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Simple heuristics and rules of thumb: Where psychologists and behavioural biologists might meet

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Abstract

The Centre for Adaptive Behaviour and Cognition (ABC) has hypothesised that much human decision-making can be described by simple algorithmic process models (heuristics). This paper explains this approach and relates it to research in biology on rules of thumb, which we also review. As an example of a simple heuristic, consider the lexicographic strategy of Take The Best for choosing between two alternatives: cues are searched in turn until one discriminates, then search stops and all other cues are ignored. Heuristics consist of building blocks, and building blocks exploit evolved or learned abilities such as recognition memory; it is the complexity of these abilities that allows the heuristics to be simple. Simple heuristics have an advantage in making decisions fast and with little information, and in avoiding overfitting. Furthermore, humans are observed to use simple heuristics. Simulations show that the statistical structures of different environments affect which heuristics perform better, a relationship referred to as ecological rationality. We contrast ecological rationality with the stronger claim of adaptation. Rules of thumb from biology provide clearer examples of adaptation because animals can be studied in the environments in which they evolved. The range of examples is also much more diverse. To investigate them, biologists have sometimes used similar simulation techniques to ABC, but many examples depend on empirically driven approaches. ABC's theoretical framework can be useful in connecting some of these examples, particularly the scattered literature on how information from different cues is integrated. Optimality modelling is usually used to explain less detailed aspects of behaviour but might more often be redirected to investigate rules of thumb.

Keywords: Animal cognition; Cognitive ecology; Cue integration; Ecological rationality; Fast and frugal heuristic; Multiple cues; Optimality modelling; Rule of thumb; Take The Best

1. Introduction

We both work in a research group called the Centre for Adaptive Behaviour and Cognition (ABC). Its main research topic is the cognitive mechanisms by which humans make decisions. We call these mechanisms *heuristics* and our thesis is that rather simple heuristics both work surprisingly well and are what humans

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widely use. Simple heuristics correspond roughly to what behavioural biologists call rules of thumb. Our aim in this paper is to relate ABC's research to biological research on behaviour. One of us (GG) is the director and founder of ABC, and, like most of the group, is a psychologist by training; the other (JMCH) is a behavioural ecologist who has worked in ABC for the last four years.

For a more thorough review of ABC's results and outlook, read the book *Simple Heuristics that Make Us Smart* (Gigerenzer, Todd and the ABC Research Group, 1999). Another book *Bounded Rationality: The Adaptive Toolbox* (Gigerenzer and Selten, 2001) provides more of a discourse between ABC and other researchers. In the current paper, we seek to identify where behavioural biologists and ABC have used similar approaches or arrived at similar results, but also to clarify exactly where the two schools disagree or diverge on tactics. We thus hope to discover ways in which each discipline might learn from the other; we try to be open about potential limitations of ABC's approach. This paper is written to inform both biologists and psychologists.

Before making more general points we start by giving some examples of the simple heuristics that ABC has studied, and then some examples of rules of thumb from biology. These will convey better than any definition the range of phenomena to which these terms are applied. The succeeding sections will deal more systematically with the principles behind ABC's research, and contrast its techniques and findings with those from research on animal rules of thumb.

2. Examples of fast and frugal heuristics in humans

2.1. Take The Best

Consider the task of which of two alternatives to choose given several binary cues to some unobservable criterion. An example is deciding which of two cities is the bigger, given such cues as whether each has a university or has a football team in the premier league. Gigerenzer and Goldstein (1996) proposed the following decision mechanism: (1) consider one cue at a time, always looking up the cue values for both alternatives; (2) if both cue values are identical examine the next cue, otherwise ignore all other cues and make a decision on the basis of this single cue; (3) if no cues are left to examine, guess. Such a process is called lexicographic because it resembles the obvious way to arrange two items into alphabetical order: first compare the first letters and only if they are identical consider the next letter. A hypothetical biological example might be a male bird that compares itself with a rival first on the basis of their songs; if the songs differ in quality the weaker rival leaves, and only otherwise do both remain to compare one another on further successive cues, such as plumage or display.

We have not yet specified the order in which cues are examined. Intuitively it makes sense to try to look up the more reliable cues first, and also those that are most likely to make a distinction. Gigerenzer and Goldstein (1996) proposed to rank cues by validity; validity is defined as the proportion of correct inferences among all inferences that this cue, if considered in isolation, allows (a tie does not allow inference). With this cue order, the heuristic has been named Take The Best. This order might have been individually estimated from a sample, or learned by instruction, or have evolved by natural selection.

Amazingly, the predictive accuracy of this heuristic, judged on a real-world dataset about German cities, was about equal to, or better than, that of multiple regression (Fig. 1; Gigerenzer and Goldstein, 1999, p. 93). Fig. 1 further compares the performance of Take The Best against two computationally sophisticated algorithms that also each construct a decision tree (H.J. Brighton, personal communication). Especially, when the "learning" sample of cities used to construct the trees is small, Take The Best nearly always outperforms these methods in accurately comparing sizes of the remaining cities (i.e. in cross-validation). Chater et al. (2003) have performed a slightly different analysis for other sophisticated algorithms, including a three-layer feedforward neural network, and observed a similar pattern. These are surprising and striking results, especially as at least the comparison against multiple regression holds in 19 other such real-world comparison tasks besides the original city-size example (Czerlinski et al., 1999).

Take The Best is fast to execute and frugal in the information used, since usually not all cues are exam-