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A heuristic for survey reduction

Documentation

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Contents

1 Web survey design and the effects of survey length

Survey design is a field of ongoing research with applications in a diverse set of fields including public health, psychology, marketing, and even human-computer interaction. The ability to administer surveys over the "World Wide Web" has made survey design more relevant than ever and continues to drive research in traditional areas (e.g., the effect of question design on survey data [11]) as well as in new directions (e.g., the effect of visual aesthetics and progress bars on survey data [5], [12]).

Even with the application of well documented web survey design techniques [4] [5], web surveys still face problems with subjects producing disengaged/random responses or dropping out of the survey altogether. Of particular interest to us is survey length, which has been shown to increase subject dropout rates and negatively influence data quality [8]. That is, participants "tend to give less thought and get sloppier towards the end of surveys, particularly long ones" [10] possibly due to fatigue, frustration, boredom, and/or distractions.

2 Ecologically valid moral vignettes

Here we consider survey data from rating 312 ecologically valid moral vignettes on 13 dimensions: emotional intensity, emotional aversion, harm, self-benefit, other-benefit, pre-meditation, illegality, social norm violations, socialness, frequency, personal familiarity, general familiarity, and moral appropriateness [9]. Knuston et al. adapted these moral vignettes from first-person episodic memories solicited via a cue word [7]. In order to shorten the reading comprehension time, each vignette was condensed to down to two or three sentences of 28-59 words (mean 43± words). Ratings on a scale of

1 (least) to 7 (greatest) were then collected from 30 normal healthy adults via a "computer-based" survey. A principal components analysis [1], [2] using 10 of the 13 rated dimensions (emotional intensity, emotional aversion, harm, self-benefit, other-benefit, pre-meditation, illegality, social norm violations, socialness, and moral appropriateness) was performed on the survey data to resolve factors most likely to represent "underlying moral components" in the *collective set* of moral vignettes [9].

3 Future research using the moral vignettes

3.1 Practicality of using all moral vignettes

The survey of ecologically valid moral vignettes requires the subject to read 312 vignettes and make a total of 4056 ratings. Knuston et al. do not cite the average length of time subjects required to complete the survey. However, we **estimate the survey length as 72-188 minutes.** Specifically, if we assume reading rate for comprehension to be 250-350 words per minute [3] and the average word length (43 words) across all 312 vignettes, then the reading portion of the survey alone requires 38-53 minutes. The rating portion of the survey would take 34-135 minutes assuming each individual rating requires 0.5-2 seconds. Indeed, a major complaint was that the full survey took around 3 hours (180 minutes) to complete when it was piloted within Edelyn Verona's Emotion and Behavior Lab and Aron Barbey's Decision Neuroscience Lab. Consequently, the survey, as presented in Knuston et al., is likely to suffer from high subject dropout rates as well as biases from subject fatigue and disengaged/random responses if administered as a web survey. It is also unfeasible to administer the full survey within the context of a functional neuroimaging task.

3.2 Subsets of moral vignettes

In order to study the "underlying moral components" of the vignettes in a larger population and eventually administer the survey as part of a functional neuroimaging task, we wish to select a "representative" subset of the moral vignettes. Ideally, we would like to create several 30-minute surveys that when combined have no duplicate moral vignettes.

A subset of 40 questions would require 5-7 minutes of reading and 4-17 minutes of rating dimensions. This would put the estimated total survey time at 9-24 minutes giving 6 additional minutes for demographics questions, reading instructions, and "clicking through" the survey. In actuality, we selected a subset of 39 moral vignettes. The number of combinations from selecting k elements from a set of n elements is

$$\binom{n}{k} = \frac{n!}{k!(n-k)!}, \quad k \leq n$$

Thus choosing 39 questions from a survey with 312 questions results in 7.68671e+49 total combinations! Searching these combinations for "representative" subsets is impractical. By "representative" we mean that the results of the factor analysis applied to the subset of 39 moral vignettes reflects the results of the factor analysis applied to the full set of 312 moral vignettes.

Here we apply a simple heuristic to reduce the search space from 7.68671e+49 down to a handful combinations that are likely to be "representative" and have no elements in common. This handful

of combinations can be manageably tested for desirable features, such as their ability to replicate analyses performed on larger combinations.

3.3 Our subset selection heuristic

Factor ratings are averaged across all subjects for each vignette. We wish to classify vignettes as "low," "medium," or "high" for each factor based on this mean rating. We define the respective intervals: $[a, b]$, (b, c), $[c, d]$ such that a is the minimum rating for the factor, b is the mean factor rating minus the standard deviation of factor ratings, c is the mean factor rating plus the standard deviation of the factor ratings, and d is the maximum rating for the factor. Next we choose how many vignettes categorized as "low," "medium," or "high" should be selected for each factor. The sum of the number of vignettes across the three categories times the number of dimensions determines the number of vignettes in the subset. For example, we select one "low," one "medium," and one "high" vignette for each factor for a total of $3 \times 13 = 39$ vignettes. Even though vignettes are added based on a specific category for a particular factor, each vignette still has ratings for the other dimensions. Thus adding the vignette will change the subset composition for the non-selected dimensions in an "unconstrained" way.

First we select a category "low," "medium," or "high" randomly. Then we select vignettes with this category for each dimension using a random ordering of the dimensions. Note that only vignettes that have not been previously added to *any* subset are eligible for selection. This proceeds until the subset is full and can be repeated to produce more subsets.

3.4 Application to moral vignettes

1. Download data (excel format) provided in the Supplementary Materials [9].
2. Open the excel file in Google spreadsheets.
3. Insert a column of question ID numbers (integers).
   (a) Select row 1 (header) and copy (control-c).
   (b) Select row 1 (header), right click, and select *Delete row.*
   (c) Select column S, right click, and select *Sort sheet A -¿ Z.*
   (d) Select row 1, right click, and select *Add 1 above.*
   (e) Select row 1 and paste (control-v).
   (f) Select column A, right click, and select *Insert 1 left.*
   (g) Enter 1 into cell (2, A).
   (h) Enter "= A2 + 1" in cell (3, A).
   (i) Drag the lower right corner of cell row (3, A) down to cell (313, A).
   (j) Enter "QuestionID" into cell (1, A).
4. Delete columns B (Main Cue), C (Story), Q (Norm Violation Component), R (Social Affect Component), S (Intention Component), and T (Word Count).

5. In row 1, convert any spaces and hyphens to underscores e.g., "Emotional Intensity" → "Emotional_Intensity".

6. Select *File* → *Download as* → *Comma-separated values (.csv, current sheet).*

7. Run MATLAB commands.

   (a) nlow = 1; nmid = 1; nhigh = 1;

   (b) breakdown = [nlow, nmid, nhigh];

   (c) survey_reduction('SuppData.csv', 'subQ', breakdown, 3, 'heuristic');

   (d) survey_reduction('SuppData.csv', 'subQ', breakdown, 3, 'random');

3.5 Comparison of results

Dimensions	a	b	c	d
Emotional intensity	1.77	3.26	5.38	6.63
Emotional aversion	1.60	2.79	4.90	6.47
Harm	1.30	2.16	4.84	6.07
Self-benefit	1.53	3.00	4.94	5.87
Other-benefit	1.20	1.58	4.73	6.57
Pre-meditation	1.63	3.44	5.57	6.53
Illegality	1.13	1.35	4.33	6.73
Social norm violations	1.27	2.65	5.62	6.47
Socialness	2.43	4.44	6.06	6.57
Moral appropriateness	1.30	2.24	5.42	6.83

Table 1: Ranges for dimension categorization

Dimensions	mean	standard deviation	total in $[a, b]$	total in (b, c)	total in $[c, d]$
Emotional intensity	4.32	1.06	59	204	49
Emotional aversion	3.85	1.05	61	196	55
Harm	3.50	1.34	68	185	59
Self-benefit	3.98	0.97	50	208	54
Other-benefit	3.15	1.57	33	213	66
Pre-meditation	4.51	1.07	62	197	53
Illegality	2.84	1.49	21	233	58
Social norm violations	4.14	1.48	67	194	51
Socialness	5.25	0.81	52	226	34
Moral appropriateness	3.83	1.59	56	187	69

Table 2: Summary statistics on full survey

3.5.1 Surveys generated with our heuristic

3.5.2 Subset 1

Dimensions	mean	standard deviation	total in $[a, b]$	total in (b, c)	total in $[c, d]$
Emotional intensity	4.25	1.02	7	27	5
Emotional aversion	3.60	1.18	11	20	8
Harm	3.33	1.61	14	13	12
Self-benefit	3.75	0.91	8	27	4
Other-benefit	3.43	1.74	6	21	12
Pre-meditation	4.39	1.07	8	25	6
Illegality	2.79	1.57	6	26	7
Social norm violations	3.74	1.65	14	18	7
Socialness	5.21	0.82	7	26	6
Moral appropriateness	4.21	1.80	7	18	14

Table 3: Summary statistics on Survey 1 = {2, 33, 41, 46, 49, 55, 67, 73, 74, 84, 88, 99, 105, 106, 111, 117, 126, 131, 151, 158, 165, 175, 202, 208, 217, 225, 229, 232, 238, 243, 248, 250, 264, 273, 288, 299, 308, 311, 312}

	Components					
	Full Survey			Survey 1 (heuristic)		
Dimensions	1	2	3	1	2	3
Emotional intensity	0.023	0.896	-0.065	0.128	0.902	-0.115
Emotional aversion	0.336	0.762	-0.258	0.57	0.63	-0.312
Harm	0.803	0.473	0.008	0.791	0.532	-0.056
Self-benefit	0.244	-0.304	0.772	0.054	-0.234	0.902
Other-benefit	-0.883	0.046	0.051	-0.953	-0.033	-0.051
Pre-meditation	-0.002	0.175	0.859	0.003	0.104	0.91
Illegality	0.737	-0.288	0.115	0.85	-0.047	-0.102
Social norm violations	0.948	0.154	0.144	0.959	0.166	0.098
Socialness	-0.115	0.763	0.174	-0.008	0.836	0.07
Moral appropriateness	-0.956	-0.102	-0.12	-0.968	-0.128	-0.091

Table 4: Rotated Component Matrix from Survey 1

3.5.3 Subset 2

Dimensions	mean	standard deviation	total in $[a, b]$	total in (b, c)	total in $[c, d]$
Emotional intensity	4.46	1.19	8	23	8
Emotional aversion	3.97	1.11	8	21	10
Harm	3.24	1.30	11	21	7
Self-benefit	3.97	1.03	7	23	9
Other-benefit	3.40	1.58	3	27	9
Pre-meditation	4.66	0.92	6	25	8
Illegality	2.65	1.51	3	30	6
Social norm violations	3.99	1.51	9	23	7
Socialness	5.31	0.77	6	28	5
Moral appropriateness	4.03	1.63	8	21	10

Table 5: Summary statistics on Survey 2 = {4, 13, 14,18, 22, 25, 26, 35, 40, 62, 64, 76, 77, 82, 115, 123, 138, 141, 143, 149, 152, 156, 160, 173, 177, 183, 184, 197, 200, 234, 262, 267, 268, 281, 293, 298, 303, 309, 310}

	Components					
	Full Survey			Survey 2 (heuristic)		
Dimensions	1	2	3	1	2	3
Emotional intensity	0.023	0.896	-0.065	-0.049	0.928	0.007
Emotional aversion	0.336	0.762	-0.258	0.207	0.835	-0.218
Harm	0.803	0.473	0.008	0.85	0.333	0.082
Self-benefit	0.244	-0.304	0.772	0.306	-0.394	0.732
Other-benefit	-0.883	0.046	0.051	-0.854	0.189	-0.097
Pre-meditation	-0.002	0.175	0.859	0.044	0.154	0.873
Illegality	0.737	-0.288	0.115	0.786	-0.257	-0.013
Social norm violations	0.948	0.154	0.144	0.957	0.075	0.136
Socialness	-0.115	0.763	0.174	-0.143	0.75	0.103
Moral appropriateness	-0.956	-0.102	-0.12	-0.955	-0.025	-0.14

Table 6: Rotated Component Matrix from Survey 2

3.5.4 Subset 3

Dimensions	mean	standard deviation	total in $[a, b]$	total in (b, c)	total in $[c, d]$
Emotional intensity	4.19	1.12	9	25	5
Emotional aversion	3.57	1.06	9	27	3
Harm	3.32	1.47	13	18	8
Self-benefit	3.92	0.92	6	26	7
Other-benefit	3.48	1.87	5	21	13
Pre-meditation	4.25	1.29	13	20	6
Illegality	2.74	1.56	5	27	7
Social norm violations	3.78	1.64	12	20	7
Socialness	5.19	1.01	8	25	6
Moral appropriateness	4.19	1.79	7	18	14

Table 7: Summary statistics on Survey 3 = {16, 32, 38, 44, 54, 58, 63, 65, 69, 81, 86, 90, 96, 109, 113, 119, 121, 122, 166, 167, 171, 180, 182, 189, 195, 209, 223, 224, 235, 237, 239, 241, 246, 249, 259, 261, 284, 294, 306}

	Components					
	Full Survey			Survey 3 (heuristic)		
Dimensions	1	2	3	1	2	3
Emotional intensity	0.023	0.896	-0.065	0.127	0.884	0.168
Emotional aversion	0.336	0.762	-0.258	0.442	0.736	-0.074
Harm	0.803	0.473	0.008	0.866	0.384	-0.038
Self-benefit	0.244	-0.304	0.772	0.292	-0.199	0.784
Other-benefit	-0.883	0.046	0.051	-0.904	0.102	0.01
Pre-meditation	-0.002	0.175	0.859	-0.132	0.363	0.79
Illegality	0.737	-0.288	0.115	0.721	-0.268	0.237
Social norm violations	0.948	0.154	0.144	0.953	0.173	0.099
Socialness	-0.115	0.763	0.174	-0.19	0.763	-0.01
Moral appropriateness	-0.956	-0.102	-0.12	-0.962	-0.109	-0.061

Table 8: Rotated Component Matrix from Survey 3

3.5.5 Surveys generated randomly

3.5.6 Subset 1

Dimensions	mean	standard deviation	total in $[a, b]$	total in (b, c)	total in $[c, d]$
Emotional intensity	4.40	1.08	10	23	6
Emotional aversion	3.71	0.98	9	27	3
Harm	3.62	1.34	7	22	10
Self-benefit	4.10	0.86	4	30	5
Other-benefit	3.20	1.70	3	26	10
Pre-meditation	4.84	0.87	2	30	7
Illegality	3.02	1.46	4	27	8
Social norm violations	4.39	1.55	8	24	7
Socialness	5.43	0.72	4	28	7
Moral appropriateness	3.56	1.62	10	21	8

Table 9: Summary statistics on Survey 1 = {2, 9, 14, 29, 31, 39, 44, 52, 62, 89, 107, 110, 151, 152, 162, 165, 169, 173, 181, 184, 193, 196, 203, 210, 219, 225, 227, 231, 236, 245, 246, 254, 283, 284, 288, 298, 303, 305, 312}

	Components					
	Full Survey			Survey 1 (random)		
Dimensions	1	2	3	1	2	3
Emotional intensity	0.023	0.896	-0.065	-0.021	0.858	-0.12
Emotional aversion	0.336	0.762	-0.258	0.354	0.681	-0.488
Harm	0.803	0.473	0.008	0.778	0.533	-0.008
Self-benefit	0.244	-0.304	0.772	0.265	-0.182	0.8
Other-benefit	-0.883	0.046	0.051	-0.9	0.097	0.099
Pre-meditation	-0.002	0.175	0.859	-0.157	0.142	0.84
Illegality	0.737	-0.288	0.115	0.71	-0.329	0.007
Social norm violations	0.948	0.154	0.144	0.972	0.082	0.045
Socialness	-0.115	0.763	0.174	-0.228	0.826	0.259
Moral appropriateness	-0.956	-0.102	-0.12	-0.979	-0.015	-0.034

Table 10: Rotated Component Matrix from Survey 1

3.5.7 Subset 2

Dimensions	mean	standard deviation	total in $[a, b]$	total in (b, c)	total in $[c, d]$
Emotional intensity	4.39	1.06	4	28	7
Emotional aversion	3.80	1.12	9	21	9
Harm	3.51	1.54	12	19	8
Self-benefit	4.00	0.95	5	28	6
Other-benefit	3.43	1.76	4	24	11
Pre-meditation	4.52	1.21	10	19	10
Illegality	2.80	1.53	4	28	7
Social norm violations	4.10	1.64	9	21	9
Socialness	5.44	0.83	6	25	8
Moral appropriateness	3.89	1.74	9	20	10

Table 11: Summary statistics on Survey 2 = {11, 12, 38, 40, 46, 48, 53, 56, 65, 72, 81, 84, 103, 115, 117, 120, 126, 127, 143, 159, 168, 171, 174, 175, 188, 204, 213, 215, 229, 240, 255, 260, 263, 264, 276, 281, 285, 286, 296}

	Components					
	Full Survey			Survey 2 (random)		
Dimensions	1	2	3	1	2	3
Emotional intensity	0.023	0.896	-0.065	0.257	0.858	-0.21
Emotional aversion	0.336	0.762	-0.258	0.591	0.645	-0.303
Harm	0.803	0.473	0.008	0.834	0.386	0.208
Self-benefit	0.244	-0.304	0.772	0.142	-0.338	0.822
Other-benefit	-0.883	0.046	0.051	-0.916	0.074	-0.075
Pre-meditation	-0.002	0.175	0.859	0.245	0.195	0.78
Illegality	0.737	-0.288	0.115	0.691	-0.48	0.133
Social norm violations	0.948	0.154	0.144	0.95	0.165	0.205
Socialness	-0.115	0.763	0.174	-0.135	0.891	0.195
Moral appropriateness	-0.956	-0.102	-0.12	-0.963	-0.102	-0.183

Table 12: Rotated Component Matrix from Survey 2

3.5.8 Subset 3

Dimensions	mean	standard deviation	total in $[a, b]$	total in (b, c)	total in $[c, d]$
Emotional intensity	4.28	1.02	9	27	3
Emotional aversion	3.75	0.99	6	26	7
Harm	3.71	1.37	8	23	8
Self-benefit	4.15	1.02	4	25	10
Other-benefit	2.82	1.45	8	25	6
Pre-meditation	4.32	1.15	11	20	8
Illegality	2.77	1.46	3	29	7
Social norm violations	4.24	1.47	8	23	8
Socialness	5.17	0.81	6	30	3
Moral appropriateness	3.70	1.59	9	22	8

Table 13: Summary statistics on Survey 3 = {8, 13, 18, 23, 25, 35, 41, 42, 51, 54, 55, 71, 73, 76, 77, 86, 92, 98, 121, 123, 129, 134, 144, 146, 167, 170, 186, 195, 209, 217, 228, 250, 259, 265, 270, 299, 301, 302, 306}

	Components					
	Full Survey			Survey 3 (random)		
Dimensions	1	2	3	1	2	3
Emotional intensity	0.023	0.896	-0.065	-0.176	0.895	-0.018
Emotional aversion	0.336	0.762	-0.258	0.12	0.841	-0.185
Harm	0.803	0.473	0.008	0.875	0.401	-0.044
Self-benefit	0.244	-0.304	0.772	0.096	-0.333	0.837
Other-benefit	-0.883	0.046	0.051	-0.815	0.134	0.207
Pre-meditation	-0.002	0.175	0.859	0.005	0.215	0.885
Illegality	0.737	-0.288	0.115	0.617	-0.252	0.413
Social norm violations	0.948	0.154	0.144	0.959	0.096	0.161
Socialness	-0.115	0.763	0.174	0.173	0.753	0.086
Moral appropriateness	-0.956	-0.102	-0.12	-0.956	-0.095	-0.156

Table 14: Rotated Component Matrix from Survey 3

4 MATLAB Code

```
function survey_reduction(infile, outname, breakdown, nsurvey, heuristic)
%
%   infile : string
%   outname : string
%   breakdown : 1 x 3 array of integers
%   nsurvey : integer or 'inf'
%   heuristic : string {'random', 'heuristic'}
%
    % import full survey data
    Q = importdata(infile);
    X = Q.data;
    header = Q.colheaders;

    % define ranges: low [a,b], middle (b,d), high [d,e]
    a = min(X);  e = max(X);
    c = mean(X); s = std(X);
    b = c - s;   d = c + s;

    [m, n] = size(X);
    if strcmp('random', heuristic)
        order = randperm(m);
        nq = (n - 1) * size(breakdown,2);
    else
        % create selection masks
        low_mask  = zeros(m, n);
        mid_mask  = zeros(m, n);
        high_mask = zeros(m, n);
        for i = 2:n
            low_mask(:,i)  = [X(:,i) >= a(i)] .* [X(:,i) <= b(i)];
            mid_mask(:,i)  = [X(:,i) >  b(i)] .* [X(:,i) <  d(i)];
            high_mask(:,i) = [X(:,i) >= d(i)] .* [X(:,i) <= e(i)];
        end
        masks = cat(3, low_mask, mid_mask, high_mask);
    end

    % create shortened surveys
    i = 1;
    while (i <= nsurvey)
        Y = [];

        if strcmp('random', heuristic)
            [X, Y] = create_subset_random(X, Y, i, nq, order);
            outnamei = strcat(outname, '_', int2str(i), '_random');
        else
            [X, Y] = create_subset_heuristic(X, Y, breakdown, masks);
            outnamei = strcat(outname, '_', int2str(i), '_heuristic');
        end

        save_survey(Y, header, outnamei, a, b, d, e);
        i = i + 1;
    end
end


function [A, B] = create_subset_random(A, B, i, nq, order)
    st = (i-1) * nq + 1;
```

```
57      en = st + nq - 1;
58      if (en < size(A, 1))
59          B = A(order(st:en),:);
60      else
61          error('Error: too few elements.')
62          error('Unable to create survey!')
63      end
64  end
65
66
67
68  function [A, B] = create_subset_heuristic(A, B, breakdown, masks)
69      [m, n] = size(A);
70
71      levels = cat(2, ones(1,breakdown(1)), ...
72                      ones(1,breakdown(2))*2, ...
73                      ones(1,breakdown(3))*3);
74      order = randperm(size(levels,2));
75      levels = levels(order);
76
77      for i = levels
78          if (i == 1)
79              mask = masks(:,:,1);
80          elseif (i == 2)
81              mask = masks(:,:,2);
82          else
83              mask = masks(:,:,3);
84          end
85
86          order = randperm(n-1);
87          factors = order + 1;
88          for j = factors
89              subset = A(:,1) .* mask(:,j);
90              subset(subset==0) = [];
91
92              % identifies and adds question to subset
93              l = size(subset,1);
94              if (l ~= 0)
95                  randsel = randi([1,l]);
96                  question = subset(randsel);
97
98                  % add question to B
99                  B = cat(1, B, A(question,:));
100
101                 % remove question from A
102                 A(question, 1) = 0;
103             else
104                 error('Error: empty set.')
105                 error('Unable to create survey!')
106             end
107         end
108     end
109 end
110
111
112 function save_survey(B, header, outname, a, b, d, e)
113     % save shortened survey
114     outfile = strcat(outname, '.csv');
```

```
    T = array2table(B, 'VariableNames', header);
    writetable(T, outfile, 'Delimiter', ',');

    % compute & save associated metrics
    n = size(B, 2);
    average = mean(B,1);
    stddev = std(B,1);
    minimum = zeros(1,n);
    maximum = zeros(1,n);
    total = zeros(3,n);
    for i = 2:n
        minimum(i) = min(B(:,i));
        maximum(i) = max(B(:,i));
        total(1,i) = sum([B(:,i) >= a(i)] .* [B(:,i) <= b(i)]);
        total(2,i) = sum([B(:,i) >  b(i)] .* [B(:,i) <  d(i)]);
        total(3,i) = sum([B(:,i) >= d(i)] .* [B(:,i) <= e(i)]);
    end
    ancillary = cat(1, average(:,2:n), stddev(:,2:n), ...
                       minimum(:,2:n), maximum(:,2:n), total(:,2:n), ...
                       a(:,2:n), b(:,2:n), d(:,2:n), e(:,2:n));

    outfile = strcat(outname, '_info.csv');
    rownames = {'mean'; 'stddev'; 'min'; 'max'; ...
                'nlow'; 'nmid'; 'nhigh'; ...
                'a'; 'b'; 'd'; 'e'};
    T = array2table(ancillary, 'VariableNames', header(2:n), ...
                               'RowNames', rownames);
    writetable(T, outfile, 'Delimiter', ',', 'WriteRowNames', true);
end
```

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