Available online at www.sciencedirect.com
SCIENCE DIRECT
Cognitive Psychology 52 (2006) 195–242
Cognitive Psychology
www.elsevier.com/locate/cogpsych

Suboptimal tradeoffs in information seeking

Wai-Tat Fu [a,*], Wayne D. Gray [b]

[a] *Carnegie Mellon University, USA*
[b] *Rensselaer Polytechnic Institute, USA*

Accepted 12 August 2005
Available online 13 December 2005

Abstract

Explicit information-seeking actions are needed to evaluate alternative actions in problem-solving tasks. Information-seeking costs are often traded off against the utility of information. We present three experiments that show how subjects adapt to the cost and information structures of environments in a map-navigation task. We found that subjects often stabilize at suboptimal levels of performance. A Bayesian satisficing model (BSM) is proposed and implemented in the ACT-R architecture to predict information-seeking behavior. The BSM uses a local decision rule and a global Bayesian learning mechanism to decide when to stop seeking information. The model matched the human data well, suggesting that adaptation to cost and information structures can be achieved by a simple local decision rule. The local decision rule, however, often limits exploration of the environment and leads to suboptimal performance. We propose that suboptimal performance is an emergent property of the dynamic interactions between cognition and the environment.

Keywords: Problem solving; Adaptive search; Information seeking; Suboptimal tradeoffs; Satisficing, Bayesian learning; ACT-R; Cognitive modeling; Sequential decision making

1. Introduction

Consider a person deciding which route to take to go from one city to another. The person may be seeking information about traffic conditions of various routes. Since each information-seeking action takes time, tradeoffs are often made as exhaustive information seeking may be too costly to be justified. The person may decide to stop seeking

* Corresponding author.
E-mail address: wfu@cmu.edu (W.-T. Fu).

0010-0285/$ - see front matter © 2005 Elsevier Inc. All rights reserved.
doi:10.1016/j.cogpsych.2005.08.002

information when a reasonably good route is found, and he believes that the utility (i.e., usefulness) of checking the traffic condition of the next route is unlikely to justify the cost of the next information-seeking action (Stigler, 1961). The problem of when to stop seeking information is quite common. For example, doctors need to know when to stop performing diagnostic tests to decide on a treatment, as testing cannot be carried out indefinitely. Similarly, chess players need to decide when to stop evaluating alternative moves as it is almost impossible to evaluate all possible moves. These are but instances of a general decision problem, in which the decision-maker has to decide when to stop seeking information by trading off the cost of information-seeking actions against the utility of the information being sought. In the domain of Artificial Intelligence, numerous algorithms have been proposed that optimize the solution path by minimizing search costs. Such algorithms, however, often require extensive computations that make them psychological implausible. The goal of this article is to study the degree to which people are able to adapt their information seeking to the cost-structure of their task environment; and to understand the circumstances under which this adaptation may plateau at suboptimal levels.

2. Information seeking as the interface between cognition and the environment

Most distal properties of the environment (such as the utility of information) cannot be directly perceived (Brunswik, 1952; Fiedler, 2000). Rather, these distal properties have to be inferred from proximal information obtained from dynamic interactions of the person and the environment. Information-seeking actions can be considered a major form of these cognitive-environment interactions, as the purpose of these information-seeking actions is to obtain samples from the environment so that certain distal properties of the environment can be inferred. Actions are then selected based on the person's cognitive representation of these distal properties. In the route-finding example above, each information-seeking action allows the person to update his or her knowledge of the traffic conditions of possible routes, which allows the person to make a better decision on which route to take. The amount of information obtained therefore indirectly influences performance. Ideally, perfect performance can be attained when the person has complete knowledge of the environment. But in most situations, the information-seeking costs prevent exhaustive search of information. In this article, we study the adaptiveness of this kind of information-seeking behavior. In particular, we focus on how people are able to tradeoff the cost against the utility of information adaptively. The tradeoff may not be fully under the person's cognitive control, and our goal is to characterize the cognitive processes underlying the tradeoff. To preview our conclusions, we find that suboptimal tradeoffs are often a natural consequence of the dynamic interactions between cognition and the environment.

3. Tradeoffs between information-seeking costs and utility of information

In finding a fast route to another city, both costs and utility of information can be cast in the dimension of time: information-seeking costs will be high when they take more time, and information utility will be high when the information is able to lead to a route that takes less time. One can then measure performance by the total costs required to finish the task (the lower the cost the better the performance). The total costs can be calculated as