1 **Opinion**

2 **Theory of Animal Mind: Human Nature or**

3 **Experimental Artefact?**

4

5 **Caroline E. Spence[1], Magda Osman[1],★ , Alan G. McElligott[1]**

6 [1]Queen Mary University of London, Biological and Experimental Psychology,

7 School of Biological and Chemical Sciences, London, U.K.

8 ★Correspondence: m.osman@qmul.ac.uk (M.Osman)

10

11 **Abstract**

12 Are animals capable of empathy, problem-solving or even self-recognition?

13 Much research is dedicated to these questions and yet few have considered

14 how people form beliefs about animal minds. Evidence suggests our

15 mentalising of animals may be a natural consequence of Theory of Mind

16 capabilities. However, where beliefs regarding animal mind have been

17 investigated, this review reveals slow progress in establishing the mechanism

18 underpinning how this is achieved. Here, we consider what conclusions can

19 be drawn regarding how people theorise about animal minds and the different

20 conceptual and particularly methodological issues that might limit the

21 accuracy of conclusions currently drawn from this work. We suggest a new

22 empirical framework for better capturing people's theory of animal mind, which

23 in turn has significant political and social impacts.

24

"The difference in mind between man and the higher animals,

great as it is, is certainly one of degree and not of kind." [1]

27

Thoughts on Animal Thinking

29

Scientific debate regarding the existence and nature of mental states in animals has a longstanding history [2,3] and covers an extensive range of topics from mirror recognition to numerosity (Box 1). Yet the majority of people form beliefs about animal minds based on everyday occurrences, such as when caring for pets [4] or consuming animal products. Understanding how people construct this "Theory of Animal Mind" (TAM) is therefore likely to reveal important insights, based on their experience and influence in relation to animals. Additionally, as a form of internal construal of other minds, examination of the psychological mechanisms generating TAM will likely have broad implications on account of behavior interpretation not being limited to human-animal relationships [5]. However, little research has been dedicated to exploring the basis on which mental abilities are attributed to nonhuman animals, despite few doubting the existence of animal mind [6,7]. Furthermore, when directly questioned, people often substantiate their beliefs with explanations from personal experience or media sources [7]. As a result, it is highly unlikely that the psychological mechanisms that contribute to TAM are analogous to the reasoning used by scientific experts to support judgements on animal cognition [8]. This mismatch gives rise to several ethical, scientific and societal issues. Ethical issues arise because views on

49   the sentience of different species are correlated with attitudes towards their

50   use and treatment by humans [9,10]. Therefore, not only is TAM a potential

51   driver of positive human-animal interactions [11], but also welfare-related

52   decisions for millions of animals that are currently based upon psychological

53   mechanisms we know little about. Scientific issues emanate from empirical

54   approaches to animal cognition, which likely contaminate research design and

55   produce a biased or inaccurate snapshot of the overall picture of TAM. Social

56   issues are associated with decision-making in related policy areas such as

57   animal welfare, food security and climate change that are, understandably,

58   driven by current scientific opinion. The behavior change envisaged by policy

59   makers is unlikely to be realised if supporting evidence does not accurately

60   capture peoples actual thought processes [12,13].

61   As such, this article is important and timely, and designed to expose

62   some of the core issues regarding the evidence available in relation to TAM

63   as well as the research methods commonly used to investigate the

64   phenomenon. Therefore, we start by identifying, and later proposing, a

65   candidate mechanism underlying the development of TAM that generates

66   judgements on the mindedness of non-human animals. Because TAM

67   involves animal 'agents', several theories of relevance from social psychology

68   are also discussed. Following on from this, we discuss ways in which

69   research methods might be affecting the results gained from previous TAM

70   research, and thus pose **validity** (see glossary) and **reliability** issues. We

71   propose a model that allows both conceptualisation and empirical

72   investigation of the initial stages of TAM using a measurement scale model

73   (specifically **Churchill's Scale Development Paradigm** [14]), which in turn,

74 allows mechanisms contributing to TAM to be determined. We conclude by

75 discussing the importance of reframing TAM in terms of wider relevance to

76 ethical and policy issues than just animal welfare.

77

78 **TAM as a Mechanism of Belief Formation**

79

80   Often, people's views on animal mind have been speculated to reflect a

81 simple accumulation of various disparate attitudes and beliefs that are often

82 informed by general society. In essence, we suggest that TAM is more

83 nuanced. It is based on a belief-generating cognitive mechanism that begins

84 by drawing on multiple sources of experience and knowledge that are

85 integrated in order to formulate a judgement (e.g., to what extent is this animal

86 intelligent?) or belief (e.g., I'm of the view that most animals are intelligent);

87 the belief/judgement is thresholded, requiring the establishment of criteria on

88 which to assign mindedness to some species over others. The mechanism

89 underpinning TAM consists of multiple components (Figure 1), similar to

90 general models of belief formation [15]. For example, relevant information is

91 **encoded** for later use in generating beliefs about TAM. Encoded information

92 may be descriptive, e.g. chimpanzees can use tools to harvest food, or

93 inferential, e.g. my dog wags his tail when we play ball, playing ball makes my

94 dog happy, ergo my dog experiences emotions. These different types of

95 information become integrated to produce stored schemas or **constructs**

96 regarding TAM. People may actively retrieve, or through associative memory

97 processes are prompted to draw, information from this store as a way of

98 establishing the certitude of their beliefs regarding TAM [16]. In other words,

4

99   cumulative perceived knowledge/experience from multiple sources allows an

100 individual to make an estimate that a specified animal possesses a particular

101 mental attribute that is indicative of TAM. If the estimate reaches a threshold

102 limit as determined by that individual, the concept of mind is bestowed upon

103 the animal. This process of belief formation is similar to many models

104 attributed to other domains [16,17]. Below we consider evidence that supports

105 speculation on several psychological theories in this mechanism and later, we

106 outline a framework that helps clarify conceptual and empirical issues when

107 investigating some of the key components of TAM.

108

109 **TAM: Evidence of Influencing Psychological Theories**

110

111   Because views on the existence of animal mind are influenced by the

112 idea of animals as social agents [7], we consider four theories, with origins in

113 social psychology, and their supporting evidence: **Simulation Theory**,

114 **Cognitive Dissonance** Theory, **Terror Management** Theory and **Social**

115 **Dominance** Theory.

116

117 **Simulation Theory (ST)**

118

119   In interacting with social 'others', we attempt to make sense of behavior

120 and predict future actions. Therefore, TAM, as the capacity to attribute mental

121 states to non-humans, is likely to be influenced by Theory of Mind capabilities.

122 This is supported by evidence suggesting that, similar to human-human

123 attributions [18], we confer greater mind to animals as we age [19][11]; most

124   likely because we generate more experiences on which to form the

125   beliefs/judgements, and to specify the details of the criteria on which they are

126   evaluated. The influence of ToM (specifically as Simulation Theory) is also

127   supported by people's use of context and behavioral similarity between

128   animals and humans as a central factor in the psychological interpretations of

129   an animal's actions [20]. Notably, people consider species an important

130   determinant of animal mind: 72% of survey participants believe chimpanzees

131   have human-like capacities to feel pain, while only 30% believe worms can

132   feel pain to a moderate degree [21]. Previously, this has been interpreted as a

133   cognitive ability being derived from **phylogenetic** similarity [20], with

134   evolutionarily more recent animals being seen as in possession of greater

135   mental abilities [9,22,23]. We suggest this finding is more likely due to the

136   influence of mental simulation within a TAM mechanism based on the

137   following evidence: 1) where differences in perceptions of species were found,

138   results varied in degree rather than kind [20], suggesting we are extrapolating

139   or 'simulating' from a human model, and 2) mirror neuron activation occurs

140   when people observe both human and non-human animals performing similar

141   actions [24].

142   The idea that people view specific behaviors and then attribute mind

143   based on this is a common description of how we achieve TAM, and is also

144   supported by findings that when viewing animal behavior videos, participants

145   broke down scenarios into specific behavioral 'event units' [5]. Despite not

146   using every event unit to describe the behaviors seen, there was near perfect

147   agreement on the event unit nature/meaning and the total number present per

148   video. This evidence suggests that judgements were made based on

149 recognition of agent's discrete actions rather than on their similarity to
150 humans.

151

152 **A note on Simulation Theory as anthropomorphism**

153

154   Skilled mind reading of a human target (in relation to ST) requires an
155 accurate replication of their mental states, but a simulator's own mental states
156 may contaminate this process [25]. Because our interactions with animals
157 naturally preclude verbal confirmation of inaccurate mental states, it is unlikely
158 that over time, with more feedback from our interactions, we will develop
159 improvements in our mindreading. This, combined with the necessity of
160 simulating within a human mind, means attribution of **anthropomorphic**
161 mental abilities to animals is unavoidable (e.g. deception, self-recognition).
162 However, labelling these errors as anthropomorphic is unhelpful when
163 investigating TAM. In describing animal minds, people assign psychological
164 terms to specific shared behaviors, regardless of species [20] suggesting
165 'interpretative' anthropomorphism rather than 'imaginative' [26]. Along with
166 accumulated knowledge and experience, this work shows that we look to
167 simulate the mind of animals, by assuming that similar actions to our own
168 reflect similar cognitions.

169

170 **Cognitive Dissonance Theory (CD)**

171

172   Empirical evidence suggests predominant societal attitudes to meat
173 eating underpin production animals being ascribed lower mental capacities;

174 an attempt to reduce the cognitive dissonance arising from this ethically
175 contentious yet widely adopted societal custom [27,28]. As such, these
176 mechanisms of dissonance reduction are likely to impact upon TAM and
177 manifest as opposing correlations between TAM and support for i) animal use
178 (negative) [19] and ii) animal welfare (positive) [10]. Because criteria upon
179 which this dissonance reduction is achieved may vary, we consider CD in
180 relation to TAM as two forms, terror management (TM) and social dominance
181 (SD).

182   In individuals with a preference for social hierarchies, dehumanisation
183 by ridding animals of mind and therefore moral worth [29], allows their
184 conception as an out-group and subsequent exploitation [6]. For example,
185 those who support animal experimentation endorse a greater mental divide
186 between humans and other species [9,30]. Conversely, experimental framing
187 of human-animal similarity has been shown to increase moral concern for
188 animals and human outgroups simultaneously [31]. This concept of out-group
189 dementalization can also be seen in our reduced attributions of mind to pest
190 species in comparison to other animals [32].

191   In contrast to our social dominance orientation, which acts to reduce
192 animals perceived cognitive abilities, mechanisms of terror management aids
193 dissonance reduction by elevating humans in comparison to other animals. In
194 order to avoid the cognitive and emotional experiences inherent in awareness
195 of human or animal death (mortality salience), particularly as a result of
196 human activity (e.g., farming), we advocate the anthropocentric view that
197 humans rights be prioritised on the basis of sophisticated cognitive abilities
198 [6,31,33]. This elevation of own cognitive capacities can be seen in our

199 consistent segregation of humans at the top of mental ability scales [22,30]

200 (for a notable exception see [34]).

201   However, despite employing different criteria to create distinctions

202 between human and animal mentality, SD and TM show similarities in that

203 they likely depend upon the same belief formation processes. In contrast,

204 simulation theory, and anthropomorphism, are designed to develop criteria for

205 detecting similarities between humans and animals.

206

207 **Theory of Animal Mind: Innate or Acquired?**

208

209   Having set out what we propose as a candidate mechanism that

210 underpins TAM, as well as current theoretical proposals regarding TAM, we

211 now consider a key question that all theories need to address, namely that

212 TAM is innate or acquired. In other words, should a special status be

213 attributed to the formation of TAM? From the theories reviewed, the basic

214 mechanism of TAM is much like other processes/theories of belief formation.

215 However, the bank of perceived knowledge the mechanism employs is

216 subject to several influences that would likely predict individual differences in

217 the types of beliefs formed. For example, factors such as education [9],

218 exposure to media [7] and political orientation [35] are likely to cause variation

219 in TAM. Therefore, despite evidence of similarities across cultures when

220 ascribing mental states [36], individual and cultural context are likely to affect

221 the mechanism, as seen in Japanese students who ascribe greater

222 intelligence to crows compared to other nationalities [10]. However, while

223 observed variations may be considered the result of social traditions and

224   practices, the contribution of specific societal influences on TAM is

225   unsubstantiated as previous research has predominantly sampled WEIRD

226   (Western, educated, industrialised, rich and democratic) populations [37].

227

228   **Are there limitations to conclusions drawn from empirical research on**

229   **TAM?**

230

231   To summarise, the effects of individual and social factors on the

232   mechanism of TAM is clearly interactive, fluid and warrant investigation. Yet

233   despite several variables such as age, species of animal and cultural

234   background being of consequence, based on the evidence we have at

235   present, the direction and magnitude of effects is often disputed e.g. meat

236   consumption based on gender. Additionally, even for those factors considered

237   influential, the variance in TAM they account for is typically small [11,19].

238   These issues suggest that research methods may be a potential barrier to not

239   only understanding the underlying mechanics of TAM but also in clearly

240   identifying predictive factors. As discussed above, human tendency to

241   anthropomorphise has received much academic attention, predominantly as a

242   methodological and individual weakness [38]. TAM research often proposes

243   avoidance of the former by claiming to purely substantiate beliefs, rather than

244   test accuracy of knowledge. While valid, this perspective is problematic,

245   primarily because variation in experience and encoded knowledge is likely a

246   determinant of beliefs formed [29,39], (as evidenced by the demonstrated

247   effect of psychology-focused education on TAM [40]).

248   In conjunction with this issue, heavy reliance on scale-based methods

249   may exaggerate the influence of cognitive dissonance on judgements. TAM

250   research typically presents animals as phylogenetic bands on the basis of

251   mapping onto confirmed, yet incorrect, evolutionarily linear beliefs held by

252   non-scientists [30,32,41]. This runs the risk of reducing TAM to a simple

253   ranking exercise against 'advanced' humans.

254   These methodological problems combine to perpetuate the idea that

255   TAM is easily explained, prompting a 'dumbing-down' of the parameters

256   investigated. Much research has focused on a single attribute or dimension of

257   TAM [42,43], perhaps because evidence suggests that there are

258   commonalities in assigning TAM across the board [44]. This approach

259   promotes a narrow and unsophisticated demonstration of TAM and distorts

260   the manner in which variation in knowledge/information is used to consider

261   the multiple attributes/dimensions on which to assign TAM. If the devil is in the

262   detail, understanding specific and unexpected results (e.g. 25% of Finnish

263   people surveyed believe shrimp can remember **conspecifics)** is surely

264   imperative [45]. Furthermore, restricting the TAM constructs considered

265   worthy of investigation not only limits opportunities for understanding but also

266   assumes an even weighting in the importance of mental attributes.

267   The consequences of this inflexibility and lack of precision when

268   employing rating scales is highlighted by use of the 'belief in animal mind'

269   scale [41]. When originally devised, the four-part scale showed high internal

270   consistency. No subsequent study has managed to reproduce this level of

271   reliability. This issue could be attributed to views on animal mind having

272   undergone temporal changes, a credible theory since i) the amount of

273 research on animal cognition has increased over time [11] and ii) exposure to

274 animals via influential media e.g. TV [46] has increased. However, minor

275 changes to the scale may well be affecting the reliability of findings on the

276 basis that TAM is more nuanced than previously claimed (for instance,

277 inclusion of the term "human-like" in surveys appears to reduce participants

278 willingness to ascribe emotions to animals [40]). Additionally, in its original

279 use, specific categories of animals were provided (mammals excluding

280 humans, birds, fish and insects) on a 5-point scale. Much subsequent work

281 condensed the four groups into "most animals" (a term typically construed as

282 a mammal [47]) alongside a variety of scale measurements [19,32,47,48] and

283 subtle changes in wording. This highlights the crucial issues of scale

284 construction and vague or dual meanings for cognitive terms.

285   Much research on TAM has hinged on the generalised concept of

286 intelligence. While this widely used term allows rapid entry into our

287 frameworks of mind [49], there is often little confirmation of what constitutes

288 intelligence to sample populations despite evidence that it comprises varying

289 constructs to different individuals [50]. Intelligence also involves associations

290 alien to the natural world (e.g. IQ tests). With no specifics to work from,

291 people may simply execute cognitively accessible judgements of 'advanced'

292 mammals, generating repeated correlations between intelligence and

293 phylogeny [43].

294   We suggest this inconsistency in methods accumulates to produce the

295 varied reported findings detailed previously. Hence, while regression and

296 correlation analysis has provided evidence for relationships between TAM and

297 several other factors, findings have rarely been repeatedly substantiated.

298 These discrepancies are understandable on the basis that TAM comprises

299 different constructs within a study, as well as variation for the different species

300 on which TAM is being investigated [48].

301   Taken together, these concerns reassert the need to have precise

302 scale items for establishing factors that truly influence TAM formation as well

303 guarding against experimenter bias when designing such scales. As noted,

304 'respondents are constrained by the categories provided' [44], which are often

305 transferred directly from animal cognition literature to social science studies

306 [51]. This is acceptable if testing transmission of scientific knowledge is our

307 aim, but precludes accurate understanding of how we construct TAM. Despite

308 suggestions that our attributions of emotion to animals aligns with scientific

309 views of a basic/higher emotional divide, only a minority of participants believe

310 that animals experience disgust [32]. This demonstrates the importance of

311 ascertaining specific meanings of participant-generated constructs before

312 overlaying scientific theory.

313

314 **Targeting Issues and Improving Tools of Assessment**

315

316   In order to align scale use with meaningful comparisons between

317 findings investigating TAM, we propose a more focused research programme

318 examining the construct formation in TAM. To achieve this, we propose a

319 **Reflective Measurement Model** [52] (Figure 2). This model would allow

320 movement away from considering TAM as a single dimension (supported by

321 the results of [21,35]), allowing greater analysis of the role of specific mental

322 capacities within an overarching belief in animal mentality.

323   We suggest the use of Churchill's measurement model [14] in order to

324   generate a valid and reliable model. While full discussion of the model is

325   beyond the scope of this article, in figure 3 we detail the way in which this 8-

326   step approach to measurement will aid the development of reliable tools for

327   generating theoretical predictions as well as empirically testing a critical but

328   often neglected component of the TAM mechanism, namely construct

329   formation; the way in which knowledge and experience is integrated in order

330   to formulate constructs that are used to make decisions/judgements, and form

331   beliefs.

332   The benefits of this model are that, it would more likely reveal the types

333   of dependencies that have been speculated over, such as the association

334   between TAM and empathy. Furthermore, a reliable scale would support

335   empirical work that continues to employ innovative methods to assess animal

336   behavior through videos [5,20]. People's beliefs, judgements and decisions of

337   animals is context sensitive [23], and so using techniques like this can allow

338   comparison of how animal mentality may be viewed in both imagined and real

339   terms. Having a measurement framework that comes with the theoretical

340   apparatus to generate testable predictions around construct formation that

341   underpins beliefs, judgements and decision-making behavior, will elucidate a

342   richer understanding of how we come to our TAM.

343

344   **Concluding Remarks and Future Perspectives**

345

346   People's views of the mental abilities of animals, and the resulting

347   moral duty for their welfare, have considerable economic, social and political

348 consequences. Despite this, TAM has received relatively little scientific

349 attention and the ambiguity in the findings generated from work in this area

350 may be attributable to methods and tools. More to the point, we propose that

351 construct formation, a core component of the mechanism of TAM, has been

352 particularly underexplored. Future progress on the subject will likely be

353 mediated by the convergence of scientific approaches to determine a wider

354 range of cognitive constructs (see 'Outstanding Questions'), a process that

355 application and examination of the proposed model should aid. Certainly, the

356 use of validated scale measurements in combination with other methods

357 would shift focus away from confirming unwarranted assumptions around

358 TAM. In addition, a richer conceptual framework for generating hypotheses

359 would improve ways of uncovering people's assumptions of animal's mental

360 capacity. Moreover, focusing TAM research away from seeking correlation

361 with diverse attitude measures in an attempt to predict human treatment of

362 animals, would allow exploration of other potentially substantial influences

363 such as an individual's history of interaction with specific species. This

364 redirection is important because TAM is supported by work from many areas

365 of psychology (e.g. attribution theory, cultural norms, Theory of Mind). In

366 reducing TAM to a single predictable component within a decision-making

367 system focused only on humane animal use, we ignore its diverse

368 implications by omission.

369

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15

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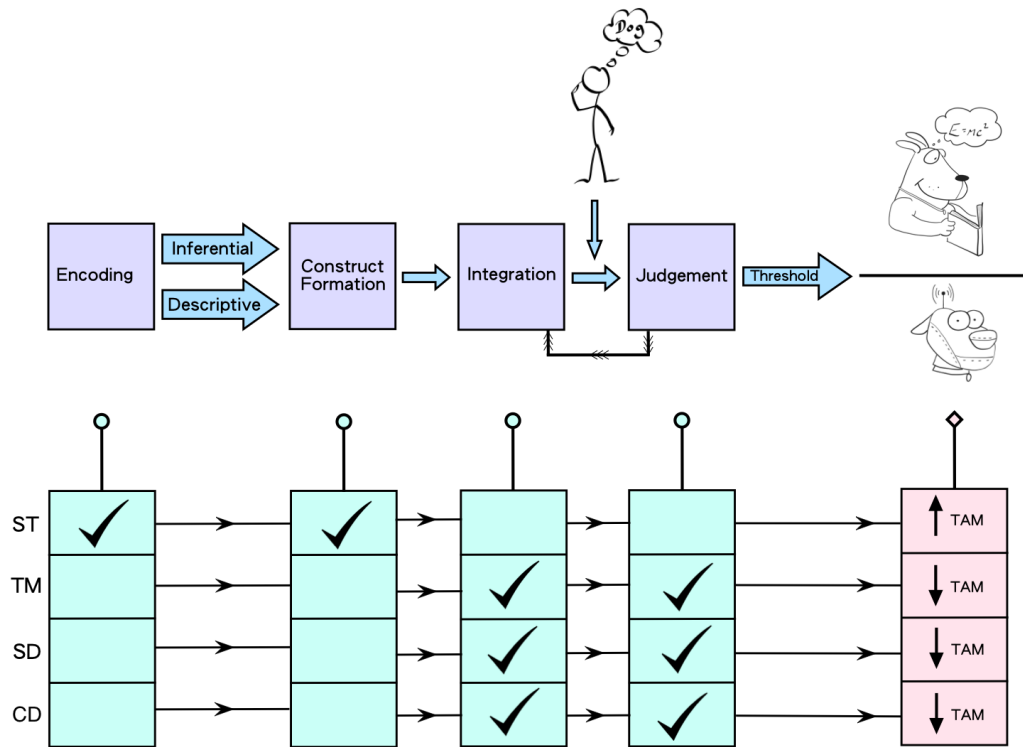
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Fig. 1 Proposed Mechanism of Belief Formation underpinning Theory of Animal Mind. The proposed mechanism is conceptualised as a series of connected components allowing relevant information to be perceived, encoded, integrated and subsequently utilised when forming judgements on the mindedness of non-human animals. Judgements are computed 'online' and represent confidence estimates of belief validity [15]. Formulated judgements may be integrated into an individual's bank of perceived knowledge to be reused in future estimates. Each component of the mechanism is susceptible to the influence of specified social theories (ST: Simulation Theory, TM: Terror Management Theory, SD: Social Dominance Theory, CD: Cognitive Dissonance Theory). For example, we propose that simulation affects perception and encoding of information relevant to TAM through recognition of cross-species behaviors/actions. Thus, Simulation

586 Theory, as a rule, acts to increase the likelihood of exceeding the judgement

587 threshold required to attribute mind to animals purely as a result of observing

588 non-human species. This mechanism is seen by the higher levels of TAM

589 reported by owners towards their pets [53,54]. Conversely, CD, TM and SD all

590 influence the judgement process by reducing the likelihood of exceeding this

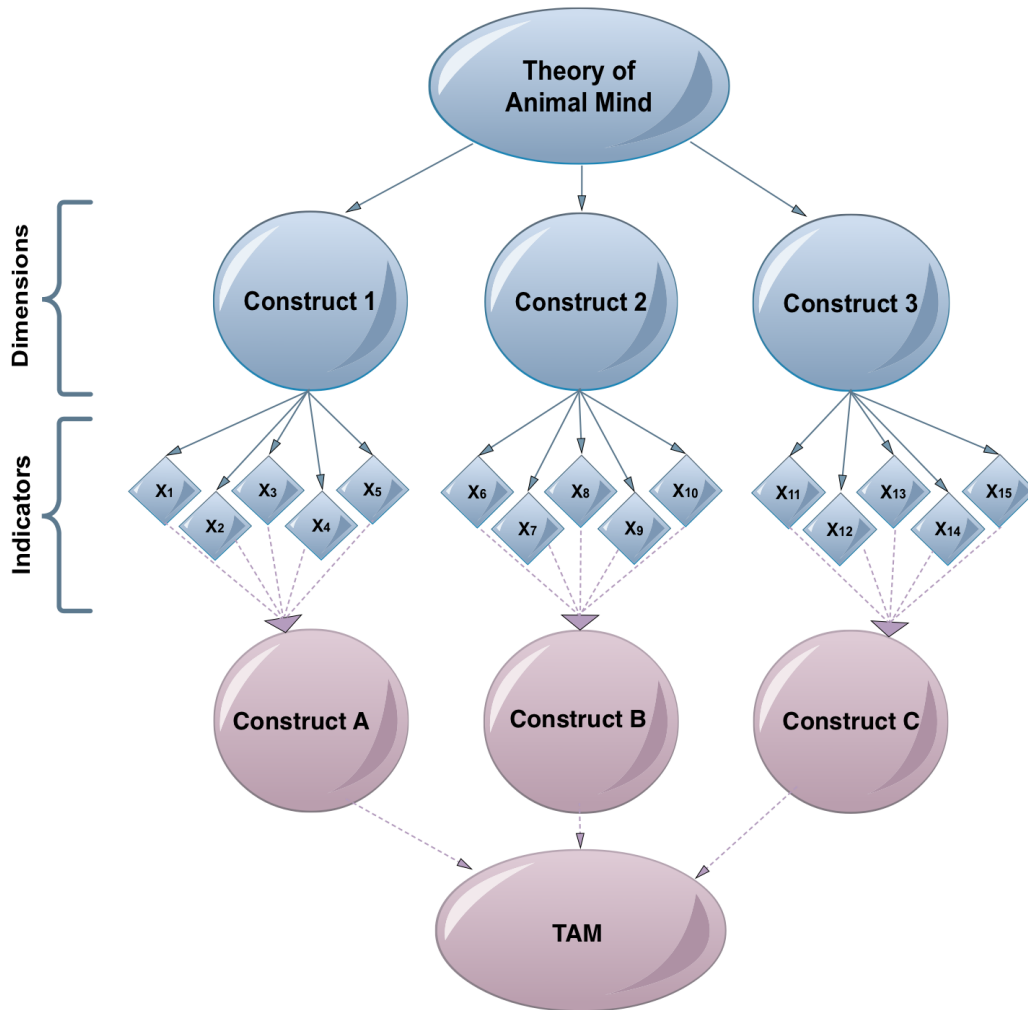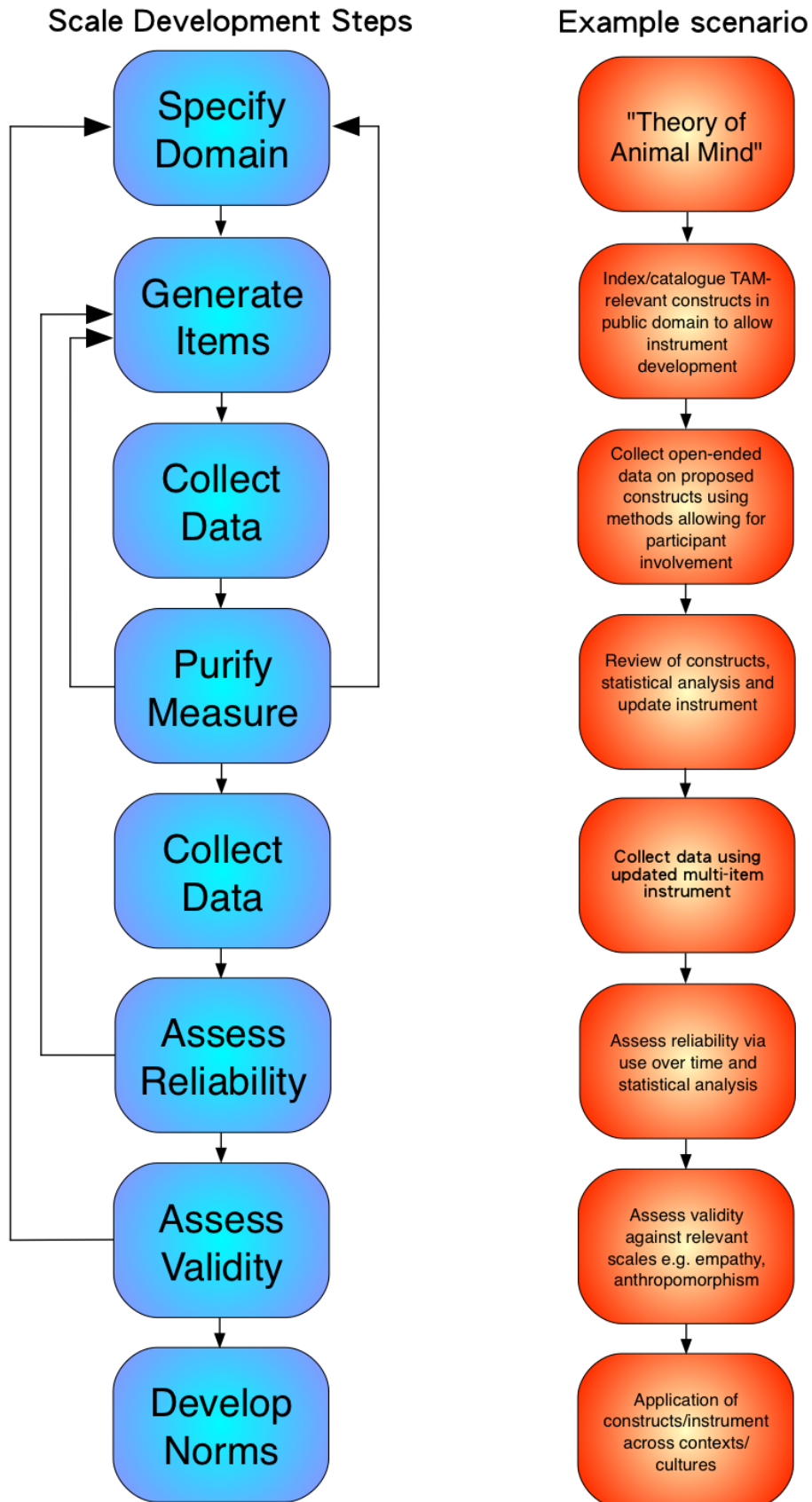591 judgement threshold.

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Fig. 2 Reflective Measurement Model depicting Theory of Animal Mind as a multidimensional construct. Within this model (indicated as blue), mechanism of TAM is conceptualised as a second order, latent construct that underlies multiple first order constructs (dimensions). Dimensions would be expected to consist of mental traits considered attributes of mind e.g. agency as seen in [35] (Note: this prediction, based on previous findings, would need confirming as part of the process). Several specific indicators are used to capture the constructs. The model acts to provide a way to both conceptualise and investigate (indicated as purple) the initial stages of TAM development i.e. construct formation.

Scale Development Steps

Specify Domain

↓

Generate Items

↓

Collect Data

↓

Purify Measure

↓

Collect Data

↓

Assess Reliability

↓

Assess Validity

↓

Develop Norms

Example scenario

"Theory of Animal Mind"

↓

Index/catalogue TAM-relevant constructs in public domain to allow instrument development

↓

Collect open-ended data on proposed constructs using methods allowing for participant involvement

↓

Review of constructs, statistical analysis and update instrument

↓

Collect data using updated multi-item instrument

↓

Assess reliability via use over time and statistical analysis

↓

Assess validity against relevant scales e.g. empathy, anthropomorphism

↓

Application of constructs/instrument across contexts/ cultures

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Fig. 3 Use of Churchill's model to improve scale development (indicated as blue). Definitions of TAM are numerous [19] and often overlap, resulting in conceptual confusion. Step 1 is designed to address this by providing a delineated definition, thereby improving scale validity and transferability. Use of Rossiter's 5 definition rules may aid the definition process [55]. Employing a multi-item scale would ensure capturing each dimension in its entirety i.e. for all animals rather than overly broad groups e.g. mammals. Because TAM is a perceptual attribute/implicit theory [50], it is unlikely that literature reviews and researcher introspection will generate sufficient scale items [56]. Use of developmental qualitative research proposed by Churchill would allow rater consultation in Step 2 (namely the public), improving validity. This is particularly important because a significant proportion of TAM research has been based on student populations. Subsequent completion of steps 1-6 of the paradigm avoids subjective 'cherry picking' of cognitive terms [51] and assumes the generation of a measure that is content or face valid [14]. Construct validity could then be assessed by a) correlating similar measures or b) confirmation of the scale behaving as predicted (e.g. can it predict an associated measure?). Correlation with connected constructs such as anthropomorphism should be assessed to ensure discriminant validity. The final step of developing norms would ensure BAM research extends beyond the Western demographics typically sampled, an important exercise since the role of culture has not been thoroughly explored and is likely to influence the development of TAM [10]. A scenario to illustrate the steps is detailed (indicated as red). For methods of statistical analysis to support each stage, refer to [14].

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Box 1. Scientific Theory of Animal Mind

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639   Peoples beliefs regarding the nature of mind are typically dualistic, with

640   mind and body being viewed as separate entities [57]. In contrast, scientists

641   working in areas relevant to animal cognition predominantly support theories

642   of materialism, in that all mental phenomena derive from the physical brain

643   [8]. Additionally, while most individuals consider mind as 'thoughts' or

644   'consciousness' [58], among academics, there is no universally agreed

645   definition of mind, animal-based or otherwise. In combination with the

646   currently limited understanding of neural correlates of cognitive traits, this

647   means empirical validation of mental states in animals is problematic [59],

648   although increasing use of modern techniques such as fMRI promises the

649   visualisation of neural states/activity such as consciousness [60,61].

650   Consequently, scientific views on animal mentality center on examination of

651   specific mental processes that are i) empirically measurable and ii)

652   considered meaningful components of human mind, thereby suggesting

653   comparable mental experiences when evidenced in nonhuman species. To

654   this end, a range of cognitive capacities have been investigated including tool

655   use (acknowledged in a range of species [62,63]), numeracy [64] and varying

656   forms of memory, with evidence of chimpanzees outperforming humans in

657   short term memory tasks [65] and facial recognition in sheep [66]. Indeed,

658   mounting evidence hints at unexpected abilities in long derided species such

659   as spiders, tortoises [67,68] and mice, which recent findings suggest might

660   experience ownership of their body parts (an aspect of self-consciousness)

661   [69]. Previously, notions of self-awareness among nonhumans have met with

662   resistance, particularly because only a few animals (e.g. chimpanzees,

663   dolphins, elephants) pass the 'mirror test', a gold standard for self-recognition

664   [70,71]. Similarly, when considering the emotional lives of animals, it is noted

665   that while the 'nature and range' of emotional experiences is debated, the

666   literature widely assumes their occurrence in animals [72]. And yet empathy,

667   although acknowledged in terms of emotional contagion or sensitivity to

668   conspecifics [73], is often disputed when defined at the level of perspective

669   taking [74] or related to Theory of Mind [75]. As such, many capacities

670   considered integral to human cognition are still contested in the literature e.g.

671   language, mental time-travel, relational reasoning or mentalising [72,76,77].

672   These views may also be bolstered by the historical accumulation of

673   experimental evidence (as a proxy for widely held scientific belief) favouring

674   particular animals e.g. primates or dogs [78], despite modern scientists

675   employing a range of models [79]. Hence, current scientific opinion remains

676   that animal mentality lies on a varied spectrum with only humans possessing

677   the combination of complex abilities and thoughts required to generate our

678   unique minds [80].

679

680   **Glossary:**

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682   **Anthropocentrism**: the belief that humans are the most important species in

683   existence and source of all value, resulting in the interpretation of reality

684   according to human values, needs and experience.

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686   **Anthropomorphism**: the attribution of 'uniquely' human characteristics to

non-human entities. Originally viewed as a hindrance to scientific methods, increasing understanding of animal cognition has generated issues in delineating anthropomorphism as the unjustified attribution of mental states vs. interspecies behavior recognition.

Churchill's Scale Development Paradigm: an 8-step framework for the systematic development of multi-item measurement scales when measuring latent constructs.

Cognitive Dissonance: a state of tension arising from inconsistent thoughts, beliefs, attitudes and actions.

Conspecifics: individuals that belong to the same species.

Construct: an abstract, psychological concept or variable that cannot be directly observed (latent) and exists independently of any resulting measurable phenomenon e.g. intelligence. Since constructs such as TAM represent psychological attributes that vary between individuals, operationalization of constructs should allow for participant involvement (participant-generated).

Encoding: the processing and conversion of perceived information into a form suitable for storage in memory.

Phylogenetics: the study and taxonomical classification of organisms based

on evolutionary relatedness. Proposed relationships between groups of organisms, inferred from similarities in genetic or physical attributes, are presented as a **phylogeny** or phylogenetic tree. For simplicity when investigating beliefs, animals are often presented as '**phylogenetic bands**' or classes e.g. mammals, birds, etc.

Reflective Measurement Model: a type of structural equation model that depicts the relationship between a latent, unobserved construct (e.g. personality) and its corresponding indicators within a measure.

Reliability: the degree to which an instrument measures a specified construct both across time (repeatability) and across scale items (consistency) e.g. test-retest reliability.

Simulation Theory: psychological theory of mind in which individuals use their own mind to model a targets mental state, to make inferences about a target.

Social Dominance: an individual's preferences for inequality and hierarchy among social groups, typically measured using the Social Dominance Orientation Scale.

Terror Management: psychological theory that individuals are motivated to manage the anxiety caused by awareness of death through investment in belief systems or culture that provide value and meaning.

Validity: the degree to which differences in observed scores on an instrument reflects true differences in the variable of interest. Validity may be confirmed by assessing the ability of an instrument to i) effectively and specifically measure the theorized latent construct (construct validity), ii) capture all facets of the construct's theoretical domain (content validity) and iii) differentiate between individuals in order to allow the predict future outcomes of a related variable (criterion validity).

Outstanding Questions

- What are the critical constructs that form TAM and in what way are these are odds with those held by the scientific community?

- Which mental attributes of animals are considered of greatest importance when judgments are made about how ethical it is to consume animals?

- How do specific cultural influences or practices affect the development of TAM?

- To what extent can TAM be considered a distinct psychological phenomenon rather than the byproduct of other processes such as anthropomorphism or adherence to cultural norms?

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- If high order mental faculties form the basis of moral worth, is anthropocentrism the dominant mechanism in disqualifying objections to the use of animals that are viewed as 'of mind'?

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Trends Box

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- Current evidence suggests widespread belief in the mental lives of animals, which has serious consequences for human-animal interactions.
- The scientific community has been slow to investigate the mechanism underlying our Theory of Animal Mind (TAM), due to oversimplification and limited objectivity.
- By expanding the study of TAM to encompass a richer multi-dimensional approach, it is possible to more accurately theorise and empirically validate investigations of TAM.

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