

# 1 **Opinion**

## 2 **Theory of Animal Mind: Human Nature or** 3 **Experimental Artefact?**

4  
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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

25           *“The difference in mind between man and the higher animals,*  
26           *great as it is, is certainly one of degree and not of kind.” [1]*

27

## 28 **Thoughts on Animal Thinking**

29

30           Scientific debate regarding the existence and nature of mental states in  
31 animals has a longstanding history [2,3] and covers an extensive range of  
32 topics from mirror recognition to numerosity (Box 1). Yet the majority of  
33 people form beliefs about animal minds based on everyday occurrences, such  
34 as when caring for pets [4] or consuming animal products. Understanding how  
35 people construct this “Theory of Animal Mind” (TAM) is therefore likely to  
36 reveal important insights, based on their experience and influence in relation  
37 to animals. Additionally, as a form of internal construal of other minds,  
38 examination of the psychological mechanisms generating TAM will likely have  
39 broad implications on account of behavior interpretation not being limited to  
40 human-animal relationships [5]. However, little research has been dedicated  
41 to exploring the basis on which mental abilities are attributed to nonhuman  
42 animals, despite few doubting the existence of animal mind [6,7].  
43 Furthermore, when directly questioned, people often substantiate their beliefs  
44 with explanations from personal experience or media sources [7]. As a result,  
45 it is highly unlikely that the psychological mechanisms that contribute to TAM  
46 are analogous to the reasoning used by scientific experts to support  
47 judgements on animal cognition [8]. This mismatch gives rise to several  
48 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,

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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374

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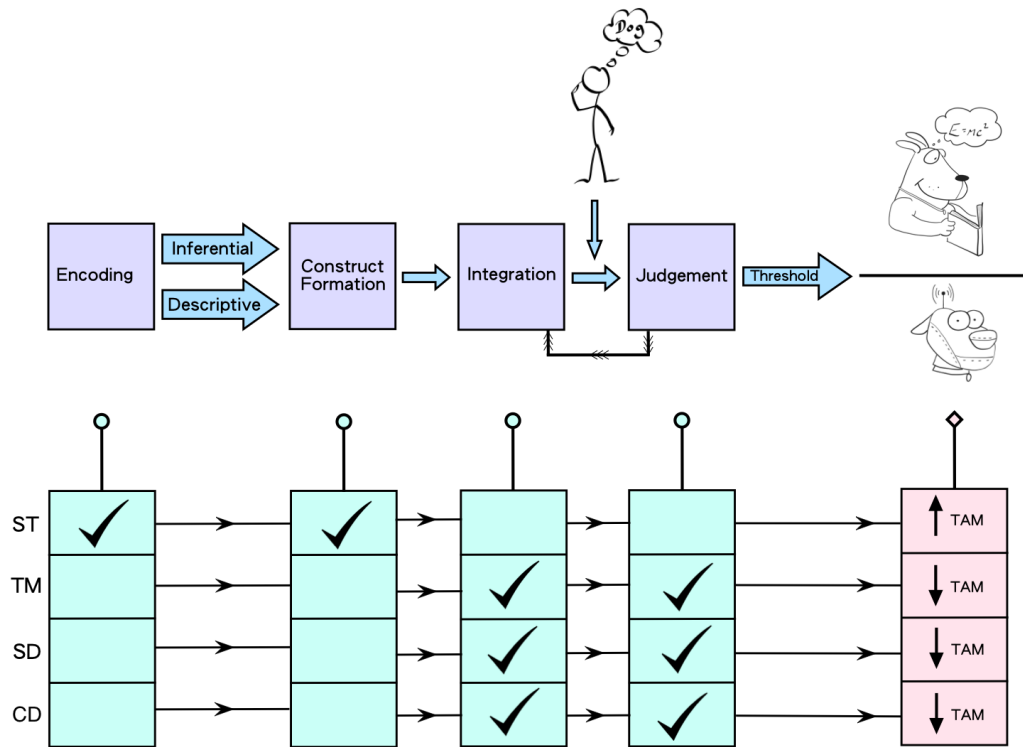
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573 **Fig. 1 Proposed Mechanism of Belief Formation underpinning Theory of**

574 **Animal Mind.** The proposed mechanism is conceptualised as a series of

575 connected components allowing relevant information to be perceived,

576 encoded, integrated and subsequently utilised when forming judgements on

577 the mindedness of non-human animals. Judgements are computed ‘online’

578 and represent confidence estimates of belief validity [15]. Formulated

579 judgements may be integrated into an individual’s bank of perceived

580 knowledge to be reused in future estimates. Each component of the

581 mechanism is susceptible to the influence of specified social theories (ST:

582 Simulation Theory, TM: Terror Management Theory, SD: Social Dominance

583 Theory, CD: Cognitive Dissonance Theory). For example, we propose that

584 simulation affects perception and encoding of information relevant to TAM

585 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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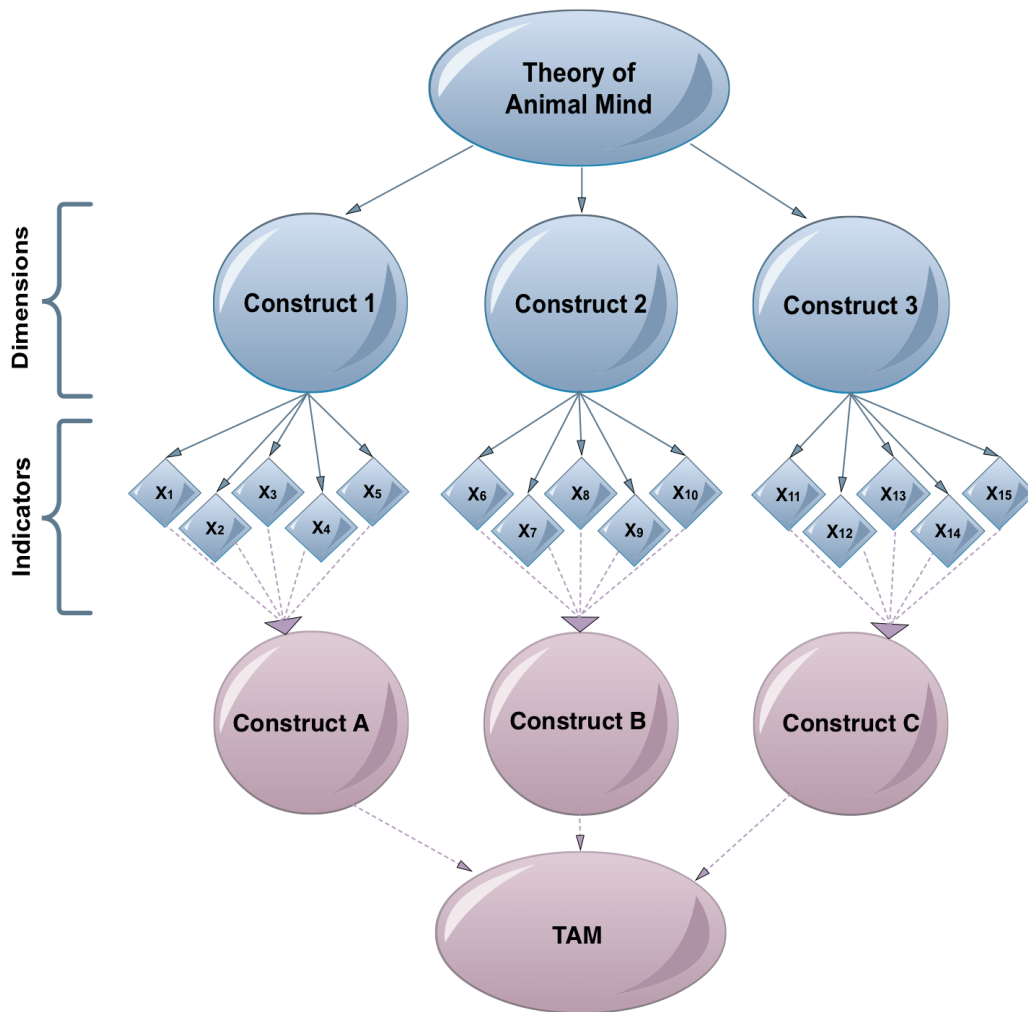
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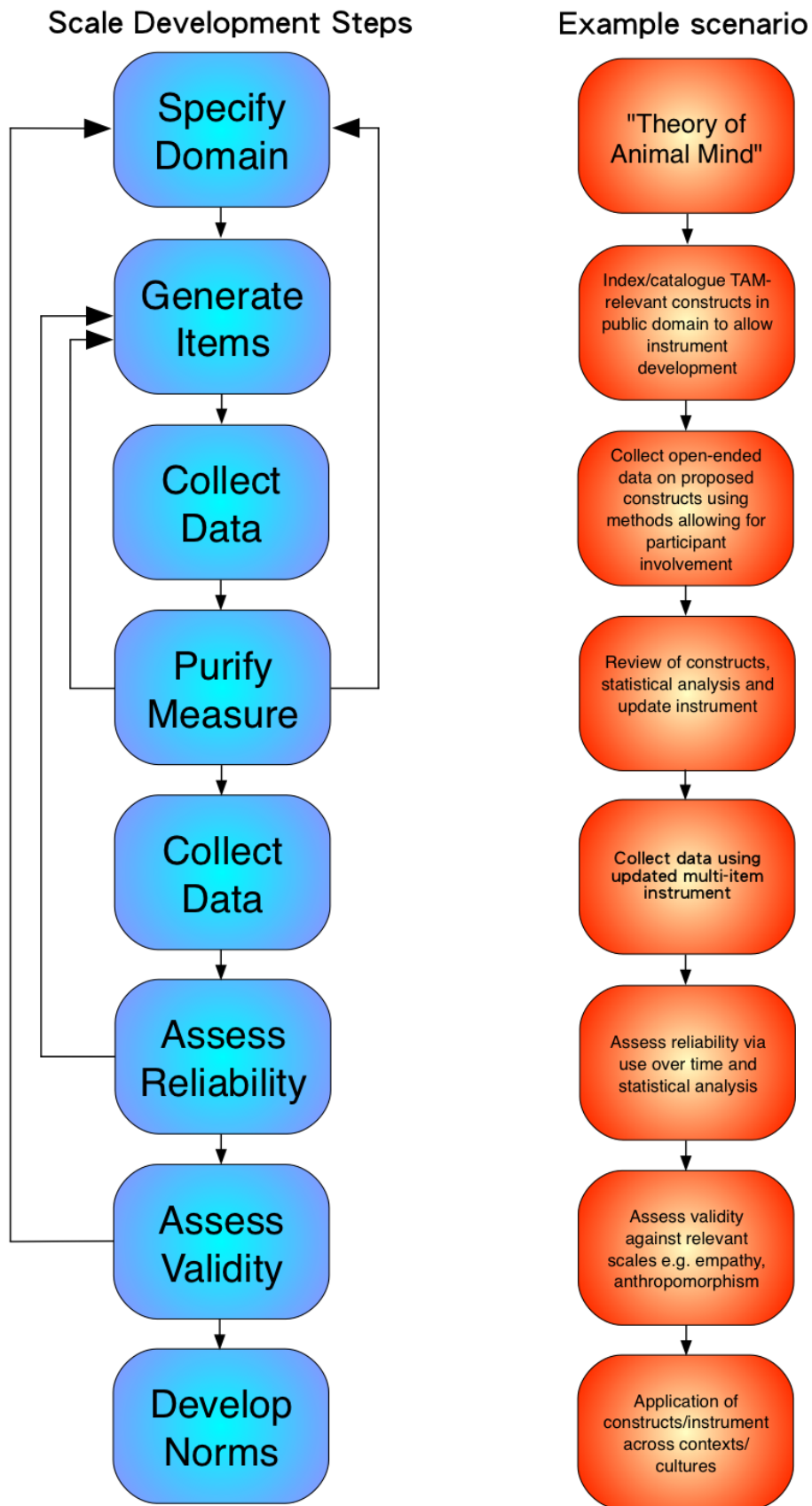
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600 **Fig. 2 Reflective Measurement Model depicting Theory of Animal Mind**  
 601 **as a multidimensional construct.** Within this model (indicated as blue),  
 602 mechanism of TAM is conceptualised as a second order, latent construct that  
 603 underlies multiple first order constructs (dimensions). Dimensions would be  
 604 expected to consist of mental traits considered attributes of mind e.g. agency  
 605 as seen in [35] (Note: this prediction, based on previous findings, would need  
 606 confirming as part of the process). Several specific indicators are used to  
 607 capture the constructs. The model acts to provide a way to both conceptualise  
 608 and investigate (indicated as purple) the initial stages of TAM development  
 609 i.e. construct formation.



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

636

637 **Box 1. Scientific Theory of Animal Mind**

638

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:**

681

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.

685

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

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

691

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

695

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

698

699 **Conspecifics:** individuals that belong to the same species.

700

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

707

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

710

711 **Phylogenetics:** the study and taxonomical classification of organisms based

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

717

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

721

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

725

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

729

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

733

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



737

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

745

746

747

#### 748 **Outstanding Questions**

749

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

752

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

756

757 • How do specific cultural influences or practices affect the development  
758 of TAM?

759

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

763  
764

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

768

769

770 **Trends Box**

771

772

773 • Current evidence suggests widespread belief in the mental lives of  
774 animals, which has serious consequences for human-animal  
775 interactions.

776 • The scientific community has been slow to investigate the mechanism  
777 underlying our Theory of Animal Mind (TAM), due to oversimplification  
778 and limited objectivity.

779 • By expanding the study of TAM to encompass a richer multi-  
780 dimensional approach, it is possible to more accurately theorise and  
781 empirically validate investigations of TAM.

782