



Commentary

Empirical tests of “Take-the-Best” with non-human subjects

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Abstract

The fast and frugal heuristics of ABC and rules of thumb of behavioural biologists represent strategies that humans and other animals might use to make decisions under time constraints and with a minimum of information. If experimental psychologists could demonstrate use of simple heuristics by non-humans in experimental settings, quantitative and empirical evaluation of those heuristics would benefit from additional formal, controlled avenues of study.

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In Simple heuristics and rules of thumb, where psychologists and behavioural biologist might meet, [Hutchinson and Gigerenzer \(2005\)](#) present a convincing argument that simple heuristics are fast and frugal to execute, as well as often perhaps surprisingly ecologically rational. Additionally, they provide a review of literature from human decision-making research and behavioural biology suggesting that humans and other animals can and do use simple heuristics in situations when those heuristics will be reasonably successful. This article has successfully delivered the integration between cognitive psychology and behavioural biology promised in its title.

One heuristic that has been subjected to particular empirical scrutiny is Take-the-Best (TTB), a lexicographic strategy that involves searching cues in a set

order, and deciding between options based on the first available distinguishing cue. TTB is a good candidate for evaluation because it is easy both to determine situations in which it is a viable strategy and to identify the choices it produces when used. Relevant studies with human subjects generally involve binary decisions based on several cues. The proportion of participants classified as TTB users is higher in situations where frugality is more advantageous due to cost of cue information ([Bröder, 2000](#); [Newell and Shanks, 2003](#)), time pressure and/or memory load ([Bröder, 2003](#); [Bröder and Schiffer, 2003](#)). [Hutchinson and Gigerenzer \(2005\)](#) suggest that animals might use TTB-type strategies when selecting a mate, deciding where to live or forage, or whether to fight. They point out that cue hierarchies in these circumstances may not be based exclusively on cue validity, and might be innate rather than learned.

It would, thus, be interesting to investigate whether non-human subjects use TTB in experimental settings where it is to their benefit to use it. Let us adopt the

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working hypothesis that animal subjects will use TTB in situations where it is an advantageous strategy, that is, non-compensatory situations where perfect use of TTB would yield the same decisions as multiple regressions. Assume that they rank cues based exclusively on validity. We will imagine that the subjects would have had enough exposure to the procedure to make TTB-based decisions and that they would be cognitively capable of doing so. This hypothesis leads to some interesting predictions.

A probabilistic criterion model of decision-making based on expected utility or energy budget predicts that if two cues in different non-compensatory situations have the same validities, their effect on the subject's behaviour will be equivalent, even if they fall in different places on their respective cue hierarchies. However, probability of reinforcement has been shown to be a poor predictor of the value of different response alternatives as assessed through transfer tests after baseline training (e.g., Belke, 1992; Williams, 1994; Williams and Royalty, 1989), which suggests that such two cues would not be treated equivalently. With a TTB strategy the predicted effect of the most valid cue is always the same, whatever its actual validity. Although there is nothing to directly confirm or disprove this idea as yet, findings to that effect would be consistent with rats' (Roper and Baldwin, 2004) and pigeons' (Roper and Zentall, 1999) indifference to discriminative versus non-discriminative stimuli when overall rates of reinforcement are the same, and would strongly suggest that animals can and do use TTB.

Still, there are unaddressed challenges to carrying out an empirical test of TTB with non-humans that could question the assumptions of this hypothesis. It could be complicated to arrange a procedure in which animals had equal experience with cues of differing validity, and it is not clear what effect frequency of exposure would have on cue hierarchy. At what point, if any, would a subject ignore a cue with higher validity but lower frequency of occurrence in favour of a less valid but more consistently available cue? In the section discussing how animals combine information from multiple cues, Hutchinson and Gigerenzer (2005) mention that in the wild, cue ranking might depend at least partially on the availability and biological cost of each cue; this could even paradoxically lead to ranking cues in increasing order of validity, presumably because complicated cues that take up time and resources

will be more accurate. Laboratory studies that systematically control for both the validity and frequency of cues could help to determine how animals rank cues and would be necessary if TTB were to be incorporated into any formal process model of decision-making.

A critical assumption of this hypothesis is that laboratory animals are capable of determining the relative validity of available cues and assessing whether their environment is non-compensatory. With human subjects, experimenters can explicitly establish cue hierarchy with verbal instruction or verify its use with questioning. Behavioural biologists can explain cue hierarchies in reasonably stable environments as having evolved through natural selection. Neither verbal instruction nor natural selection would be useful for laboratory animals; they would have to develop a cue hierarchy by estimating based on experience within the procedure. Such estimation might involve comparing tallies of correct predictions for each cue. Although animals are able to discriminate based on numerical attributes (e.g., Capaldi and Miller, 1988; Fetterman, 1993; Meck and Church, 1983), comparing tallies involves a degree of mathematical sophistication that non-primates may not possess, given that children do not develop it until approximately seven years of age (Sophian and Wood, 1997). Alternatively, estimation from a sample might be probabilistic, but that would make learning cue hierarchies susceptible to criticisms similar to those Hutchinson and Gigerenzer (2005) make of expected utility and other probabilistic models of decision-making.

Simple heuristics such as TTB have the same potential advantages for non-humans in experimental settings as they do for humans and other animals in 'real-world' situations, namely that they are fast and frugal to execute. Investigating non-human use of simple heuristics presents unique challenges regarding how animals might rank cues and identify 'ecologically-rational' environments. It could also provide opportunities for controlled studies of exactly when and how animals might use simple heuristics, as well as facilitate formalisation of predictive models of decision-making behaviour.

References

- Belke, T.W., 1992. Stimulus preference and the transitivity of preference. *Anim. Learn. Behav.* 20, 401–406.

- Bröder, A., 2000. Assessing the empirical validity of the “Take-the-Best” heuristic as a model of human probabilistic inference. *J. Exp. Psychol. Learn. Mem. Cogn.* 26, 1332–1346.
- Bröder, A., 2003. Decision making with the “adaptive toolbox”: influence of environmental structure, intelligence, and working memory load. *J. Exp. Psychol. Learn. Mem. Cogn.* 29, 611–625.
- Bröder, A., Schiffer, S., 2003. Take-the-Best versus simultaneous feature matching: probabilistic inferences from memory and effects of representation format. *J. Exp. Psychol. Gen.* 132, 277–293.
- Capaldi, E.J., Miller, D.J., 1988. Number tags applied by rats to reinforcers are general and exert powerful control over responding. *Quart. J. Exp. Psychol. Comp. Phys. Psychol.* 40, 279–297.
- Fetterman, J.G., 1993. Numerosity discrimination: both time and number matter. *J. Exp. Psychol. Anim. Behav. Proc.* 19, 149–164.
- Hutchinson, J.M.C., Gigerenzer, G., 2005. Simple heuristics and rules of thumb; where psychologists and behavioural biologists might meet. *Behav. Proc.* 69, 97–124.
- Meck, W.H., Church, R.M., 1983. A mode control model of counting and timing processes. *J. Exp. Psychol. Anim. Behav. Proc.* 9, 320–334.
- Newell, B.R., Shanks, D.R., 2003. Take-the-Best or look at the rest? Factors influencing “one-reason” decision making. *J. of Exp. Psychol. Learn. Mem. Cogn.* 29, 53–65.
- Roper, K.L., Baldwin, E.R., 2004. The two-alternative observing response procedure in rats: preference for non-discriminative stimuli and the effect of delay. *Learn. Motiv.* 35, 275–302.
- Roper, K.L., Zentall, T.R., 1999. Observing behavior in pigeons: the effect of reinforcement probability and response cost using a symmetrical choice procedure. *Learn. Motiv.* 30, 201–220.
- Sophian, C., Wood, A., 1997. Proportional reasoning in young children: the parts and the whole of it. *J. Educ. Psychol.* 89, 309–317.
- Williams, B.A., 1994. The role of probability of reinforcement in models of choice. *Psychol. Rev.* 101, 704–707.
- Williams, B.A., Royalty, P., 1989. A test of the melioration theory of matching. *J. Exp. Psychol. Anim. Behav. Proc.* 15, 99–113.