## How to Aggregate Health? Separability and the Effect of Framing

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# How to Aggregate Health? Separability and the Effect of Framing

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***Background.*** *Unweighted summation or quality-adjusted life year (QALY) utilitarianism is the most common way to aggregate health benefits in a cost-effectiveness analysis. A key qualitative principle underlying QALY utilitarianism is separability: those individuals unaffected by a policy choice should not influence the policy choice. Separability also underlies several of the alternatives for QALY utilitarianism that have been proposed.* ***Objectives.*** *To test separability and to test whether the support for separability is affected by the framing of the choice questions.* ***Methods.*** *In 2 experiments, 345 student subjects (162 in the first experiment, and 183 in the second experiment) were asked to select 1 of 2 possible treatments, with each treatment resulting in a different distribution of health across individuals. The only aspect that varied across choice questions was the state of the patients whose health was unaffected by the act of choosing a policy. In each experiment, we used 2 frames. In the* implicit frame, *it was implied but not plainly expressed what outcomes the treatments had in common. In the* explicit frame, *common outcomes of the 2 treatments were directly stated. The 2 experiments differed in the way the explicit frame was presented (verbal v. numerical).* ***Results.*** *The support for separability was significantly greater in the explicit frame. The proportion of violations in the implicit frame was 44% in Experiment 1 and 31% in Experiment 2, while in the explicit frame, the proportion of violations was 28% in Experiment 1 and 8% in Experiment 2.* ***Conclusions.*** *Framing affected the support for separability, raising issues as to whether it is possible to achieve a canonical representation of social choices.* ***Key words:*** *utility assessment; cognitive psychology; heuristics and biases; prospect theory; utilities, and valuations; utility measurement; utility inconsistencies; judgment and decision psychology; education; equity in distribution/allocation.* ***(Med Decis Making 2012;32:259–265)***

Cost-effectiveness analysis commonly aggregates health across individuals by unweighted summation, also referred to as quality-adjusted life year (QALY) utilitarianism.[1] QALY utilitarianism has been criticized for ignoring people's preference for an equal distribution of health gains.[2–4] There exists much empirical literature showing that people care about equality in the distribution of health.[5] On the other hand, it has also been shown that these preferences for equality are volatile and easily affected by changes in framing[6,7] and the perspective from which they are judged.[8]

The purpose of this short article is to present new evidence on people's preferences over distributions across individuals and how these preferences are affected by framing. In 2 experiments, we tested a preference condition (separability) that underlies not only QALY utilitarianism but also several of the alternatives to QALY utilitarianism that have been proposed in the literature. The article is organized as follows. In the next section, we formally define separability and show that it is implied by several of the models that have been proposed to aggregate health benefits in cost-effectiveness analysis. We then present the design and the results of the 2 experiments. Our results raise important questions about the nature of people's preferences over distributions of health, which are discussed in the final section.

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## BACKGROUND

We consider a social planner who has a preference relation $\succcurlyeq$ over distributions of health Q = ($Q_1$,. . . ., $Q_n$), where $Q_i$ denotes the health of individual i. We assume that health can be quantified, for instance, in terms of QALYs, and denote the value of health state $Q_i$ by $V(Q_i)$. A social utility function U represents $\succcurlyeq$ when for all distributions of health Q and R, $Q \succcurlyeq R \Leftrightarrow U(Q) \geq U(R)$. The social utility function is a function of the person-level values $V(Q_i)$. Several functional forms are considered below.

Let Q be a distribution of health, and let A be a subset of individuals. By $\alpha_A Q$, we denote the distribution of health that is obtained from Q by replacing $Q_i$ by $\alpha$ for all individuals i belonging to A. The social planner's preference relation satisfies *separability* when for all distributions of health Q, R, and for all subsets A, $\alpha_A Q \succcurlyeq \alpha_A R \Leftrightarrow \beta_A Q \succcurlyeq \beta_A R$.

The people in A have the same health state under both distributions. Separability then says that the nature of this common health state does not affect the social planner's preferences. Social preferences depend only on the individuals for whom the 2 distributions yield different health. Separability underlies the use of incremental analysis in cost-effectiveness analysis.[1] Incremental analysis implies that individuals for whom 2 treatments yield the same health should not influence the choice between these state after health treatments. This is what separability ensures.

Separability underlies not only QALY utilitarianism, which says that the social utility of distribution Q is equal to $\sum_{i=1}^{n} V(Q_i)$, but also generalizations thereof that take into account concerns for inequality. Wagstaff[9,10] proposed the following form of the social utility function:

$$U(Q)=\left[\sum_{i=1}^{n} (\lambda_i V(Q_i))^{\tau}\right]^{1/\tau}, \lambda_i \geq 0, \tau \leq 1, \tau \neq 0, \quad (1)$$

where $\tau$ captures attitudes towards inequality, and $\lambda_i$ is the weight given to individual i. Smaller values of $\tau$ correspond to more inequality aversion. The limiting case where $\tau$ goes to $-\infty$ corresponds to the Rawlsian social utility function, where the health of the worst-off individual entirely determines social preferences. The weights $\lambda_i$ reflect the special consideration that the social planner may wish to give to specific individuals, for example, war veterans or people suffering from rare diseases. QALY utilitarianism is the special case of Equation 1, for which $\lambda_i = \tau = 1$. When $\tau = 0$, Equation 1 becomes

$$U(Q) = \prod_{i=1}^{n} (\lambda_i V(Q_i))^{1/n}. \quad (2)$$

Dolan[11] suggested a slight generalization of Equation 2:

$$U(Q) = \prod_{i=1}^{n} V(Q_i)^{\beta_i} \text{with} \sum_{i=1}^{n} \beta_i = 1. \quad (3)$$

It is easy to see that Equations 1 and 3 imply that separability must hold. We will show this for Equation 1, Wagstaff's[9] model.

Suppose that Equation 1 represents $\succcurlyeq$. Then, $\alpha_A Q \succcurlyeq \alpha_A R$ implies that

$$\left[\sum_{i\in A} (\lambda_i \alpha)^{\tau} + \sum_{i\notin A} (\lambda_i Q_i)^{\tau}\right]^{1/\tau} \geq \left[\sum_{i\in A} (\lambda_i \alpha)^{\tau} + \sum_{i\notin A} (\lambda_i R_i)^{\tau}\right]^{1/\tau},$$

which is true for $\tau > 0$ if $\sum_{i\notin A} (\lambda_i Q_i)^{\tau} \geq \sum_{i\notin A} (\lambda_i R_i)^{\tau}$ and for $\tau < 0$ if $\sum_{i\notin A} (\lambda_i Q_i)^{\tau} \leq \sum_{i\notin A} (\lambda_i R_i)^{\tau}$. Consequently, it is also true that

$$\left[\sum_{i\in A} (\lambda_i \beta)^{\tau} + \sum_{i\notin A} (\lambda_i Q_i)^{\tau}\right]^{1/\tau} \geq \left[\sum_{i\in A} (\lambda_i \beta)^{\tau} + \sum_{i\notin A} (\lambda_i R_i)^{\tau}\right]^{1/\tau},$$

and hence, $\beta_A Q \succcurlyeq \beta_A R$. Because QALY utilitarianism is a special case of Equation 1, the derivation immediately implies that separability must also hold under QALY utilitarianism. Doctor and others[12] showed that the person tradeoff,[13] a method to measure health state utilities used, for instance, by the World Bank, also assumes separability. An example of a model that does not assume separability is the rank-dependent QALY model.[14] Testing separability is therefore useful to distinguish between different models for aggregating health.

## EXPERIMENTS

We performed 2 experiments to test separability. Our aim was 2-fold: first, to obtain insight into the validity of separability, and second, to explore whether the support for separability depended on the way the experimental questions were framed.

In both experiments, the subjects were requested to consider a cohort of 383 newborns who suffer a terminal illness. There exist 2 treatments that could save the newborns' lives. For some children, the treatment will have no side effects, and they will return to good health for the rest of their lives.

**Table 1** Questions Asked in the First Experiment

| Implicit Frame | | | | Explicit Frame | | | |
|---|---|---|---|---|---|---|---|
| **Question 1** | **Good Health** | **Poor Health** | **Death** | **Question 3** | **Newborns 1–4** | **Newborns 5–23** | **Newborns 24–383** |
| Treatment A | 0 | 23 | 360 | Treatment A′ | Poor health | Poor health | Death |
| Treatment B | 19 | 0 | 364 | Treatment B′ | Death | Good health | Death |
| **Question 2** | **Good Health** | **Poor Health** | **Death** | **Question 4** | **Newborns 1–4** | **Newborns 5–23** | **Newborns 24–383** |
| Treatment C | 360 | 23 | 0 | Treatment C′ | Poor health | Poor health | Good health |
| Treatment D | 379 | 0 | 4 | Treatment D′ | Death | Good health | Good health |

The other children will either be in poor health for the rest of their lives or they will die. Good health was defined as no symptoms or problems. Poor health was defined as some problems with walking, washing, and dressing; difficulty performing work, study, housework, and leisure activities; and moderate pain and discomfort.

We used 2 types of framing for the choice between the treatments. In one frame, the *implicit frame*, we specified for each health state how many newborns would end up in it. In the other frame, the *explicit frame*, we made it clear what the treatments had in common. Previous studies in decision under risk have observed that violations of expected utility can be reduced by making clear what alternatives have in common.[15–17] We wished to explore whether something similar held for social preferences. To counter potential order effects, the 2 frames were presented in random order in both experiments.

## First Experiment

### Methods

*Subjects.* The subjects were 162 pharmacy students from the University of Southern California School of Pharmacy and Loma Linda School of Pharmacy in the United States, of whom 44 students were male and 118 were female. Subjects who completed the experiment received extra credit for their class.

*Design and procedure.* Subjects completed a paper-based survey in class. All subjects completed the survey at the same time. Table 1 shows the 4 choice questions, 2 for both frames. Each question asked participants to select 1 of 2 possible treatments, with each treatment resulting in a different distribution of health for the treated population. The first treatment listed always had 19 fewer people in ‘‘Good Health,’’ 23 more people in ‘‘Poor Health,’’ and 4 fewer people in the ‘‘Death’’ state relative to the second treatment listed. Within each frame, the only aspect that varied between the 2 choice questions was the state of the patients unaffected by the treatment choice.[a] Two additional questions acted as fillers to minimize memory of responses across frames.

*Statistical analysis.* In the implicit frame, subjects satisfy separability if they choose either AC or BD and in the explicit frame if they choose either A′C′ or B′D′. All other choice patterns violate separability. The significance of the difference between the proportions of subjects violating separability was assessed using the McNemar test for equality of correlated proportions. If observed violations were due to random error, then they should be symmetric; that is, the proportions of BC [B′C′] and of AD [A′D′] responses in the implicit [explicit] frame should be equal. To test whether violations of separability were symmetric, we ran repeated-measures logistic regressions using generalized estimating equations.[18] An advantage of generalized estimating equations is that they account for correlations among observations from the same subject.[19] The $Z$ test was used to test significance in the logistic regressions. The independent variables in the logistic regressions were question, frame, and interaction between question and frame. The question and frame variables were contrast coded (–1, 1). The repeated-measures logistic regressions were completed using the generalized estimating equation xtgee command in STATA version 10.0 (StataCorp, College Station, TX).

[a]The implicit frame provides a valid test of separability in the presence of anonymity, the requirement that people with the same endowment of health should have the same priority in health policy. Anonymity is widely regarded as a desirable property for social choice and is commonly assumed. Bleichrodt H. Health utility indices and equity considerations. J Health Econ. (1997;16:65–91. p 74–75).

**Table 2** Response Patterns in the First Experiment

| Implicit Frame | | | | Explicit Frame | | | |
|---|---|---|---|---|---|---|---|
| **Choice** | **C** | **D** | **Total** | **Choice** | **C′** | **D′** | **Total** |
| A | 22 | 21 | 43 | A′ | 48 | 20 | 68 |
| B | 51 | 68 | 119 | B′ | 25 | 69 | 94 |
| Total | 73 | 89 | 162 | Total | 73 | 89 | 162 |

### *Results*

Table 2 shows that the proportion of violations of separability was significantly higher in the implicit frame than in the explicit frame (44% of violations in the implicit frame v. 28% of violations in the explicit frame; McNemar test, $P < 0.002$). The lower violation rate in the explicit frame was caused by a reduction in the number of subjects who first chose B′ and then C′. The decrease in the number of B′C′ responses benefited the number of A′C′ responses.

The repeated-measures logistic regression results comparing the effect of question, frame, and question-by-frame interaction are presented in Table 3. The effect of question was significant ($Z = 2.93$, $P < 0.003$), with the positive coefficient indicating that participants were more likely to choose C or C′ in question 2 (which was coded as +1) than they were to choose A or A′ in question 1 (which was coded as –1). The effect of frame was also significant ($Z = 2.52$, $P = 0.01$), with the positive coefficient indicating that participants were more likely to choose A′ or C′ in the explicit frame (which was coded as +1) than they were to choose A or C in the implicit frame (which was coded as –1). However, the interpretation of these effects is substantially affected by the presence of a significant negative interaction between question and frame ($Z = -2.87$, $P < 0.002$). Specifically, the effect of question was evident only in the implicit frame, with the choice of C in question 2 being more likely than the choice of A in question 1 (45% v. 27%, respectively). A reason could be that in the comparison between A and B, the difference of 19 newborns loomed larger than in the comparison between C and D. The extra 19 newborns in good health in option D were buried in the larger good health numbers. This asymmetry was greatly diminished in the explicit frame, with the choice of C′ in question 2 being not much different from the choice of A′ in question 1 (45% v. 42%, respectively).

**Table 3** Generalized Estimating Equation Regression Analysis of the Probability of Choosing A (or C) as a Function of Question, Frame, and Their Interaction in Experiment 1

| **Variable** | **Coefficient** | ***Z*** | ***P* Value** | **95% Confidence Interval** |
|---|---|---|---|---|
| Question | 0.236 | 2.93 | 0.003 | (0.078 to 0.394) |
| Frame | 0.174 | 2.52 | 0.012 | (0.039 to 0.308) |
| Question*frame | −0.174 | −2.87 | 0.004 | (–0.292 to –0.054) |

There are 2 plausible interpretations why choosing A′ was more common in the explicit frame than in the implicit frame. The first explanation is that the first column of B (19 newborns in good health) offered a better outcome than the first column of A (0 newborns in good health), whereas the first column of A′ (poor health) offered a better outcome than the first column of B′ (death). If subjects anchored on the first column and adjusted their responses from the anchor but did so insufficiently, then this could explain the larger proportion of A′ responses than A responses.

Another explanation could be that in the comparison between A and B, the difference is quantitative (19 v. 0), whereas in the comparison between A′ and B′, the difference is qualitative (poor health v. death). This difference could invoke different response strategies. For example, it has been shown that in questions entailing the exchange of a cherished resource (a protected value[20]), like saving lives, the question format can lead people to respond either more categorically or more quantitatively.[21] Something similar may be occurring in our data, where the implicit frame invites more quantitative reasoning (focus on numbers) and the explicit frame more qualitative reasoning (focus on health states).

### Second Experiment

A concern about experiment 1 was that the formats of the implicit frame and of the explicit frame were different. In the implicit frame, the headings of the columns are health states; in the explicit frame, they are numbers referring to newborns. Moreover, in the explicit frame, it is known which newborns get which health states, whereas in the implicit frame, this is not always known. For instance, in the explicit frame, it is known that the 360 newborns getting good health with treatment C′ are a subset of the 379 newborns getting good health with treatment D′. In the implicit frame, the 360 newborns getting good health with treatment C

**Table 4** Questions Asked in the Second Experiment

| Implicit Frame | | | | Explicit Frame | | | | |
|---|---|---|---|---|---|---|---|---|
| **Question 1** | **Good Health** | **Poor Health** | **Death** | **Question 3** | **Death** | **Good Health** | **Poor Health** | **Death** |
| Treatment A | 0 | 23 | 360 | Treatment A′ | 360 | 0 | 23 | 0 |
| Treatment B | 19 | 0 | 364 | Treatment B′ | 360 | 19 | 0 | 4 |
| **Question 1** | **Good Health** | **Poor Health** | **Death** | **Question 3** | **Death** | **Good Health** | **Poor Health** | **Death** |
| Treatment C | 360 | 23 | 0 | Treatment C′ | 360 | 0 | 23 | 0 |
| Treatment D | 379 | 0 | 4 | Treatment D′ | 360 | 19 | 0 | 4 |

are not necessarily a subset of the 379 newborns getting good health with treatment D. Identifiability of subjects can influence preferences.[22] Even though identifiability was minimal in the first experiment, we wanted to avoid its impact and therefore performed a second experiment. In experiment 2, the format of both frames was identical, and all column headings were health states.

### Methods

*Subjects.* The subjects were 183 pharmacy students from the University of Southern California School of Pharmacy in the United States, of whom 61 students were male and 122 were female. Subjects who completed the experiment received extra credit for their class. No participant of experiment 1 participated in experiment 2 as well.

*Design and procedure.* Subjects were enrolled in 1 of 5 laboratory sessions with between 30 and 40 subjects per session. The experiment was computer run and administered using Qualtrics software (Provo, UT). All 5 administrations of the experiment were completed within a 3-day period. Table 4 shows the way the questions were presented in the second experiment. The instructions and definitions of health states for the second experiment were identical to those of the first. Because the explicit frame had 2 columns with the same label, we informed subjects prior to each session that in some questions a health outcome may have 2 columns of the same type. Frame order was still randomized for each of the participants. Eighteen filler questions were used between frames. The filler questions were part of an unrelated study.

*Statistical analysis.* The statistical analysis of experiment 2 was identical to that of experiment 1.

### Results

Table 5 shows the response patterns in the second experiment. The results were similar to those of the first experiment. We observed again significantly more support for separability in the explicit frame than in the implicit frame (8% violations of separability in the explicit frame v. 31% in the implicit frame; McNemar test, $P < 0.001$). Only 7 subjects violated separability in both frames. As in the first experiment, the main difference between the 2 frames is that the response pattern B′C′ was much less common in the explicit frame. In contrast with the first experiment, however, category B′D′ instead of category A′C′ benefited primarily from the decline in the proportion of B′C′ responses.

As in experiment 1, the effect of question was significant in the repeated-measures logistic regressions ($Z = 6.04$, $P < 0.001$), with the positive coefficient indicating that participants were more likely to choose C or C′ in question 2 (which was coded as +1) than they were to choose A or A′ in question 1 (which was coded as –1). In contrast to the results of experiment 1, the effect of frame was negative and insignificant ($Z = –1.86$, $P = 0.10$). As in experiment 1, these effects were qualified by a significant negative interaction between question and frame ($Z = –4.07$, $P < 0.001$). Again, the effect of question was evident only in the implicit frame, with the choice of C in question 2 being much more likely than the choice of A in question 1 (33% v. 8%, respectively). As in the first experiment, the reason could be that the difference between 0 and 19 looms larger than the difference between 360 and 379. This asymmetry was once again greatly diminished in the explicit frame, with the choice of C′ in question 2 being not much different than the choice of A′ in question 1 (15% v. 11%, respectively).

## DISCUSSION

We tested separability, the condition that underlies not only QALY utilitarianism, the common way to aggregate health in cost-effectiveness

**Table 5** Response Patterns in the Second Experiment

| Implicit Frame | | | | Explicit Frame | | | |
|---|---|---|---|---|---|---|---|
| **Choice** | **C** | **D** | **Total** | **Choice** | **C′** | **D′** | **Total** |
| A | 10 | 5 | 15 | A′ | 16 | 4 | 20 |
| B | 51 | 117 | 168 | B′ | 11 | 152 | 163 |
| Total | 61 | 122 | 183 | Total | 27 | 156 | 183 |

analyses, but also several of its alternatives. We found that the support for separability and, hence, for the social utility functions that are based on it depended strongly on the way the choices were framed. In the implicit frame, between 30% and 45% of the choices violated separability. In the explicit frame, this proportion was significantly lower. These conclusions held in both experiments even though they differed in design and presentation of the questions. In both experiments, the lower rate of violations of separability in the explicit frame was caused by a decrease in B′C′ responses compared with the implicit frame. Whereas in the first experiment the A′C′ category primarily benefited, in the second experiment, the B′D′ category was the main beneficiary. We hypothesize that this difference was due to a difference in the way options were presented and could either be explained by anchoring on the first column that distinguished between the 2 treatments and insufficient adjustment or by a difference between qualitative or categorical and quantitative response strategies.

There are 2 ways in which our findings can be interpreted. A first interpretation is that the explicit frame clarifies what is at issue and helps people discover their true preferences. This interpretation is close to Plott's[23] discovered preference hypothesis, which claims that people can only discover their underlying preferences through learning and that testing preference theories in contexts where learning is impossible makes no sense. Likewise, one may argue that testing separability only makes sense in decision frames where the content of separability is made transparent. Clarifying the content of separability helps subjects to decide whether they consider the condition appealing and would like to behave according to it. A similar point was made by Raiffa[24] regarding tests of the Ellsberg paradox. In this interpretation, the explicit frame is the preferred frame to test for separability, and our data show that using the explicit frame can lead to more consistent choices. In contrast, previous research in decision under risk has shown that violations of separability mostly persist if these violations are demonstrated to subjects, and they are offered the opportunity to revise their preferences.[25]

An alternative interpretation is that people have no true underlying preferences and construct their preferences on the spot.[26] In this interpretation, the larger support for separability in the explicit frame may follow from the way preferences were constructed. In the explicit frame, the common dimension of the 2 treatments was emphasized, and this may have led subjects to cancel this dimension. Then the choice between A′ and B′ and the choice between C′ and D′ become identical, and any inconsistencies are due to random error. Unfortunately, our design is not able to tell which of the 2 interpretations, discovered preferences or constructed preferences, is the correct one. Future research should shed more light on this.

Our findings suggest preferences over distributions of health are volatile and can easily be manipulated. This may serve as a cautionary reminder that the measurement of social preferences, like that of risky prospects, is complicated by violations of invariance assumptions; because of framing effects, 2 ways of asking the same set of questions may not result in the same preference order. This finding does not refute the normative status of cost-effectiveness analysis, but it does suggest that cost-effectiveness analysis and other models of social choice that assume separability do not readily, or in all cases, describe our preferences for aggregate health outcomes. Policy makers that rely on preferences for aggregate health outcomes for their recommendations need to consider how framing may influence their results.

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