NB: ANOVA results were comparable between data sets

Repeated measures ANOVA	Repeated measures: Assessment point (1-2) Repetitive thought speed conditions only	ISS: activation (pre) SQRT data	N/A	98.4%	100%	YES	N/A	N/A
		ISS: activation (post) SQRT data	N/A	99.2%	100%	YES	N/A	N/A
SECTION:	**H2-3: Objective symptoms of mania and anxiety**							
Analysis	***IV***	***DV***	***Covariate***	***Std. Resid. within +/- 2***	***Std. Resid. within +/- 3***	***Adequate fit***	***Action taken***	***Outcome of action***
ANCOVA	Thought speed X variability	AST threat (post)	AST threat (pre)	95.9%	100%	YES But levene's test sig.	SQRT transformation LOG transformation	SQRT = 95.8% +/-; Levene's still sig. LOG = 95.4% +/-2; Leven's still sig. Untransformed data used. NB: ANCOVA results were comparable between data sets
ANCOVA	Thought speed X variability	AST threat (post)	AST threat (pre) AND Participant pool vs. non-pool	95.2%	100%	YES But levene's test sig.	SQRT transformation LOG transformation AND consulted histograms	SQRT = 95.8% +/-2; Levene's still sig. LOG = 95.8% +/-2; 99.6% +/-3; Levene's still sig. Histograms between SQRT and untransformed data both demonstrate normal distribution. As Levene's not resolved by transformation and residuals not substantially improved, untransformed data used. NB: ANCOVA results were comparable between data sets

SECTION:	**H4-5: Affective state**							
Analysis	***IV***	***DV***	***Covariate***	***Std. Resid. within +/- 2***	***Std. Resid. within +/- 3***	***Adequate fit***	***Action taken***	***Outcome of action***
ANCOVA	Thought speed X variability	Single-item PA (post)	Single-item PA (pre)	94.3%	98.5%	NO	SQRT transformation LOG transformation AND histograms consulted	SQRT = 94.6% +/-2; 97.7% +/-3; Levene's still sig. LOG = 95% +/-2; 97.7% +/-3; Levene's still sig. Untransformed data used as best fit, histogram demonstrated normal distribution, and best Levene's statistic NB: ANCOVA results were comparable between data sets
ANCOVA	Thought speed X variability	Single-item NA (post)	Single-item NA (pre)	93.9%	99.2%	NO	SQRT transformation LOG transformation AND histograms consulted	SQRT = 93.9% +/-2; 98.8% +/-3 LOG = 93.9% +/-2; 98.4% +/-3 Histograms demonstrated normal distribution for all sets; best for SQRT (NB: ANCOVA for SQRT provided comparable results to untransformed). Untransformed data used as best fit and distribution appeared normal

Repeated measures ANOVA	Repeated measures: Assessment point (1-2) Fast thought speed conditions only	Single-item PA (pre)	N/A	94.8%	100%	NO	SQRT transformation LOG transformation	SQRT = 94.8% +/-2; 100% +/-3 LOG = 94.8% +/-2; 94.8% +/-3 Untransformed data used as best fit (very near adequate)
		Single-item PA (post)	N/A	94.8%	100%	NO	SQRT transformation LOG transformation	SQRT = 94% +/-2; 100% +/-3 LOG = 94% +/-2; 94.8% 96.3%+/-3 Untransformed data used as best fit (very near adequate)
Repeated measures ANOVA	Repeated measures: Assessment point (1-2) Slow thought speed conditions only	Single-item PA (pre)	N/A	95.3%	100%	YES	N/A	N/A
		Single-item PA (post)	N/A	100%	100%	YES	N/A	N/A
Repeated measures ANOVA	Repeated measures: Assessment point (1-2) Fast thought speed conditions only	Single-item NA (pre)	N/A	96.3%	100%	YES	N/A	N/A
		Single-item NA (post)	N/A	96.3%	100%	YES	N/A	N/A

Repeated measures ANOVA	<u>Repeated measures:</u> Assessment point (1-2) Slow thought speed conditions only	Single-item NA (pre)	N/A	94.6%	99.2%	NO	SQRT transformation LOG transformation	SQRT = 94.5% +/-2; 100% +/-3 LOG = 94.2% +/-2 Untransformed data used as consistent with NA ANCOVA and fit only slightly improved by SQRT (and SQRT and untransformed ANOVA results were comparable)
		Single-item NA (post)	N/A	95.3%	100%	YES	SQRT transformation only conducted for comparison with pre score	SQRT = 95.3% +/-2; 100% +/-3 Untransformed data used
SECTION:	**Mood state classification**							
Analysis	***IV***	***DV***	***Covariate***	***Std. Resid. within +/- 2***	***Std. Resid. within +/- 3***	***Adequate fit***	***Action taken***	***Outcome of action***
Logistic regression	Thought speed Thought variability Speed X Variability	Hypomania (0 = does not meet criteria; 1 = meets criteria)	Baseline categorisation (meeting or not meeting criteria)	95.4%	100%	YES	N/A	N/A
Logistic regression	Thought speed Thought variability Speed X Variability	Mixed state (0 = does not meet criteria; 1 = meets criteria)	Baseline categorisation (meeting or not meeting criteria)	93.9%	98.1%	NO	No action taken as extreme outliers already conservative treated in data screening	Model fit reported in thesis text
Logistic regression	Thought speed Thought variability Speed X Variability	Euthymia (0 = does not meet criteria; 1 = meets criteria)	Baseline categorisation (meeting or not meeting criteria)	94.7%	97.7%	NO	No action taken as extreme outliers already conservative treated in data screening	Model fit reported in thesis text
Logistic regression	Thought speed Thought variability Speed X Variability	Depression (0 = does not meet criteria; 1 = meets criteria)	Baseline categorisation (meeting or not meeting criteria)	94.7%	98.1%	NO	No action taken as extreme outliers already conservative treated in data screening	Model fit reported in thesis text

Appendix E: Dissemination Information

Appendix E: Dissemination Statement

Study results are intended to be disseminated through several means. First, they will be reported, in conference-style presentation, to the course programme and other clinical psychology trainees as part of the clinical doctorate. Furthermore, study summary poster or presentation may also be made to the wider psychological community through national conference, such as those convened by the British Psychological Society. Finally, the study is intended for submission for publication in a peer-reviewed journal, such Cognitive Therapy and Research.

Appendix E1: Author Instruction for Submission (Cognitive Therapy and Research)

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Stefan G. Hofmann e-mail: shofmann@bu.edu
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