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Tailoring value elicitation to decision makers' numeracy and fluency: Expressing value judgments in numbers or words

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ABSTRACT

In organizational settings, options evaluation requires managers to express value judgments on multiple criteria. This research investigates the influence of decision makers' numeracy (ability to use appropriate numerical principles) and fluency (ability to express oneself in words) on their subjective experience of value elicitation as supported by two different techniques: direct rating and MACBETH. The former asks for value judgments to be expressed numerically, the latter non-numerically. The results of our experiment indicate that the two techniques are not psychologically equivalent: decision makers with higher numeracy express values more easily when assisted by the numerical technique whereas decision makers with higher fluency find value elicitation easier with the non-numerical technique. These findings highlight the importance of tailoring value elicitation to decision makers' numeracy and fluency. Implications for decision scientists and analysts are discussed.

1. Introduction

Interest in multi-criteria decision analysis increased as the sphere of application of quantitative management science moved from operational decision making situations, for which a more-or-less well-defined single objective function could be identified with little controversy (e.g., maximize profit), to more complex levels of managerial planning and decision making, which are naturally multi-dimensional problems (in p. 30 of [1]). This has also been recognized in engineering [2]. In organizations, the pressure to make defensible value judgments heightens the importance of a consistent approach to elicitation of preferences [3]. Indeed, managers continuously face the task of expressing, and justifying, judgments about the relative attractiveness or value of several options at the level of each criterion individually. For unaided individuals, this process is challenging and sometimes even arbitrary [4]. To assist them, decision analysts often use multicriteria value methods, which are extensively reviewed in the decision analysis literature [3,5–8]. Goodwin and Wright provide a simple and intuitive example of a managerial office location problem to illustrate the usefulness of different techniques to elicit value judgments (from p. 33, on Chs. 3 and 4 of [7]).

Experimental research in the management science literature has shown that these techniques to elicit value judgments appeal differently to decision makers (see, for example, [9,10]). This notion has been flagged by Larichev and Brown [11] who suggested (but did not experimentally assess) that preference for verbal versus numerical aiding techniques is a matter of decision analysts' habit and expertise, as well as decision makers' education.

Here, we conduct a behavioral experiment to examine the extent to which decision makers' numeracy and verbal fluency impact their perception and preferences for two different value-elicitation techniques, one numerical and one non-numerical. In our experiment we use a laptop choice problem to compare the numerically based direct rating technique used in the Simple multi-attribute rating technique, or SMART approach [12,13] and the non-numerical Measuring Attractiveness by a Categorical-Based Evaluation Technique (MACBETH) [14–16]. These two have been widely applied in public and private managerial and engineering settings (see examples [17–22]) and complex policy frameworks [23–27]. Moreover, they are of particular interest because on the one hand they are "technically equivalent": they are found on the same principles of value-difference measurement [8], both aim at scoring the options on an interval scale of measurement and for this purpose both require comparison of intervals of value during the elicitation process. Interval value scales are quantitative representations of preferences and reflect not only the order of attractiveness of the options, but also differences in their relative attractiveness, or in other words, the strength of the decision maker's preferences for one option over another. On the other hand, the questioning procedures of the two techniques differ: using SMART the analyst asks decision makers

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to produce direct *numerical* representations of their preferences, MACBETH asks for *non-numerical* pairwise comparisons of differences in value. This distinction might matter "where decision makers have problems in directly assigning the numerical scores required by SMART" [7] (p. 86). Elaborating this point, we explore these two techniques and show that they are not psychologically equivalent; that is, they are not perceived and experienced in the same manner by decision makers. We test whether this differential experience is linked to their ability to use appropriate numerical principles ("numeracy", [28]) and to produce words also ("fluency").

The rest of this paper is structured as follows. First we describe both techniques, in the context of the choice example used in our experiment. Then we review recent behavioral decision research on links between numeracy and decision making, which provides the theoretical basis for our empirical research. Next, we test these expectations by means of an experiment. We conclude with a general discussion and implications for decision scientists and analysts.

2. Two value elicitation techniques

2.1. Choice example

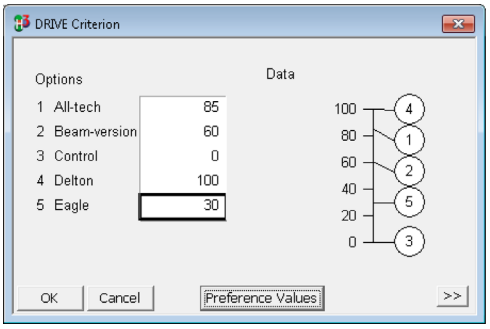
Imagine you are shopping for a laptop for your own personal use. You have the choice of several, including laptop Control, with a CD-R drive, and laptop Delton, with a combination DVD-RW and CD-RW drive. You value the ability to read and write CDs, and if possible to view DVDs, but how exactly do you express your preference for the drive of laptop Delton over that of laptop Control?

2.2. Numerical value-elicitation technique

The numerical direct-rating technique would require you to assign to each laptop a numerical value according to your relative preference for its drive, for instance, from 0 (the value score of the least preferred drive) to 100 (the score of the most preferred drive). According to the drive preferences stated above, you would then assign 0 to the drive of laptop Control and 100 to the drive of laptop Delton. Any other option would be directly assigned an intermediate score, according to the perceived difference in value from the laptop drives already scored, and such that intervals of equal size carry the same difference of score. The value scale constructed in Fig. 1 illustrates this: the improvement perceived by the decision maker when upgrading from computer Control to Eagle (30 value points) would be the same as the improvement felt when upgrading from computer Eagle to Beam version (another 30 points). Good practice requires analysts to perform "a number of consistency checks" [8] (p. 228).

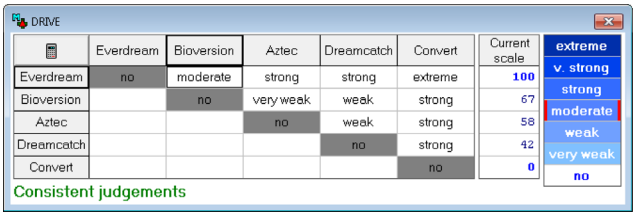
2.3. Non-numerical value-elicitation technique

A different technique would be to judge non-numerically the difference in value you perceive between the drives of different laptops, two at a time: is there no difference, or is the difference very weak, weak, moderate, strong, very strong, or extreme? MACBETH relies on such a pairwise comparison technique. For instance, the difference in attractiveness between the drives of Everdream and Bioversion (see Fig. 2) is judged to be "moderate". MACBETH uses a mathematical programming algorithm to derive scores for the laptops from the set of qualitative judgments [29] (for simple cases, the scores can be obtained by hand using a straightforward procedure [16]). Hereafter, MACBETH will be referred to as the non-numerical technique.



Attribute	Laptops				
	All–Tech	Beam–Version	Control	Delton	Eagle
Drive	CD-R DVD-RW	CD-RW DVD-R	CD-R	CD-RW DVD-RW	CD-R DVD-R

Fig. 1. Illustration of numerical technique (top panel) and the options' raw feature values (bottom panel).



Attribute	Laptops				
	Aztec	Bioversion	Convert	Dreamcatch	Everdream
Drive	CD-RW DVD-R	CD-R DVD-RW	CD-R	CD-R DVD-R	CD-RW DVD-RW

Fig. 2. Illustration of non-numerical technique (top panel) and options' raw feature values (bottom panel).

2.4. Psychologically equivalent techniques?

In the experience of decision analysis practitioners, the two techniques are not equally accepted by users—the numerical and non-numerical techniques can be wholeheartedly rejected by some and endorsed by others [30]. This suggests that the two techniques—although technically equivalent—might not be psychologically equivalent, but there is no experimental evidence for this perceived difference in the decision sciences literature. We hope to rectify this with the current study.

3. Behavioral literature on decision making and numeracy

3.1. Expressing one's values in numbers versus words

In the context of consumer research, Viswanathan and Childers [31] found experimentally that the specific forms in which numerical and verbal information about products are presented drive how this information is processed by consumers. These researchers have studied differences in preferences for numerical versus verbal information, but not differences in preferences for expressions of value which is the focus of this paper.

The question of which format—numbers or words—decision makers prefer to use to express a *belief* about the world has been addressed by behavioral researchers in the domain of probability judgment. Expressing probabilities as numbers rather than words has been suggested to be preferable because of the numbers'