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SoftwareX 5 (2016) 211–215
www.elsevier.com/locate/softx

UT Biomedical Informatics Lab (BMIL) probability wheel

Sheng-Cheng Huang[a,b,*], Sara Lee[a], Allen Wang[a], Scott B. Cantor[c], Clement Sun[a,b], Kaili Fan[a], Gregory P. Reece[b], Min Soon Kim[d], Mia K. Markey[a,e]

[a] *Department of Biomedical Engineering, The University of Texas at Austin, 107 W Dean Keeton Street Stop C0800 Austin, TX 78712, USA*
[b] *Department of Plastic Surgery, The University of Texas MD Anderson Cancer Center, 1515 Holcombe Blvd. Houston, TX 77030, USA*
[c] *Department of Health Services Research, The University of Texas MD Anderson Cancer Center, Unit 1444, P.O. Box 301402, Houston, TX 77230-1402, USA*
[d] *Department of Health Management and Informatics, The University of Missouri, CE707 Clinical Support & Education Building, DC006.00 Columbia, MO 65212, USA*
[e] *Department of Imaging Physics, The University of Texas MD Anderson Cancer Center, 1515 Holcombe Blvd. Houston, TX 77030, USA*

Received 23 February 2016; received in revised form 26 August 2016; accepted 2 October 2016

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
Support email for questions	utbmil@gmail.com

* Corresponding author at: Department of Biomedical Engineering, The University of Texas at Austin, 107 W Dean Keeton Street Stop C0800 Austin, TX 78712, USA.

E-mail addresses: huangsc@utexas.edu (S.-C. Huang), sara.lee@utexas.edu (S. Lee), allenwang@utexas.edu (A. Wang), sbcantor@mdanderson.org (S.B. Cantor), clement.sun@gmail.com (C. Sun), fankiwi@hotmail.com (K. Fan), greece@mdanderson.org (G.P. Reece), kimms@health.missouri.edu (M.S. Kim), mia.markey@utexas.edu (M.K. Markey).

http://dx.doi.org/10.1016/j.softx.2016.10.001

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].

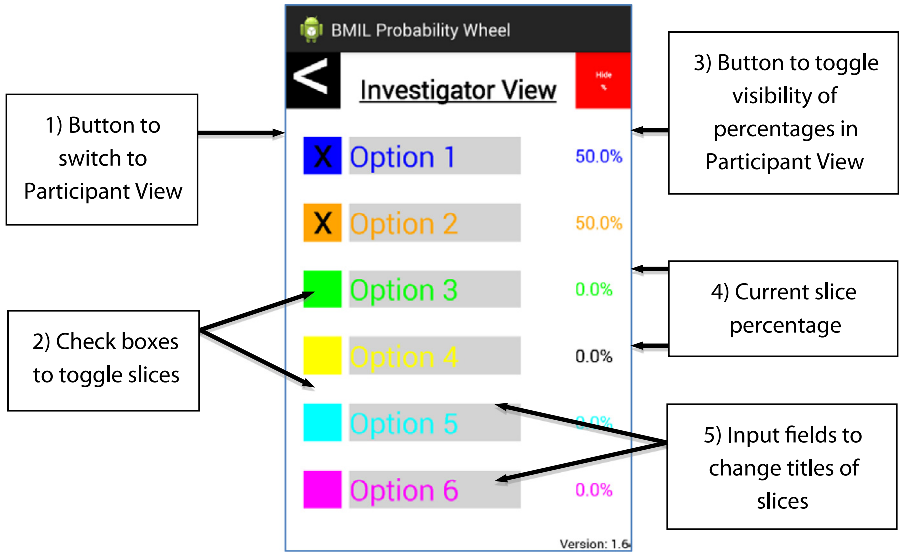

Fig. 1. Investigator View, Android version. The Investigator View has five functions: (1) a button to switch to Participant View, (2) check boxes to toggle visibility of slices in Participant View, (3) a button to toggle visibility of percentages in Participant View, (4) a display to show the current slice percentage, and (5) input fields to change titles of slices in Participant View.

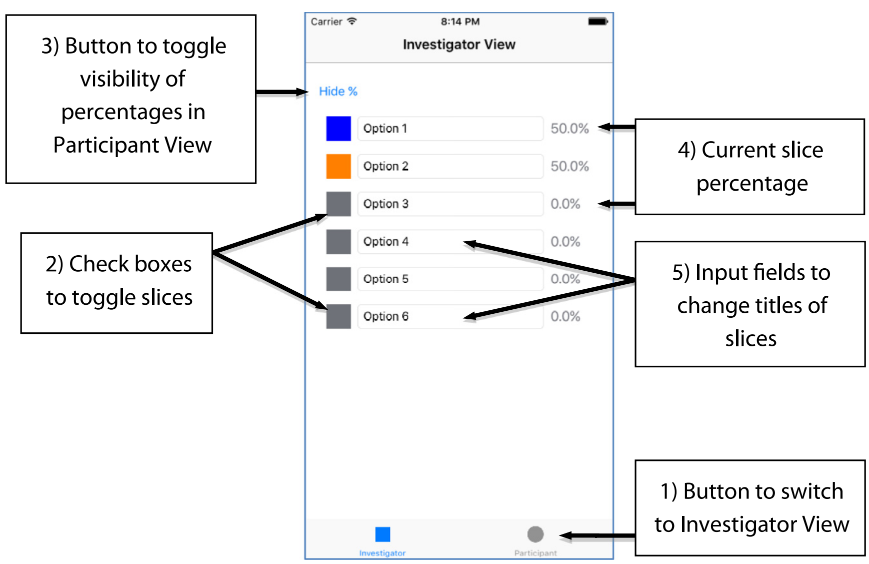

Fig. 2. Investigator View, iOS version. The iOS version is similar to the Android version. The Investigator View has five functions: (1) a button to switch to Participant View, (2) check boxes to toggle visibility of slices in Participant View, (3) a button to toggle visibility of percentages in Participant View, (4) a display to show the current slice percentage, and (5) input fields to change titles of slices in Participant View.

2. Software framework

Here we present the software framework for both the Android and iOS versions of the software application. The user interactions are almost identical in both platforms. The app is designed to facilitate a discussion about uncertainty between two people, referred to as “Participant” and “Investigator”. The app has two separate screens, Investigator View (Figs. 1 and 2) and Participant View (Figs. 3 and 4), which are used by the Investigator and the Participant, respectively. The Participant View is the default view when the app is launched.

In the Investigator View, the investigator specifies what the participant will see in the Participant View. By default, each slice is named “Option 1”, “Option 2”, etc. The investigator can change slice titles in the Investigator View and the Participant View will reflect such changes. The boxes next to the titles are used to activate or deactivate slices on the probability wheel in the Participant View, and the number of activated slices ranges from 2 (default) to 6. The investigator also has the ability to show or hide from the Participant View the percentage of the wheel that is taken up by each slice, which is always displayed in the Investigator View. The final percentages can be easily logged by the investigator, e.g., by taking a screen shot.

In the Participant View, the participant uses the knobs to manipulate sizes of slices on the wheel. The participant is also able to use the reset button to re-initialize the wheel to equally sized slices. The participants can view the slice titles and if the

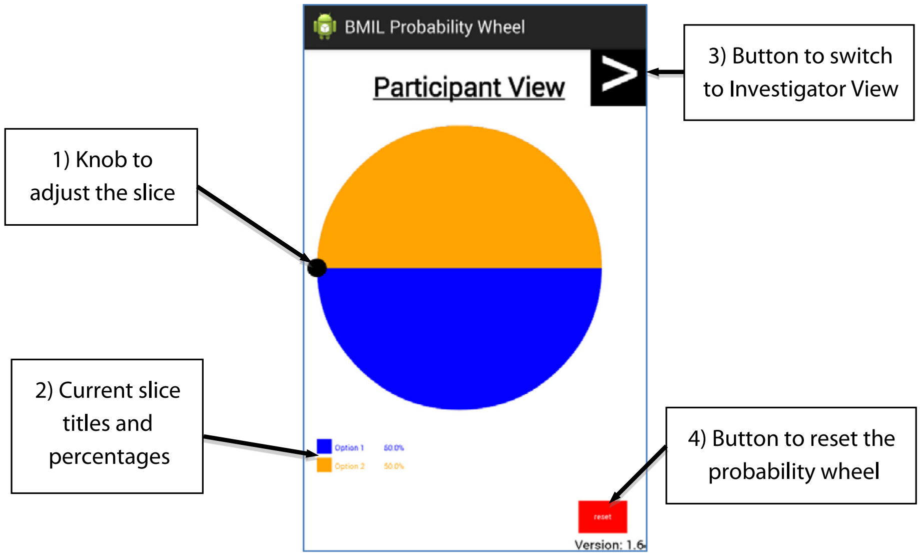

Fig. 3. Participant View, Android version. The Participant View has four functions: (1) a knob to adjust the area of the slices, (2) a display of the current slice titles and associated percentages if permitted by the investigator, (3) a button to switch to Investigator View, and (4) a button to reset the probability wheel to equal slice areas.

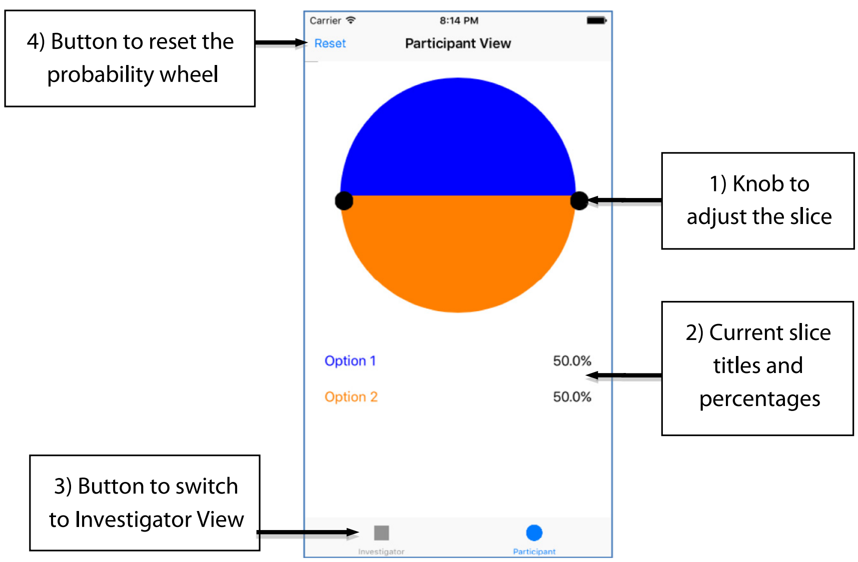

Fig. 4. Participant View, iOS version. The iOS version is similar to the Android version. The Participant View has four functions: (1) a knob to adjust the area of the slices, (2) a display of the current slice titles and associated percentages if permitted by the investigator, (3) a button to switch to Investigator View, and (4) a button to reset the probability wheel to equal slice areas.

investigator allows, the participant can also see the percentages of the wheel that are currently occupied by each slice.

It is simple to toggle between the Investigator and Participant Views. In a typical usage setting, the investigator will use the Investigator View to set the desired settings for the question to be asked, and the participant will adjust the slices of the wheel with the touchable knobs to give a visual estimate of their answer. The investigator can then switch back to Investigator View, log the information (e.g., by taking a screenshot) and proceed to the next question.

The probability wheel could be used to help a person estimate the probabilities of possible events occurring. For example, in a consultation about transverse rectus abdominis muscle (TRAM) flap breast reconstruction, the attending surgeon could use the probability wheel to estimate the probabilities that no complications will arise; that the worst complication will be minor enough to only require local wound care; that the worst complication will be serious enough to require an invasive procedure; or that the worst complication will be a life-threatening complication. Using the above case as an example, in the mobile app, the attending surgeon can set up four options such as (1) no complications, (2) minor complications with local wound care, (3) serious complications with invasive procedures, and (4) life-threatening complication in the investigator view, and use the probability wheel in the participant view to estimate the probabilities of these possible events occurring. The attending surgeon can also use the mobile app's visualization as a graphic aid while explaining these possible outcomes to the patient.

The probability wheel could also be used to assist in the utility assessment process. The probability wheel could be used to vary the probabilities of two complementary health states to determine the evaluation of an intermediate health state. For example, in a breast reconstruction consultation, the complementary health states could be a TRAM flap reconstruction surgery with no complications vs. a TRAM flap reconstruction with life threatening complications. The attending surgeon can use the mobile app's to show a visualized utility assessment between these two possible events to the patient. This notion of a standard gamble, where the anchors are the best possible state and the worst possible state, is well-established in the decision science literature [14]. In clinical decision analysis, the standard gamble evaluates an intermediate health state compared to the best possible health state and the worst possible health state [15]. Procedures and tools for computerized utility assessment have been previously developed [16].

3. Conclusions

Here we presented a mobile app implementation of the probability wheel on both Android and iOS platforms. Compared to the physical prop of a traditional probability wheel, this software application is more portable, available, and versatile, e.g., it is simple to adjust the number of slices. We envision that this tool will improve decision consultations by enabling accurate quantitative estimates of probabilities and utilities.

Acknowledgment

This study was supported in part by NIH grant R01 CA143190.

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