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Naturalistic multiattribute choice☆

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ABSTRACT

We study how people evaluate and aggregate the attributes of naturalistic choice objects, such as movies and food items. Our approach applies theories of object representation in semantic memory research to large-scale crowd-sourced data, to recover multiattribute representations for common choice objects. We then use standard choice experiments to test the predictive power of various decision rules for weighting and aggregating these multiattribute representations. Our experiments yield three novel conclusions: 1. Existing multiattribute decision rules, applied to object representations trained on crowd-sourced data, predict participant choice behavior with a high degree of accuracy; 2. Contrary to prior work on multiattribute choice, weighted additive decision rules outperform heuristic rules in out-of-sample predictions; and 3. The best performing decision rules utilize rich object representations with a large number of underlying attributes. Our results have important implications for the study of multiattribute choice.

1. Introduction

Most choices that people make on a day-to-day basis can be seen as involving objects defined on two or more attribute dimensions. These choices involve trading off the relative values of the component attributes, so as to select the object whose attributes are, overall, the most desirable (Keeney & Raiffa, 1993). The study of these types of multiattribute choices is a key topic of inquiry across numerous fields, where scholars attempt to develop theories to predict individuals' multiattribute choices, as well as the relationship between these choices and various psychological, biological, and socio-economic variables (Hastie, 2001; Oppenheimer & Kelso, 2015; Weber & Johnson, 2009).

There is a disconnect between the way in which multiattribute choices are currently studied, and the way in which these choices are often made. Nearly all multiattribute choice experiments explicitly present choice objects and their attributes to participants in a matrix of numerical quantities (see Ettlin, Bröder, & Henninger, 2015 for a summary). For example, participants may be given a choice between two hypothetical phones with each phone being described in terms of its memory, its processing speed, and its screen size. This choice would be shown in a simple 3×2 attribute-by-object matrix (e.g. Fig. 1a). Although some consumer decisions do involve the evaluation of a small set of explicitly presented and quantified attributes, many other common decisions – involving, for example, movies to watch or food items to eat – do not. The objects in these common decisions may be listed using only their names (without any attribute information), but the underlying attribute structure is typically very rich and complex (e.g. Fig. 1b). Decision makers do often have knowledge about these objects and their underlying attributes, but this knowledge is represented in the decision makers' minds after having been learnt through prior experience with the choice domain.

The divergence between the highly stylized stimuli used in current research and the complex multiattribute objects often involved in real-world settings is problematic. Choice processes and resulting behaviors depend greatly on the ways in which attributes and objects are presented. For example, altering attribute-by-object matrices, by displaying the objects separately rather than side-by-side, can reverse certain behavioral patterns (Bettman & Kakkar, 1977; Kleinmuntz & Schkade, 1993). Making some attributes more salient by altering the order in which they are displayed in the matrices can also have a powerful effect on behavior (Levav, Heitmann, Herrmann, & Iyengar, 2010; Russo, Medvec, & Meloy, 1996). Similarly, presenting information verbally instead of numerically can lead to different decision strategies and subsequently different choices (Stone & Schkade, 1991). There is also a well-documented difference between memory-based and stimuli-based decisions, and decision makers are known to use different choice processes when retrieving attribute information from memory vs. when using attribute information presented explicitly during the

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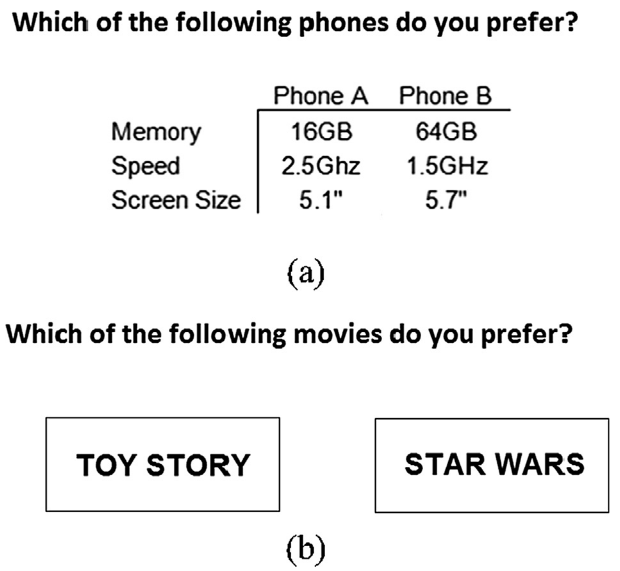

Fig. 1. (a) A typical attribute-by-object matrix presentation for a choice between two phones. (b) The type of naturalistic decision studied in this paper.

choice task (Lynch, Marmorstein & Weigold, 1988; Lynch & Srull, 1982; Rottenstreich, Sood & Brenner, 2006). This sensitivity to presentation and choice format suggests that real-world decisions, which seldom involve actual attribute-by-object matrices, may be different to the types of decisions observed in current experimental work. Indeed, some scholars have suggested that multiattribute choice effects documented in the laboratory with artificial stimuli do not emerge in more naturalistic settings (see, e.g., Frederick, Lee, & Baskin, 2014).

The divergence between experimental research and naturalistic multiattribute choice also impedes theory development. By using artificial designs in which the attributes of objects are directly presented to decision makers, existing theoretical work has largely ignored the role of object representation. Storing, retrieving, and processing attribute information about the objects in a given choice problem is a pivotal part of the decision process, and a complete account of choice requires an approach that is able to specify the mechanisms involved at this stage in the decision, as well as the relationship between these mechanisms and the final outcomes of the decision. Of course a theory of object representation in multiattribute choice need not be completely novel: It can adopt existing insights regarding object and concept representation in semantic memory research, and combine these insights with common decision rules studied in multiattribute decision research. Such a theory would not only extend the descriptive scope of decision research, but would also help integrate two important areas of inquiry in psychology.

However, there is a significant methodological issue involved in studying multiattribute choice with naturalistic objects. Computational and mathematical theories of choice can make predictions and be tested only when underlying objects and attributes are quantified. However, unlike the attributes of object used in existing choice experiment (e.g., those in Fig. 1a), the attribute of common choice objects (e.g., those in Fig. 1b) are not directly observable. Although participants may know the underlying attributes of common choice objects, and use these attributes to make every-day multiattribute decisions, researchers do not currently have a way of uncovering and quantifying the precise attribute compositions of objects. Thus in addition to developing a theory of object representation in everyday multiattribute choice, it is also necessary to develop practical techniques to apply this theory to actual choice data obtained from experimental and field settings.

The goal of this paper is to address these theoretical and methodological challenges. We begin by examining how common choice objects can be represented. Here we build upon insights in semantic memory research, which suggest that people use latent attribute spaces for representing common non-choice objects and concepts (e.g., Landauer & Dumais, 1997; Shepard, 1962). We argue that these insights can be extended to everyday multiattribute choice, with decision makers using the distribution of observable features across objects to obtain a large number of latent attributes for representing the choice objects in the environment. Furthermore, we propose that it is these latent attributes that are evaluated and aggregated during the decision process. This evaluation and aggregation can be modelled using the types of existing decision rules already used to describe choice behavior in decision making research (e.g. Gigerenzer & Gaissmaier, 2011; Keeney & Raiffa, 1993; Payne, Bettman, & Johnson, 1993; Shah & Oppenheimer, 2008).

We also consider computational techniques for uncovering the latent attribute representations of common choice objects. We propose that crowd-sourced keywords, tags, and other natural language descriptors for choice objects on internet websites, can be considered suitable proxies for the observable features of these objects. For a sufficiently rich online dataset, it is possible to train semantic models and learn the latent attribute representations for the objects in a choice environment, and subsequently examine peoples' choices between these objects. To demonstrate this idea, we give experimental participants naturalistic choices between different movies (Studies 1 and 4) and between different foods (Studies 2 and 3). We attempt to predict these choices using multiattribute choice rules applied to latent attribute representations trained on crowd-sourced data from websites like www.IMDB.com and www.AllRecipes.com.

2. Object representation

Imagine a choice between watching *Toy Story* and *Star Wars.* This choice does not only involve evaluative processes for comparing the two movies, but also semantic memory processes for representing the movies and knowing what the movies actually are. In order to understand how people may make these types of choices we need to study the cognitive basis of the mental representations of choice objects, as well as the ways they are integrated into evaluative choice processes during the decision.

Although the issue of representation is not often addressed in multiattribute decision research (but see Hastie, 2001 for a discussion), it has received much attention in others areas of cognitive psychology, particularly semantic memory research. The relevant object and concepts studied in this area are often described in terms of features that the objects possess (Estes, 1950; Garner, 1978; Smith & Medin, 1981; Tversky, 1972, 1977). The number of observable features possessed by a given object can be very large, making it difficult to manipulate and utilize feature-based representations. Thus individuals represent common objects and concepts using latent attributes, which they recover by performing a low-dimensional mapping on the observable feature space.

Consider, for example, a child exposed to different animals and plants (e.g., *robin*, *salmon*, *rose*), each with a different set of observable features (e.g., *wings*, *fins*, *thorns*). By examining the distributional structure of the features across objects, the child can uncover a set of latent dimensions (possibly resembling categories like *animal, fish, plant, flower*) that define this feature space. These dimensions, or attributes, can be then be used for a variety of cognitive tasks, including categorization, feature induction, object recognition, language use and comprehension, similarity judgment, as well as sophisticated reasoning and inference.

Such representations can be uncovered through techniques with varying statistical interpretations, and techniques applied to a diverse range of stimuli and training data. For example, multi-dimensional scaling (Shepard, 1962, 1980) passes pairs of similarity ratings through a matrix decomposition algorithm, resulting in the recovery of latent attributes that best describe the structure of similarity (i.e. featural proximity) for a given domain. Recently, Nosofsky and coauthors