1 **Title**

2 Beliefs are multidimensional and vary in stability over time - psychometric properties
3 of the Beliefs and Values Inventory (BVI)

4 **Authors**

5 Barnby, J.M.^{1*}, Bell, V.², Sheridan-Rains, L.², Mehta., M.A.^{1Ψ}, Deeley, Q.^{1Ψ}

6 *Corresponding Author: Centre for Neuroimaging Sciences, Institute of Psychiatry,
7 Psychology, and Neuroscience, King's College London, De Crespigny Park,
8 Camberwell, London SE5 8AB (joe.barnby@kcl.ac.uk)

9 Ψ Joint last author

10 ¹ Centre for Neuroimaging Sciences, Institute of Psychiatry, Psychology, and
11 Neuroscience, King's College London, De Crespigny Park, Camberwell, London SE5
12 8AB

13
14 ² Division of Psychiatry, University College London, Maple House, 149 Tottenham
15 Court Rd, Fitzrovia, London W1T 7BN
16
17

18 **Abstract**

19 The cognitive processes underlying belief are still obscure. Understanding these
20 processes may lead to more targeted treatment to better address functional
21 impairment, such as delusions. One way in which this might be accomplished is to
22 identify the mechanisms of healthy, everyday belief, and how these may relate to
23 characteristics observed in delusions. As yet, no such measure exists to accurately
24 measure belief across a range of themes and dimensions. This paper outlines two
25 studies documenting the creation and psychometric properties of a novel measure
26 assessing three different dimensions of belief across themes of politics, science, the
27 paranormal, religion, and morality in UK samples (n = 1673 total). Reliability
28 estimates suggested good to excellent consistency ($\alpha > 0.8$ per theme) with
29 moderate to excellent reliability at 48 hours (ICC = 0.61 – 0.96) and 3.5 months (ICC
30 = 0.61 – 0.89). Factor analyses suggested good support for our five chosen themes
31 of belief, suggesting they are distinct topic areas. Correlations across theme and
32 dimension suggested dissociable characteristics within themes. These results have
33 implications for 1. understanding the stability and relationship between themes of
34 belief in a population and, 2. exploring how beliefs may change over time or as a
35 result of an intervention.

36

Introduction

Beliefs and values are central to both normal and abnormal psychology - for example, to understand political, religious, or economic behavior¹ or in the case of delusions the formation of fixed beliefs causing distress and disability². Beliefs have been defined as 'a disposition to assent to, or otherwise act in accordance with some proposition'³ and have been studied in a variety of ways. The attitudes and values of populations have long been studied using nationwide surveys (e.g. Ipsos and Gallup polls). While these give useful information about the distribution of beliefs and attitudes across a population, they have tended to treat beliefs as discrete items rather than as having different dimensions or components.

By contrast, the study of delusions as a type of abnormal belief in clinical psychology has explored dimensions and components of belief. For example, measures such as the Peter's Delusion Inventory⁴ analyse delusional beliefs as including dimensions of distress, preoccupation, and conviction. Changes in these dimensions as a result of psychiatric intervention suggest that they are related but distinct characteristics⁵.

The 'continuum' model of psychosis - which locates delusions and ordinary beliefs on a continuum – implies that dimensions of delusions should also be present in ordinary beliefs. Equally, the continuum model implies that dimensions of normal beliefs and their underlying social, cognitive, and neural processes can be linked to delusions. However, at present no study has systematically analysed the characteristics of *normal* beliefs as a basis for understanding delusions.

Understanding whether there are shared dimensions or characteristics across types of belief is important to help identify potential mechanisms of belief formation and maintenance, and why some types of belief (such as paranormal or conspiracist beliefs) seem more closely linked to delusion formation than others (such as scientific or moral beliefs)⁶.

Here we present a novel questionnaire aimed at 1. assessing multiple types or themes of propositional belief relating to the paranormal, religion, politics, morality, and science by bringing together previously dispersed themes^{7,8,9,10} and, 2. assessing multiple dimensions of belief in relation to characteristics of agreement, self-relevance, and interest toward propositions.

These dimensions were chosen based on observations that antipsychotics frequently reduce the preoccupation and distress of delusions (putatively one's interest in and perceived self-relevance of a belief) but not the conviction (agreement) in them⁵. We aimed to test whether these dimensions were dissociable aspects of different types of propositional belief.

This article introduces and reports on the psychometric properties of the Beliefs and Values Inventory (BVI) using a large online general population sample specifically recruited on a platform with a large and diverse participant pool¹¹.

Two short studies drawing from five samples are reported, which are motivated by the following aims:

1. To understand the factor structure of our measure and identify whether beliefs were stable in the short (48 hours) and long (3.5 months) term. This uses four separate online samples for cross sectional and longitudinal analysis.
2. To determine if these extracted items were stable in an independent sample. This was conducted using a confirmatory analysis to determine the weighting of the stable extracted factors. We also sought to understanding the association between agreement, self-relevance, and interest across and within themes. Samples from 1., and 2. were combined in a large composite sample.

Results

Study 1

After cleaning (see <https://osf.io/hzvwr/>), four samples were obtained (see Fig.1):

- $N = 736$ (Time point 0 sample excluding test-retest participants)
- $N = 98$ (Time point 0 sample test-retest participants)
- $N = 98$ (Time point 48 hours sample test-retest participants)
- $N = 69$ (Time point 3.5 months sample test-retest participants)

The Time Point 0 and Time Point 48 hours samples were combined and ordered by submission to assess the frequency of independent identification numbers (ID). Frequencies of independent IDs over 2 (retest participants) were then removed from the sample to isolate participants that had completed the questionnaire at the two time-points. Participant IDs were then ordered by submission and separated to generate samples at 0 hours and 48 hours.

Blank IDs (IDs where participants had not recorded their prolific participant numbers) were removed from the original sample to prevent unknown duplicates being detected between “Test-Retest IDs” at time points 0 and 48 hours when sub setting in R.

Retest participants collected 3.5 months later were ID matched to their time 0 answers. 3.5-month participants were treated as a separate sample and compared to their time 0 answers in test-retest analysis.

145 **Table 1: Demographics of the original sample (n = 736) excluding those used for ICC analysis.**

Category	Frequency (n=736)									
Sex	Male					Female				
	286					449				
Age	18-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	65+
	110	135	104	101	68	80	61	32	28	16
Political Affiliation	Labour	Conservative	Green	SNP	DUP	UKIP	Liberal Democrat	Other	None	
	287	128	30	18	5	19	40	3	206	
Religion	Christian	Islamic	Jewish	Hindu	Buddhist	Sikh	Spiritualist	Atheist	Agnostic	Other
Participant	313	17	5	2	4	5	9	256	85	40
Mother	505	16	7	3	5	5	6	118	46	25
Father	409	18	7	5	5	5	3	182	61	45
Education	Primary	Secondary	A levels/ College		Undergraduate	Postgraduate	Masters	Doctorate		
	2	103	180		317	38	80	16		

147 *Descriptive Statistics*

148 The distribution of answers (density) within item dimensions (agreement, relevance
149 and interest) across themes (paranormal, moral, politics, science, and religion) of the
150 BVI-55 were calculated for the original, and all three retest samples.

151 No significant differences in mean were found between the original and retest 1
152 sample (0 hours or baseline) samples.

153 Graphical histogram comparisons of original and retest samples can be found in
154 **Figure 2.**

155 *Reliability – Cronbach's Alpha*

156 The BVI as a whole showed good internal reliability (alpha of 0.95; 95% CI: 0.95-
157 0.96). By theme, Cronbach's alpha scores were reported as Science (0.87),
158 Paranormal (0.96), Politics (0.84), Religion (0.96), and Morality (0.86). All item
159 dimensions and theme had an alpha of above 0.7 except Morality-Agreement (0.61),
160 Politics-Agreement (0.61), and Politics-Self Relevance (0.65).

161 To understand whether scores below 0.7 were due to issues with summation across
162 general and specific subthemes, Morality-Agreement, Politics-Agreement, and
163 Politics-Self Relevance were split by their subthemes.

164 Splitting themes by their subthemes did not improve alpha:

- 165 • Morality-Agreement (Moral transgressions) = 0.46 (95% CI: 0.40-0.52)
166 • Morality-Agreement (Conventional transgressions) = 0.54 (95% CI: 0.49-0.59)
167 • Politics-Agreement (Socialist principles) = 0.45 (95% CI = 0.39 – 0.51)
168 • Politics-Agreement (Liberal values) = 0.53 (95% CI = 0.48-0.58)
169 • Politics- Self Relevance (Socialist principles) = 0.56 (95% CI = 0.41 – 0.61)
170 • Politics- Self Relevance (Liberal values) = 0.61 (95% CI = 0.57 – 0.66)

171 Figure 2 visually represents the raw alpha and 95% confidence interval between BVI
172 total, theme totals, and themes by their item dimensions.

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175 **Figure 2: Cronbach's alpha for all BVI individual item dimensions by theme.**
 176 Bars represent 95% confidence intervals. BVI = Beliefs and Values Inventory; M =
 177 Morality, P = Paranormal, Pol = Politics, R = Religious, S = Science; Tot = Total
 178 items across all dimensions; A = Agreement dimension, R = Self-Relevance
 179 dimension, I = Interest dimension. Grey boxes highlight total scores. We found that
 180 the total measures of themes were very stable, with their respective dimensions
 181 varying to different degrees.

182 *ICC analysis*

183 We aimed to establish whether agreement, interest, and self-relevance toward
184 themes of belief in the BVI were stable over a 48-hour and 3.5-month period.

185 After cleaning we had two samples:

186 1. 98 ID matched participants to check stability over a 48-hour period. This used
187 participants from Time 0 Hour Retest and Time 48 Hour Retest participants.

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189 2. 69 ID matched participants were used to check stability over a 3.5-month
190 period. This used participants from Time 0 Hour Retest and Time 3.5 Month
191 Retest participants. Fewer participants were in this group because of attrition
192 between recruitment via Prolific.ac between 48 hours and 3.5 months.

193 ICCs across all dimensions, themes, and time samples were generally good to
194 excellent (>0.75).

195 Exceptions were:

196 1. At 48 hours

197 The self-relevance dimension of the Morality theme scored moderate reliability,
198 scoring between 0.61 and 0.77.

199 2. At 3.5 months

200 All dimensions of morality were of moderate reliability, all scoring between 0.61 and
201 0.69. Self-relevance dimensions for Politics and Science themes scored moderate
202 reliability, scoring 0.69 and 0.71, respectively.

203 Figure 3 demonstrates the ICC (3,1) for agreement, interest, and self-relevance item
204 dimensions across themes over 48 hours and 3.5 months with their respective 95%
205 CI. Weighted means are discussed later.

206 See *Appendix A* for all items in each theme of the BVI used in Study 1. See
207 *Appendix D* for full statistical output and ICC breakdown.

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Figure 3: ICC (3,1) scores (95% CI) over a 48-hour period (n = 98), and 3.5-month period (n = 69) across themes within item dimensions for weighted and unweighted means. Bars represent standard error. Horizontal lines are inserted to denote ICC cut off at 0.50 (moderate), 0.75 (good) and 0.90 (excellent). A = Agreement, SR = Self Relevance, I = Interest; R = Religion, Po = Politics, M = Morality, S = Science, PA = Paranormal. Overall we found moderate to excellent evidence that beliefs are stable over 48 hours and 3.5 months.

216 *Exploratory Factor Analysis*

217 Exploratory Factor Analysis (Orthogonal, Varimax rotation) was run with a parallel
218 analysis. This was to determine the number of factors and items to extract for a
219 confirmatory analysis of the BVI. This was conducted for the total questionnaire (no
220 dimensional partitioning) and all three BVI dimensions individually.

221 *Total BVI*

222 A solution of 10 factors was considered adequate upon observation of the scree plot
223 and cross-checking with the *Psych* package “nfactor” function to compute optimal
224 eigenvalue decomposition ¹².

225 Factors 1-5 explained 0.77 of the proportion across factors (see Table 2).

226 Summary of items that loaded onto each factor across the BVI can be found in
227 Appendix B.

228 *Agreement*

229 A solution of 7 factors was considered adequate upon observation of the scree plot
230 and cross-checking with the *Psych* package “nfactor” function to compute optimal
231 eigenvalue decomposition ¹².

232 Factors 1 and 2 explained 32% and 31% of the proportion across factors
233 respectively, with the rest of the factors contributing less than 10%.

234 Full loadings and outputs can be found in Appendix B.

235 *Self-Relevance*

236 A solution of 7 factors was considered adequate upon observation of the scree plot
237 and cross-checking with the *Psych* package “nfactor” function to compute optimal
238 eigenvalue decomposition ¹².

239 Factors 1- 4 explained 27%, 23%, 14%, and 13% of the proportion respectively, with
240 the rest of the factors contributing less than 10%.

241 Full loadings and outputs can be found in Appendix B.

242 *Interest*

243 A solution of 7 factors was considered adequate upon observation of the scree plot
244 and cross-checking with the *Psych* package “nfactor” function to compute optimal
245 eigenvalue decomposition ¹².

246 Factors 1-5 explained 27%, 21%, 15%, 14%, and 12% of the proportion across
247 factors, respectively, with the rest of the factors contributing less than 10%.

248 Full loadings and outputs can be found in Appendix B.

249 **Table 2: Variance and Sum of Squares loading for each extracted factor across**
 250 **all themes of the BVI.** Figures recorded to two decimal points.

<i>Statistic</i>	<i>Factor</i>									
	1	2	3	4	5	6	7	8	9	10
<i>SS loading</i>	24.10	22.33	11.61	11.51	10.00	5.89	5.18	4.72	4.27	3.15
<i>Proportion Variance</i>	0.12	0.11	0.06	0.06	0.05	0.03	0.03	0.02	0.02	0.02
<i>Cumulative Variance</i>	0.12	0.24	0.30	0.36	0.41	0.44	0.46	0.49	0.51	0.53
<i>Proportion Explained</i>	0.23	0.22	0.11	0.11	0.10	0.06	0.05	0.05	0.04	0.03
<i>Cumulative Proportion</i>	0.23	0.45	0.56	0.68	0.77	0.83	0.88	0.93	0.97	1.0

252 *Item selection*

253 Following the exploratory factor analysis, all items that did not load onto any factor or
254 cross-loaded with another item were removed for confirmatory analysis.

255 If a proposition from one dimension loaded onto a factor, but a different dimension
256 from the same proposition didn't load onto any factor in the analysis, that proposition
257 was still retained in the revised questionnaire. For example, item 'S_S1_I' loaded
258 onto a factor for the *interest* item dimension, but was absent from the *agreement*
259 analysis, so was retained.

260 Control questions were all retained.

261 42 items from the BVI were retained for confirmatory analysis (10 paranormal, 10
262 religious, 6 science, 5 politics, 6 morality, and 5 control questions).

263 All retained items can be found in Appendix C (BVI-42).

264 **Study 2**

265 *Participants*

266 Following data cleaning by control questions (using the same procedure for **Study 1**)
267 we were left with 381 participants. All participants in the cleaned sample were then
268 used for all further analyses

269 *Descriptive Statistics*

270 The distribution of answer total (density) within item dimensions (agreement,
271 relevance and interest) across themes (paranormal, moral, politics, science, and
272 religion) of the BVI-55 were calculated.

273 Figure 4 demonstrates the density across agreement, self-relevance and interest
274 across all five samples, including the confirmatory sample.

275 *Cronbach's Alpha*

276 Cronbach's alpha was used to test the cross-sectional reliability within the
277 confirmatory sample ($n=736$) across all the entire questionnaire and themes
278 (Morality, Paranormal, Politics, Religion, Science) with items retained from the EFA
279 in **Study 2**.

280 The BVI as a whole reached a very high reliability (0.96; 95% CI: 0.95-0.96)

281 When divided by theme alone, alpha scores maintained very high scores. This was
282 true for Science (0.87), Paranormal (0.96), Politics (0.75), Religion (0.96), and
283 Morality (0.86).

284

285 **Figure 4 - Density of answer totals within themes and faceted by Agreement,**
 286 **Self-Relevance and Interest dimensions, across original (n=736), retest 1 (0**
 287 **hours; n=98), retest 2 (48 hours; n=98), retest 3 (3.5 months; n=69) and**
 288 **confirmatory samples (n=381).** Mor = Morality, Para = Paranormal, Pol = Politics,
 289 Rel = Religion, Sci = Science. A = Agreement, R = Relevance, I = Interest. No
 290 significant differences in mean scores were found between the original, retest1 and
 291 confirmatory samples.

292

293 *Exploratory Associations*

294 Within dimensions, self-relevance and interest were positively and significantly ($p <$
295 0.001) associated for all themes. Morality and politics, religion and paranormal, and
296 politics and science had particularly strong associations ($r > 0.5$).

297 Within the agreement dimension, morality was not strongly associated with any other
298 theme. Religion and paranormal, and science and politics themes were moderate to
299 strong and positively correlated ($r > 0.4$). Religion and science, and science and
300 paranormal items showed a moderate to strong negative association ($r < 0.4$).

301 Figure 5 gives a visual depiction of all associations within dimensions and themes.

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Figure 5 – Pearson r correlation matrices. A) associations within dimensions across themes. B) associations within themes across dimensions. Both include all items before exclusion. All correlations are rounded to two decimal points. This used samples from Study 1 ($n = 736$; $n = 89$) and Study 2 ($n = 381$) in a new large combined sample. Mor = Morality, Para = Paranormal, Pol = Politics, Rel = Religion, Sci = Science. A = Agreement, I = Interest, R = Self-Relevance. Self-relevance and interest dimensions were positively and significantly correlated across all themes. For the agreement dimensions, there was high variation between themes. The correlations between agreement and interest, and agreement and self-relevance were significantly lower than the correlation between interest and self-relevance for all themes ($ps < 0.001$).

315 *ICC analysis (means weighted by factor)*

316 We aimed to establish whether agreement, interest, and self-relevance toward
317 themes of belief in the BVI were stable over a 48-hour and 3.5-month period when
318 items were reduced and summed by their weighted mean within factors suggested
319 by the EFA in **Study 1**.

320 After cleaning we had two samples:

- 321 1. 98 ID matched participants to check stability over a 48-hour period (0-hour
322 retest and 48-hour retest).
- 323
- 324 2. 69 ID matched participants were used to check stability over a 3.5-month
325 period (0-hour retest and 3.5-month retest).

326 ICCs across all dimensions, themes, and time, samples were generally good to
327 excellent (>0.75).

328 Exceptions were:

- 329 1. At 48 hours

330 All dimensions within the Morality factor were between 0.52 and 0.71.

- 331 2. At 3.5 months

332 All dimensions within the Morality factor, the self-relevance dimension of the
333 Politics factor, and agreement and self-relevance dimensions of the Science
334 factor were between 0.52 and 0.72.

335 Figure 3 demonstrates the ICC (3,1) for agreement, interest, and self-relevance item
336 dimensions across factors (weighted) and themes (unweighted – from **Study 1**) over
337 48 hours and 3.5 months with their respective 95% CI.

338 See *Appendix E* for full statistical output and ICC breakdown.

339

340 *Confirmatory Factor Analysis (CFA)*

341 *Agreement*

342 A 5-factor fit was acceptable (Tucker-Lewis Index = .84; RMSEA = .075 - 90%CI =
343 .070 - .080) and fitted the data significantly better than a 4-factor model ($\chi^2(4) =$
344 117.2, $p < 0.001$).

345 Significant positive factor loadings were found with all items but one (0.57 – 2.73)
346 with only one politics item reaching a low of 0.14.

347 *Interest*

348 A 5-factor fit was acceptable (Tucker-Lewis Index = .86; RMSEA = .059 - 90%CI =
349 .055 - .063) and fitted the data significantly better than a 4-factor model ($\chi^2(4) =$
350 140.54, $p < 0.001$).

351 Significant positive factor loadings were found with all items (1.13 – 2.87).

352 *Self-Relevance*

353 A 5-factor fit was acceptable (Tucker-Lewis Index = .86; RMSEA = .057 - 90%CI =
354 .053 - .062) and fitted the data significantly better than a 4-factor model ($\chi^2(4) =$
355 126.2, $p < 0.001$).

356 Significant positive factor loadings were found with all items ($\beta = 0.92 - 2.87$).

357 Figure 6 demonstrates the confirmatory factor models for each dimension, including
358 inter-factor associations.

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36 Agreement

Interest

Self-Relevance

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363 **Figure 6 – Agreement, Interest, and Self Relevance confirmatory factor models**
364 **with a 5-factor solution.** Each factor has the same names as the themes originally
365 devised in the BVI-55 as each factor included items that were originally in the pre-
366 named themes devised. Numbers represent regression (β) coefficients. All items
367 included for each dimension model scored >0.4 loading in the exploratory factor
368 analysis in **Study 1**.

369 Discussion

370 The Beliefs and Values Inventory (BVI) was developed to measure dimensions of
371 different types of belief found in the general population. Specifically, it aims to
372 measure dimensions of agreement, self-relevance, and interest towards propositions
373 from paranormal, religion, politics, morality, and science themes. It was constructed
374 with the dimensions drawn from literature on the mechanisms of normal and
375 pathological belief formation.

376 Cronbach's alpha suggested that theme summary scores and the total BVI scores
377 were stable (when agreement, self-relevance and interest were combined), but
378 dimensions analysed individually varied somewhat. All dimensions of the paranormal
379 and religion theme were highly reliable, and all dimensions of the science theme
380 were satisfactorily reliable. Agreement for both politics and morality scored lower
381 than other themes. This was perhaps in part due to the variance in item domains that
382 comprised each theme. Participants may agree strongly with one item (e.g. belief in
383 abortion as a positive influence) but not others (e.g. that public services are
384 necessary for the greater good), and this disparity was not uniform across the group.

385 Test-retest ICC analysis confirmed that beliefs are stable over a 48-hour and 3.5-
386 month period, although belief in moral concepts are less stable. As with Cronbach's
387 alpha scores, paranormal and religion themes were most stable. The science and
388 politics themes were also stable. This indicates that the contrast between reliability
389 scores (Cronbach's alpha and ICC) is reflective of items being answered in a very
390 similar manner over time despite variance within the theme itself. Morality was the
391 least stable, but still achieved moderate ICC scores. This may be related to the more
392 variable scores in the morality theme, as well as belief in moral concepts being more
393 likely to vary over time – for example, political or life events may cause attitudes to a
394 proposition to alter.

395 Exploratory and confirmatory analyses suggest that a 5-factor model of the BVI-42 is
396 supported, with factors consistent with pre-defined themes after item redaction.
397 Notably, when performing an exploratory factor analysis on the entire BVI-55, items
398 fitted into five factors, mainly segregated into their five themes (see *Appendix B*).
399 This included a mix of agreement, self-relevance and interest dimensions for each

factor, meaning that the confirmatory factor analysis on each dimension contained a different number of items.

Given the strong coefficient scores from the confirmatory factor analysis the BVI-55 or BVI-42 could be used. However, taking into consideration that the reliability estimates were considerably higher in the BVI-55, we suggest using the BVI in its full 55 item form using the summary of each theme and dimension for total scores. Theoretically, this is also supported by the fact that items that do not load strongly onto one factor may not necessarily be irrelevant. Instead they are reflective of the broad range of phenomenological content within each theme. Therefore, we would expect all items to be useful when examining change in belief over time in a single individual. The intended use of this questionnaire is as a single, composite measure to observe alterations in belief over time. Consequently, summary scores for each theme will encompass all the necessary variation of each theme adequately. This means that it is unnecessary to remove items that are orthogonal to the latent factors underlying particular sets of items within the theme.

Correlational analyses suggest that beliefs are dissociable by dimension and theme to varying degrees. When looking within themes, dimensions are dissociable – both interest and self-relevance are highly associated, and their relationship with agreement is the equivalent, but significantly weaker. In addition to observing within-dimension correlations, it is clear that self-relevance and interest are separate components to agreement which is highly variable in its association between themes. It is notable to point out that agreement between themes are associated as one may expect, e.g. paranormal and religious items are positively associated, as are liberal values (politics) with belief in science as a tool for enquiry. However, it is striking that morality did not correlate with agreement from the other themes. We suggest that within the range of scores in our large population this is perhaps due to its independence from other beliefs – religious or liberal status does not necessarily have a uniform impact on moral values. In combination within the exploratory factor analysis, we suggest that themes are distinct, but associated entities, as are dimensions within a particular theme.

Despite the similarity between associations of self-relevance and interest within themes, we suggest keeping them as separate dimensions. This is based on

theoretical grounds. In a healthy population these constructs appear to be highly coherent, perhaps the same. However, we do not yet know how this measure fares in clinical populations or intervention designs. The Peter's Delusion Inventory (PDI⁴) has suggested similar trends. Both the original study⁴ and more recent studies¹³ using the questionnaire have found its dimensions of distress and preoccupation to be highly related in healthy and clinical populations, and dissociable from the conviction dimension. However, in some populations these dimensions are dissociable¹⁴. Likewise, self-relevance and interest dimensions are theoretically separable but are highly associated. Even though our data in healthy volunteers suggest these dimensions are highly associated, it remains possible that this is not the case in different populations or under different conditions.

There are a few limitations to note. We have not yet tested this measure in a clinical population. The dimensional structure of our measure may be variable when used in those with a need for care, or indeed when participants are part of a drug intervention. Additionally, our questionnaire has not yet been compared with other measures that purport to measure the same thematic constructs. Such comparisons are ongoing. We hope that future studies using the questionnaire in clinical populations, as part of an intervention, and alongside other measures will test the variability and validity of the BVI.

The reliability of the BVI show that it has utility in the assessment of belief over time. Additionally, it can be used in cohort research alongside measures such as the PDI to test if certain beliefs are more closely aligned with delusions⁶. Converging evidence on the stability of belief over time and within different individuals will help understand mechanisms of belief change, and whether certain cognitive components are more involved in the development of inflexible beliefs.

457 **Conclusion**

458 The Beliefs and Values Inventory (BVI) is a multidimensional tool assessing belief
459 agreement, interest, and self-relevance. Correlational analyses confirm that belief is
460 comprised of multiple dimensions. Results additionally suggest that beliefs can be
461 stable over a 48 hour and 3.5-month period across dimensions. In regard to politics
462 and morality themes, answers should be interpreted with more caution when
463 considering the agreement dimension and items may need to be analysed
464 individually for more specific conclusions. Through intervention, the BVI may reveal
465 differential changes in dimensions of beliefs in a population – whether clinical or
466 otherwise.

467

Acknowledgments

We would like to thank Sara DeSimoni for her work constructing the prototype BVI. We would also like to thank Georgianna Adams for her useful discussion around beliefs about physical therapy during the construction of this questionnaire.

Author Contributions

JMB, VB, and QD and MAM initially devised the study. JMB collected the data, analysed the data and wrote initial the draft of the manuscript. JMB, VB, MAM, and QD critically revised the manuscript. LSR, MAM, and QD developed the prototype Beliefs and Values Inventory. JMB, VB, QD, and MAM revised the Beliefs and Values Inventory for exploratory and confirmatory analysis.

Additional Information

Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Funding

JMB is supported by the UK Medical Research Council (MR/N013700/1) and King's College London member of the MRC Doctoral Training Partnership in Biomedical Sciences. VB is supported by a Wellcome Trust Seed Award in Science (200589/Z/16/Z).

489 **Methods**

490 **Study 1**

491 Study 1, 2, and 3 were all approved by King's College London research ethics
492 committee (MRS-17/18-5956).

493 *Participants*

494 Prolific Academic (prolific.ac; hereafter Prolific), an online crowd-sourcing platform,
495 was used to recruit all participants anonymously from the UK. The survey was
496 hosted on Qualtrics (www.Qualtrics.com), an online survey and task platform. Each
497 part of the study was put up online through Prolific until recruitment slowed to <2
498 responses/day or our participant quota was completed.

499 Our inclusion criteria were to recruit UK nationals over the age of 18 who were also
500 fluent in English. Participants were asked not to participate if they ever had or
501 currently had a mental health diagnosis.

502 We recruited at three time points:

- 503 1. The first sample recruited 1035 individuals anonymously through Prolific.
- 504 2. The second sample recalled 150 individuals from the first sample 48 hours
505 later using user IDs through Prolific.
- 506 3. The third sample recalled 69 individuals from the second sample (sample
507 recruited at 48 hours later) 3.5 months later using user IDs through Prolific.

508 Individuals who were part of the test-retest analyses in the first sample were
509 excluded from the exploratory factor analysis.

510 *Beliefs and Values Inventory*

511 The BVI is a 55-item questionnaire (Appendix A) that contains propositional items
512 across Political (10), Moral (10), Scientific (10), Paranormal (10), and Religious
513 beliefs (10). There are an additional five items that act as attention check questions,
514 for example, "Barack Obama was president of the USA."

Each theme contains 10 items, divided equally into two subthemes: more specific and more general propositions regarding the subject matter. For the purposes of reporting, we refer to these as 'specific' and 'general.' For example, a more specific science question is "Smoking contributes toward the development of lung cancer" and a more general science question is "Science will eventually be able to provide a more reliable account of human behaviour than literature, poetry, and art."

The division of themes into their subthemes was based upon previous phenomenological distinctions outlined in the literature. Specifically, items in the Moral theme were based upon the moral (harm)/conventional (social) distinction outlined in Social Domain Theory^{15,16} – these two classes of moral judgment are normally distinguished by age three¹⁷. The Moral Foundations Questionnaire was also used as a reference for the development of items in the morality theme¹. Political items were clustered by liberal/conservative dimensions and government responsibility and style (democratic/autocratic). These were constructed from the observations that political ideology tends to divide down liberal and conservative dimensions^{17,1}. Paranormal items were developed from concepts in existing questionnaires, for example, drawing from the Revised Paranormal Belief Scale^{18,9}. Beliefs toward religion and science were agreed upon through group consensus of the authors.

The general/specific distinction, while applicable to most themes, was chosen as a general indicator to delineate phenomenological clustering of items in a theme. This was for practical data handling and coding purposes more than a reflection of the content of a subtheme. For example, items in the Morality theme were divided by transgressional/conventional aspects of morality, but for the purposes of uniform data management were arbitrarily placed into general/specific subthemes, respectively.

Each item is further subdivided into three dimensions: agreement, self-relevance, and interest. Participants are asked to decide how much they agree with each statement, how relevant the statement is personally to them, and how interested they are in the statement. Participants score these dimensions on a visual scale from 0-10.

546 For the full listing of specific items see Appendix A.

547 *Analysis*

548 All analysis was conducted in R (version 3.3.1 ¹⁹) (full script from
549 <https://osf.io/hzvwr/>). R is an open source statistical software with robust packages to
550 cover a range of analyses. All visualisation was conducted using the *ggplot2*
551 package ²⁰.

552 An exploratory analysis on the demographics, reliability (Cronbach's alpha),
553 exploratory factor structure, and intra-class coefficients were performed.

554 *Data cleaning and scoring*

555 Participants were removed if they did not at least answer '6' (agree) on the control
556 questions.

557 We coded items based upon their theme (W), theme subsection (X), question
558 number (Y), and dimension (Z) as follows: "W_XY_Z", where Y is a number from 1-5.
559 For example, the 3rd politics question (agreement dimensions) from its 'specific'
560 subsection would be "Pol_S3_A".

561 Specifically, codes for items were:

562 *Theme*

- 563 - Pol = Politics
- 564 - M = Morality
- 565 - R = Religion
- 566 - P = Paranormal
- 567 - S = Science

568 *Theme subsection*

- 569 - G = General
- 570 - S = Specific

571 Agreement score for questions “Pol_G3_A”, “Pol_G5_A”, “Pol_S5_A”, “M_G5_A”,
572 “M_S2_A”, “M_S4_A”, “R_G4_A”, “S_G1_A”, and “S_S4_A” were reverse coded so
573 that all agreement in each theme moved toward the same overall concept.

574 Therefore, higher ratings in each theme for the agreement dimension indicated:

- 575 • General Politics – Government responsibility and style (the use of government
576 and taxes to benefit the population and address wellbeing).
- 577 • Specific Politics – High agreement with liberal values addressed using specific
578 policy.
- 579 • General Morality – High agreement with acceptability of moral transgressions
580 (harm to others in absence of discovery).
- 581 • Specific Morality – High agreement with acceptability of conventional
582 transgressions (in absence of discovery).
- 583 • General Science – High agreement with the power of science as a tool for
584 establishing reliable knowledge.
- 585 • Specific Science – High agreement with current evidence for specific scientific
586 questions.
- 587 • General Religion – High agreement with propositions expressing religious
588 views about the nature of reality.
- 589 • Specific Religion – High agreement with religion as a tool for good in the world
590 and society.
- 591 • Paranormal (both general and specific) – High agreement with superstitious
592 concepts (e.g. “The number 13 is unlucky”) and magical thinking (e.g.
593 “Crystals can be used for healing”).

594 *Dimension*

- 595 • Agreement (A)
- 596 • Interest (I)
- 597 • Self-Relevance (R)

598 High scores on the interest and self-relevance dimensions indicate high interest and
599 high self-relevance, respectively, across all themes.

600 *Demographics*

601 Frequencies were calculated for the age, sex, religion, mother's religion, father's
602 religion, ethnicity, education, and political orientation. Religion, ethnicity, religion, and
603 education demographic options were based upon the UK census (ONS, 2011).
604 Parent's religion was included as they may relate to the development of beliefs in the
605 participant.

606 *Descriptive Statistics*

607 Total answer density scores were calculated for each dimension for the original and
608 all retest samples. This gives a visual distribution of the sum of item scores for each
609 theme across each sample.

610 *Reliability (Cronbach's Alpha)*

611 Cronbach's alpha was used to compute the internal reliability for the entire
612 questionnaire, and each theme calculated separately for each dimension.
613 Calculations were completed with the *Psych* package (v.1.8.4¹²) for *R*.

614 In the case of our questionnaire, alpha values also give a reliable representation of
615 the volatility of beliefs across the group – in essence, how frequently participants
616 answer in the same way for agreement, interest, and reliability across themes in the
617 group.

618 *Test-Retest Intraclass Correlation Coefficients.*

619 Intraclass Correlation Coefficients (ICC) compute the relative similarity of quantities
620 within a group, members of which have been given identical measurements^{21,22}.
621 This provides a metric as to how consistent a group of participants' answers are
622 between two time points, in this case, over 48 hours and over 3.5 months. ICC
623 analysis has been suggested as a robust measure of test-retest reliability when
624 comparing factor structures and psychometric tools²³. An ICC of between .05 and
625 0.75 is considered "moderate", between 0.75 and 0.9 is considered "good", and an
626 ICC over .09 is considered excellent²⁴.

Item dimensions grouped by each theme were summed and input into an ICC analysis using the *Psych* package. ICC analyses were conducted to assess the stability of answers over 48-hour and 3.5-month periods. The 48-hour analysis used ID matched participants from baseline and 48-hour time points. The 3.5-month analysis used ID matched participants from baseline and 3.5-month time points – these were recruited from participant IDs who had taken part in the 48-hour analysis to enable ICC comparison between samples.

Item totals for each dimension and theme were summed for each participant and compared between time points. For example, agreement with scientific statements were summed for participants at 0 hours and 3.5 hours and analysed for consistency. We used Model 3 (3, 1), which considers our population as the only population of interest and further counts one single measure per time point ^{24,21}.

Exploratory Factor Analysis (EFA)

We selected five themes to comprise the BVI, each containing a number of theme-relevant items. An EFA was used to support our presupposed structure in the BVI. This also served to identify items which may not contribute to the theme reliably.

In an EFA, factors are extracted which represent putative latent variables underlying a group of items. These latent variables are then able to be tested in a confirmatory analysis with a new sample.

Factor analysis was conducted as opposed to a principal component analysis because we aimed to determine to what degree each item within a theme contributed to the latent variable of belief. We used the *Psych* package (v.1.8.4¹²) for *R*.

Parallel analysis was first conducted to calculate the appropriate number of eigenvectors to extract. Appropriate number of factors were determined upon viewing the scree plot ²⁵.

EFA was applied to the dimensions Agreement, Self-Relevance, and Interest to determine overall loading across themes. An exploratory orthogonal (varimax) factor

655 analysis was conducted, which allows for the factors to not correlate. A threshold of
656 0.4 was applied to factor loadings.

657

658 **Study 2**

659 *Participants*

660 Prolific.ac was used to recruit all participants anonymously from the general
661 population in the UK.

662 Inclusion Criteria:

- 663 • UK National
- 664 • Over the age of 18
- 665 • Do not have or never have had a diagnosis of a mental health condition
- 666 • Prolific.ac approval rate over 80%

667 We recruited 488 anonymous participants at one time-point.

668 The original BVI-55 was used (before item removal), however for confirmatory factor
669 analysis, only the items shown to be significantly weighted to a factor were retained
670 for analysis.

671 The extra items were used to collate large sample size associations.

672 *Analysis*

673 All analysis was conducted in R (version 3.3.1¹⁹)(full script from
674 <https://osf.io/hzvwr/>). Both are open source statistical software with robust packages
675 to cover a range of analyses. All visualisation was conducted using ggplot2²⁰.

676 A confirmatory factor analysis of the factor structure obtained in **Study 1** was
677 conducted.

678 *Data cleaning and scoring*

679 All data cleaning procedures for **Study 2** are identical to those performed in **Study 1**.
680 For further details please see our script (<https://osf.io/hzvwr/>).

681 *Descriptive Statistics*

682 Total answer density scores were calculated for each dimension for the confirmatory
683 sample. This gives a visual distribution of the sum of item scores for each theme,
684 dimension, and sample.

685 *Exploratory associations*

686 Samples from **Study 1** (original - n=736; retest1 - n=98) and **Study 2** (confirmatory –
687 n= 381) were combined to form a new large sample (n=1213). No significant mean
688 differences were found between samples across themes and item dimensions.

689 We conducted Pearson *r* correlations to understand the associations of all 55 item
690 totals across themes within dimensions.

691 *Cronbach's Alpha*

692 Cronbach's alpha was used to compute the cross-sectional reliability in the
693 confirmatory (n = 381) sample using items retained from the EFA in **Study 2**. This
694 gives a metric to identify the coherence of answers across the entire questionnaire
695 and its component themes. We used the *Psych* package (v.1.8.4 ¹²).

696 *ICC analysis (means weighted by factor)*

697 Item dimensions grouped by each factor (determined from the pattern matrix output
698 in **Study 1**) were multiplied by their factor loading to generate a weighted score,
699 summed and input into an Interclass Correlation Coefficient (ICC) analysis using the
700 *Psych* package in R to assess the stability of answers over 48 hours and 3.5 months.

701 *Confirmatory Factor Analysis (CFA)*

702 A CFA was run to determine the strength of loading of each item onto factors
703 identified in the EFA. This also provides a metric to determine the interaction of the
704 factors identified in **Study 1**.

705 Using the results from **Study 1**'s exploratory factor analysis, six CFAs were run to
706 determine the degree to which the extracted items under each theme across
707 agreement, interest, and self-relevance fitted together in:

1. 5 factor model, where politics and morality are treated as separate latent variables.
2. 4 factor model, where politics and morality are treated as a single latent variable.

The model was specified using items extracted under each theme using the outputs from the EFA across agreement, interest, and self-relevance. Items were grouped into a theme if they loaded independently onto a factor without cross-loading.

All items were coded as numerical continuous variables (from 0 – 10).

A confirmatory factor analysis was conducted using the R package 'lavaan' ('cfa' and 'sem' function ²⁶).

The package 'semPlot' was used to visualise the results using the 'semPaths' function.

Maximum likelihood estimation was used. The latent factors were standardised allowing free estimation of all factor loadings.

Agreement, Self-Relevance, and Interest were fitted separately across models (1) and (2).

Networks of observed and implied items within each factor model were created using the "semCors" function in semPlot. These used LASSO estimation algorithms.

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