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UT Biomedical Informatics Lab (BMIL) probability wheel

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Abstract

A probability wheel app is intended to facilitate communication between two people, an "investigator" and a "participant", about uncertainties inherent in decision-making. Traditionally, a probability wheel is a mechanical prop with two colored slices. A user adjusts the sizes of the slices to indicate the relative value of the probabilities assigned to them. A probability wheel can improve the adjustment process and attenuate the effect of anchoring bias when it is used to estimate or communicate probabilities of outcomes. The goal of this work was to develop a mobile application of the probability wheel that is portable, easily available, and more versatile. We provide a motivating example from medical decision-making, but the tool is widely applicable for researchers in the decision sciences.

Keywords: Probability wheel; Mobile application; Decision-making; Preference elicitation; Probability estimation; Cognitive biases

Code metadata

Current Code version	1.6
Permanent link to code/repository used of this code version	https://github.com/ElsevierSoftwareX/SOFTX-D-16-00028
Legal Code License	*MIT*
Code Versioning system used	*Git*
Software Code Language used	*Java, Swift*
Compilation requirements, Operating environments & dependencies	*iOS version requires OS X and XCode to compile, Android requires Eclipse with ADT*
If available Link to developer documentation/manual	https://github.com/UTBiomedicalInformaticsLab/ProbabilityWheelAndroid/blob/master/ProbabilityWheelInstallation.pdf https://github.com/UTBiomedicalInformaticsLab/ProbabilityWheeliOS/blob/master/ProbabilityWheelInstallation.pdf
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Software metadata

Current software version	1.6
Permanent link to executables of this version	https://github.com/ElsevierSoftwareX/SOFTX-D-16-00028
Legal Software License	*MIT*
Computing platform / Operating System	*Android, iOS*
Installation requirements & dependencies	*iOS verison requires OS X and XCode. Android requires the Eclipse with ADT bundle or can directly install Demo1.apk*
If available Link to user manual - if formally published include a reference to the publication in the reference list	*n/a*
Support email for questions	utbmil@gmail.com

1. Introduction

It is generally easier to elicit preferences when there are few options. For example, if a dog is the only pet available, then a person only has to state the extent to which he or she prefers dogs to no pets. On the other hand, it is more challenging to quantify how much one prefers pugs vs. huskies vs. corgis. Likewise, estimating probabilities when there are only two possible outcomes is less complicated although people are usually not good at it [1]. One can estimate the probability that another person will adopt a dog vs. will not adopt a dog. However, as the number of possibilities increases, it becomes more difficult to assess probabilities—it is more difficult to estimate how likely another person will choose pugs vs. huskies vs. corgis. Moreover, cognitive limitations can introduce bias into people's estimates, and all people, even experts, are subject to cognitive biases [2]. People generally like to assign probabilities rounded to the nearest multiple of five (e.g. when determining whether someone will choose to adopt a dog or not have a pet, it is more likely for people to state "adopt a dog with probability 75% and not adopt a dog with probability 25%" rather than "adopt a dog with probability 72% and not adopt a dog with probability 28%"). This is not only because the former is easier to add (people's cognitive tendency to reduce a task's complexity) [2], but also because of the anchoring bias (the tendency to choose an initial value and then make incremental adjustments) [3]. Unfortunately, the anchoring bias often leads to systematic errors because different anchoring values can yield different results and adjustments are typically insufficient to reflect reality. Factors that can influence the amount of adjustment are: (1) the perceived relevance of the anchor to the judgment, (2) beliefs about the degree of error of the anchor, (3) ambiguity and uncertainty associated with the anchor, and (4) resolution of the representational scale [4]. Hence, methods, tools, and aids have been developed to improve the adjustment process and attenuate the effect of anchoring bias. One such tool is the probability wheel [5]. Traditionally, a probability wheel is a mechanical prop with two differently-colored slices representing the probabilities of two complementary events. Visualization via a probability wheel makes it easier for the user to adjust the magnitudes of the event probabilities. A probability wheel can reduce the influence of anchoring bias because the person using it focuses on the task of adjusting options' proportions instead of worrying about calculating each option's numerical values and/or being influenced by numerical figures [6].

The goal of this work was to develop a mobile application of the probability wheel that is portable, easily available, and more versatile. Our motivation to develop a probability wheel app arose from our experiences studying decision-making about breast reconstruction surgery. In a previous study to elicit women's preferences about breast reconstruction, we used a probability wheel to help reduce cognitive load and biases, but the process was cumbersome for the reasons discussed in the subsequent paragraph [7]. Estimating probabilities and eliciting preferences is even more challenging in the context of such medical decisions, especially those that require shared decision-making by the patient and health provider. Using a framework of decision analysis for shared decision making, the clinician needs to present available treatment options, discuss the probabilities of the outcomes associated with each of those options, and elicit the patient's preferences for the possible outcomes. To minimize ambiguity in the communication during the decision-making process, studies have suggested that it is useful to quantify judgment of uncertain quantities [8]. For example, it is more meaningful for an expert or anyone to say that an event has a "75% chance of happening" rather than it will "most likely happen [3]". Such quantified opinions are helpful to understand a person's perception of risk, their general beliefs, and expert estimates involving outcomes given different situations [9–11].

While a probability wheel is useful for eliciting the weights or preferences of decisions through the sequential identification of probabilities in a utility assessment procedure the traditional probability wheel in its physical form is not convenient to carry and cannot be modified to have more than its fixed number of two sections. In addition, values must be recorded and manipulated by hand with each use. A software solution exists in the form of a simple spreadsheet with a pie chart for use on a personal computer, but the mechanisms to adjust the proportions are cumbersome and the portability is not better. Our goal was to create a mobile application (or "app") of the probability wheel for use on a smart phone or a tablet device. We envision our app, the Biomedical Informatics Lab (BMIL) Probability Wheel being used to facilitate communication between two users, the person who wishes to elicit probabilities or preferences ("Investigator"), and the person from whom the probabilities and/or preferences will be elicited ("Participant"). While we have presented a motivating example from medical decision-making, we envision this tool will also be useful to decision science researchers in other fields [12,13].