The Factorial Survey

Design Selection and Its Impact on Reliability and Internal Validity

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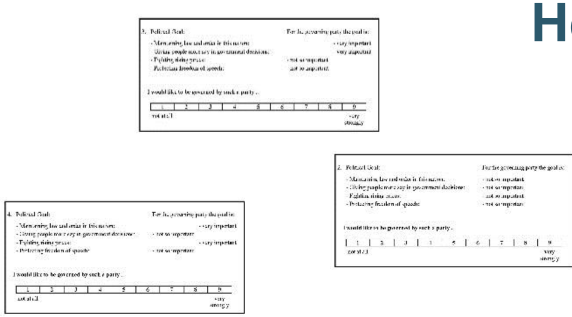

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Overview

1. Introduction: The Factorial Survey
2. Random or Quota Design
3. Analysis of Factorial Surveys
4. Operationalization and Data
5. Conclusion

Introduction: The Factorial Survey

Factorial Survey (Vignette Analysis):

Experimental design in which the researcher

- constructs varying descriptions of situations or persons (vignettes) for a selected topic
- which will be judged by respondents under a particular aspect.

Simple Example
(Value orientations according to Inglehart):

Importance of the Goals: Estimated β-coefficient from regression analysis

4. Political Goal: For the governing party the goal is:

- Maintaining law and order in this nation: - very important
- Giving people more say in government decisions: - not so important
- Fighting rising prices: - very important
- Protecting freedom of speech: - not so important

I would like to be governed by such a party ...

1	2	3	4	5	6	X	8	9
not at all								very strongly

Introduction: The Factorial Survey

Factors and Levels of the Factorial Survey
(Value Orientations according to Inglehart):

Factor (or Dimension)	Level (or Value)
X1: Maintaining law and order in this nation	not so important, very important
X2: Giving people more say in this nation	not so important, very important
X3: Fighting rising prices	not so important, very important
X4: Protecting freedom of speech	not so important, very important

Introduction: The Factorial Survey

Fully Crossed Vignette Universe (Full Factorial Design): 2^4=16 Vignettes

	Independent Variables			
Vignette No.	x_1	x_2	x_3	x_4
1	-1	-1	-1	-1
2	-1	-1	-1	1
3	-1	-1	1	-1
4	-1	-1	1	1
5	-1	1	-1	-1
6	-1	1	-1	1
7	-1	1	1	-1
8	-1	1	1	1
9	1	-1	-1	-1
10	1	-1	-1	1
11	1	-1	1	-1
12	1	-1	1	1
13	1	1	-1	-1
14	1	1	-1	1
15	1	1	1	-1
16	1	1	1	1

Coding: -1: not so important
1: very important

Features of the Vignette Universe:

- **orthogonal**: all main effects and interaction effects can be estimated uncorrelated
- **balanced**: each level occurs equally often within each vignette factor, which means that the intercept is orthogonal to each effect

Random and Quota Designs

The number of vignettes increases as a *power function* of the number of factors (x-variables) and/or the number of levels

→

Each respondent can in general only judge a sample (vignette set) of the fully crossed vignette universe.

2 approaches for generating vignette samples can be distinguished:

1. **Random Designs**
2. **Quota Designs**

Random and Quota Designs

Random Designs (Rossi/Anderson 1982, Jasso 2006):

- **Basic idea**: Representing the vignette universe through different vignette samples of same size (simple random design without replacement)

Quota Designs:

- **Basic idea**: Representing the central features of the vignette universe via generating one or relatively few vignette samples

  a) **Classical Fractional Factorial Designs** (Gunst/Mason 1991, Steiner/Atzmüller 2006):

  - always orthogonal but not always balanced
  - *Problem*: especially when different factors have different prime number of levels (2, 3, 5) there exists frequently no fractional factorial design within the limits of a reasonable set size

  b) **D-efficient Designs (**Kuhfeld et al. 1994, Dülmer 2007**)**:

  - Orthogonality and balance are simultaneously optimized (*Minimizing the standard error of the estimated β*-coefficients)

Random and Quota Designs

$$\hat{\sigma}(\hat{\beta}_1) = \sqrt{\frac{\sum_{i=1}^{n} e_i^2 \Big/ (n-k-1)}{\sum_{i=1}^{n} \left(X_{1i} - \bar{X}_1\right)^2 \cdot \left(1 - R^2_{X_1;\, X_2,\, X_3 \,\ldots\, X_k}\right)}}$$

where

$\hat{\sigma}(\hat{\beta}_1)$ is the estimated standard error of the estimated unstandardized regression coefficient of X_1,

$\sum_{i=1}^{n} e_i^2 \Big/ (n-k-1)$ is the estimated error variance, i.e. the quotient of the observed error variance and the remaining degrees of freedom (*n* refers to the set size, *k* to the number of estimated β -coefficients for the included predictor variables),

$\sum_{i=1}^{n} \left(X_{1i} - \bar{X}_1\right)^2$ is the variation of X_1 across the vignettes 1 to *n*, and

$R^2_{X_1;\, X_2,\, X_3 \,\ldots\, X_k}$ is the coefficient of multiple determination of the predictor variables X_2 to X_k on X_1.

Analysis of Factorial Surveys

Multilevel Analysis:
Since in general respondents have to answer more than one vignette, the collected data are hierarchically nested.

Mathematical equation system for a multilevel model with one vignette variable X and one respondent characteristic Z:

Vignette Level (Level 1): $Y_{ij} = \beta_{0j} + \beta_{1j} X_{1ij} + r_{ij}$

Respondent Level (Level 2): $\beta_{0j} = \gamma_{00} + \gamma_{01} Z_j + u_{0j}$

$$\beta_{1j} = \gamma_{10} + u_{1j}$$

The more homogenous the answer behavior of the respondents, the less u-terms become significant (OLS-regression, if no u-term becomes significant) ➡
Depending on the heterogeneity of the respondents' answer behavior, the estimated β-coefficients are stronger based on the **estimates for the separate vignette sets** or on the **estimates for the combined vignette sample**.

Operationalizations and Data

Given Example: Value Orientations According to Inglehart

Yardstick for the empirical design comparison:

- Fully crossed Factorial Design (2^4=16 vignettes)
- Vignettes were presented to the respondents in randomized order (paper and pencil interviews)

Participants:

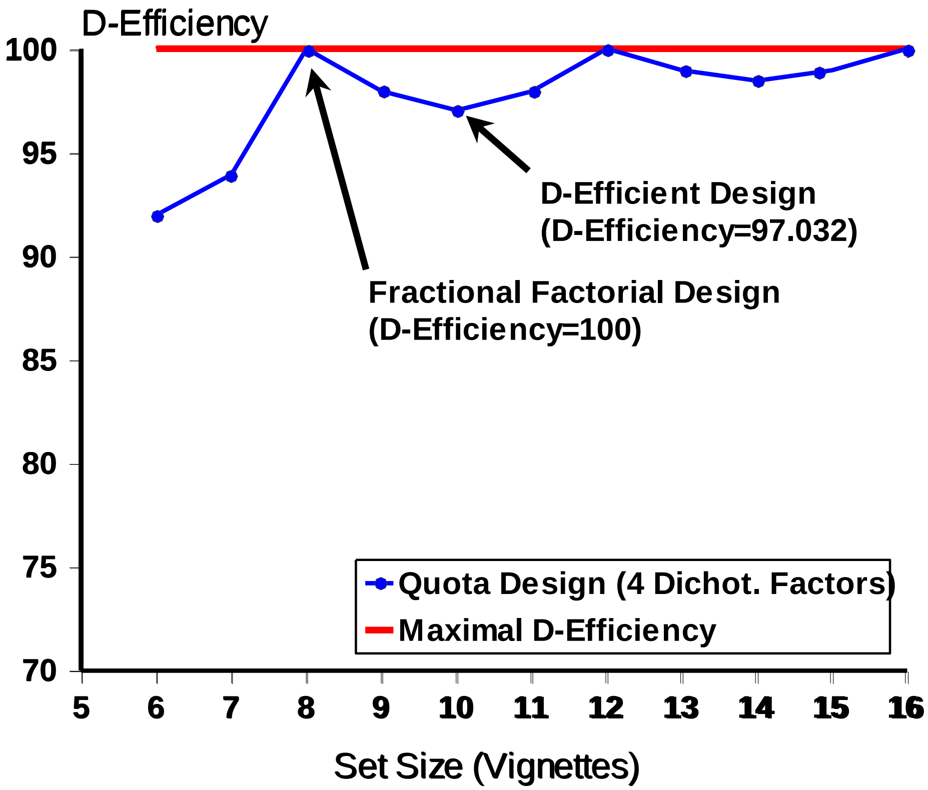
- 137 students (first session of 2 identical methodological courses, University of Cologne, October 2006)
- 5 questionnaires had to be excluded (not sufficiently filled out)
- **Net sample size**: 132 students (72 females, 60 males)

Design comparison:

- **2 Quota Designs** (Confounded Factorial Design of set size 8 and Confounded D-efficient Design of set size 10)
- **2 Random Designs** (without replacement, set size of 8 and 10 respectively)

Operationalizations and Data

Quota Designs:



D-Efficiency (qualitative factors):

- **Range**: 0 to 100 (for standardized orthogonal contrast coding)
- **Maximum**: only for orthogonal, balanced designs
- D-Efficiency is independent of the set size
- Generating D-efficient Designs: Computerprogramme (SAS)

$$\text{D-Efficiency} = 100 \cdot \frac{1}{N_D \cdot \left|(X' \cdot X)^{-1}\right|^{\frac{1}{p}}}$$

N_D: set size; p: estimated β-coefficients;
$X' \cdot X$: information matrix

Operationalizations and Data

Factorial Designs:

Fractional Factorial Design

Construction (- = 0, + = 1):

$$X_1 + X_2 + X_3 + X_4 = 0, \text{ modulo } 2$$

$$X_1 + X_2 + X_3 + X_4 = 1, \text{ modulo } 2$$

	Factors				Confounding Structure							
Vignette-number	x_1	x_2	x_3	x_4	$x_1x_2 = x_3x_4$	$x_1x_3 = x_2x_4$	$x_1x_4 = x_2x_3$	$x_1x_2x_3 = x_4$	$x_1x_2x_4 = x_3$	$x_1x_3x_4 = x_2$	$x_2x_3x_4 = x_1$	$x_1x_2x_3x_4$ = Interc.
Set 1												
1	-	-	-	-	+	+	+	-	-	-	-	+
2	-	-	+	+	+	-	-	+	+	-	-	+
3	-	+	-	+	-	+	-	+	-	+	-	+
4	-	+	+	-	-	-	+	-	+	+	-	+
5	+	-	-	+	-	-	+	+	-	-	+	+
6	+	-	+	-	-	+	-	-	+	-	+	+
7	+	+	-	-	+	-	-	-	-	+	+	+
8	+	+	+	+	+	+	+	+	+	+	+	+
Vignette-number	x_1	x_2	x_3	x_4	$x_1x_2 = -x_3x_4$	$x_1x_3 = -x_2x_4$	$x_1x_4 = -x_2x_3$	$x_1x_2x_3 = -x_4$	$x_1x_2x_4 = -x_3$	$x_1x_3x_4 = -x_2$	$x_2x_3x_4 = -x_1$	$x_1x_2x_3x_4$ = -Interc.
Set 2												
1	-	-	-	+	+	+	-	-	+	+	+	-
2	-	-	+	-	+	-	+	+	-	+	+	-
3	-	+	-	-	-	+	+	+	+	-	+	-
4	-	+	+	+	-	-	-	-	-	-	+	-
5	+	-	-	-	-	-	-	+	+	+	-	-
6	+	-	+	+	-	+	+	-	-	+	-	-
7	+	+	-	+	+	-	+	-	+	-	-	-
8	+	+	+	-	+	+	-	+	-	-	-	-

Operationalizations and Data

Factorial Designs:

a) **2 half fractional factorial Designs:** Selecting either Set 1 *or* Set 2

b) **1 confounded factorial Design** Selecting both Set 1 *and* Set 2

	Factors				Confounding Structure							
Vignette-number	x_1	x_2	x_3	x_4	$x_1x_2 = x_3x_4$	$x_1x_3 = x_2x_4$	$x_1x_4 = x_2x_3$	$x_1x_2x_3 = x_4$	$x_1x_2x_4 = x_3$	$x_1x_3x_4 = x_2$	$x_2x_3x_4 = x_1$	$x_1x_2x_3x_4$ = Interc.
Set 1												
1	-	-	-	-	+	+	+	-	-	-	-	+
2	-	-	+	+	+	-	-	+	+	-	-	+
3	-	+	-	+	-	+	-	+	-	+	-	+
4	-	+	+	-	-	-	+	-	+	+	-	+
5	+	-	-	+	-	-	+	+	-	-	+	+
6	+	-	+	-	-	+	-	-	+	-	+	+
7	+	+	-	-	+	-	-	-	-	+	+	+
8	+	+	+	+	+	+	+	+	+	+	+	+
Vignette-number	x_1	x_2	x_3	x_4	$x_1x_2 = -x_3x_4$	$x_1x_3 = -x_2x_4$	$x_1x_4 = -x_2x_3$	$x_1x_2x_3 = -x_4$	$x_1x_2x_4 = -x_3$	$x_1x_3x_4 = -x_2$	$x_2x_3x_4 = -x_1$	$x_1x_2x_3x_4$ = -Interc.
Set 2												
1	-	-	-	+	+	+	-	-	+	+	+	-
2	-	-	+	-	+	-	+	+	-	+	+	-
3	-	+	-	-	-	+	+	+	+	-	+	-
4	-	+	+	+	-	-	-	-	-	-	+	-
5	+	-	-	-	-	-	-	+	+	+	-	-
6	+	-	+	+	-	+	+	-	-	+	-	-
7	+	+	-	+	+	-	+	-	+	-	-	-
8	+	+	+	-	+	+	-	+	-	-	-	-

Operationalizations and Data

Factorial Designs:

a) **2 half fractional factorial Designs:**
Selecting either
Set 1 *or* Set 2
Aliasing:
Confounding within a vignette set

b) **1 confounded factorial Design**
Selecting both
Set 1 *and* Set 2

	Factors				Confounding Structure							
Vignette-number	x_1	x_2	x_3	x_4	$x_1x_2 = x_3x_4$	$x_1x_3 = x_2x_4$	$x_1x_4 = x_2x_3$	$x_1x_2x_3 = x_4$	$x_1x_2x_4 = x_3$	$x_1x_3x_4 = x_2$	$x_2x_3x_4 = x_1$	$x_1x_2x_3x_4$ = Interc.
Set 1												
1	-	-	-	-	+	+	+	-	-	-	-	+
2	-	-	+	+	+	-	-	+	+	-	-	+
3	-	+	-	+	-	+	-	+	-	+	-	+
4	-	+	+	-	-	-	+	-	+	+	-	+
5	+	-	-	+	-	-	+	+	-	-	+	+
6	+	-	+	-	-	+	-	-	+	-	+	+
7	+	+	-	-	+	-	-	-	-	+	+	+
8	+	+	+	+	+	+	+	+	+	+	+	+
Vignette-number	x_1	x_2	x_3	x_4	$x_1x_2 = -x_3x_4$	$x_1x_3 = -x_2x_4$	$x_1x_4 = -x_2x_3$	$x_1x_2x_3 = -x_4$	$x_1x_2x_4 = -x_3$	$x_1x_3x_4 = -x_2$	$x_2x_3x_4 = -x_1$	$x_1x_2x_3x_4$ = -Interc.
Set 2												
1	-	-	-	+	+	+	-	-	+	+	+	-
2	-	-	+	-	+	-	+	+	-	+	+	-
3	-	+	-	-	-	+	+	+	+	-	+	-
4	-	+	+	+	-	-	-	-	-	-	+	-
5	+	-	-	-	-	-	-	+	+	+	-	-
6	+	-	+	+	-	+	+	-	-	+	-	-
7	+	+	-	+	+	-	+	-	+	-	-	-
8	+	+	+	-	+	+	-	+	-	-	-	-

Operationalizations and Data

Factorial Designs:

a) **2 half fractional factorial Designs:**
Selection of either Set 1 *or* Set 2
Aliasing:
Confounding within a vignette set

b) **1 confounded factorial Design**
Selection of both Set 1 *and* Set 2
Confounding:
Confounding across vignette sets

	Factors				Confounding Structure							
Vignette-number	x_1	x_2	x_3	x_4	$x_1x_2 = x_3x_4$	$x_1x_3 = x_2x_4$	$x_1x_4 = x_2x_3$	$x_1x_2x_3 = x_4$	$x_1x_2x_4 = x_3$	$x_1x_3x_4 = x_2$	$x_2x_3x_4 = x_1$	$x_1x_2x_3x_4$ = Interc.
Set 1												
1	-	-	-	-	+	+	+	-	-	-	-	+
2	-	-	+	+	+	-	-	+	+	-	-	+
3	-	+	-	+	-	+	-	+	-	+	-	+
4	-	+	+	-	-	-	+	-	+	+	-	+
5	+	-	-	+	-	-	+	+	-	-	+	+
6	+	-	+	-	-	+	-	-	+	-	+	+
7	+	+	-	-	+	-	-	-	-	+	+	+
8	+	+	+	+	+	+	+	+	+	+	+	+
Vignette-number	x_1	x_2	x_3	x_4	$x_1x_2 = -x_3x_4$	$x_1x_3 = -x_2x_4$	$x_1x_4 = -x_2x_3$	$x_1x_2x_3 = -x_4$	$x_1x_2x_4 = -x_3$	$x_1x_3x_4 = -x_2$	$x_2x_3x_4 = -x_1$	$x_1x_2x_3x_4$ = -Interc.
Set 2												
1	-	-	-	+	+	+	-	-	+	+	+	-
2	-	-	+	-	+	-	+	+	-	+	+	-
3	-	+	-	-	-	+	+	+	+	-	+	-
4	-	+	+	+	-	-	-	-	-	-	+	-
5	+	-	-	-	-	-	-	+	+	+	-	-
6	+	-	+	+	-	+	+	-	-	+	-	-
7	+	+	-	+	+	-	+	-	+	-	-	-
8	+	+	+	-	+	+	-	+	-	-	-	-

Operationalizations and Data

Confounded D-efficient Design (set size 10):

		D-efficient Design 1					D-efficient Design 2			
Variable:		X_1	X_2	X_3	X_4		X_1	X_2	X_3	X_4
Balance:		4/6	4/6	5/5	5/5		4/6	5/5	5/5	5/5
Correlations:	X_1		.167	.000	.000	X_1		.000	.000	.000
	X_2			.000	.000	X_2			.200	.200
	X_3				-.200	X_3				.200

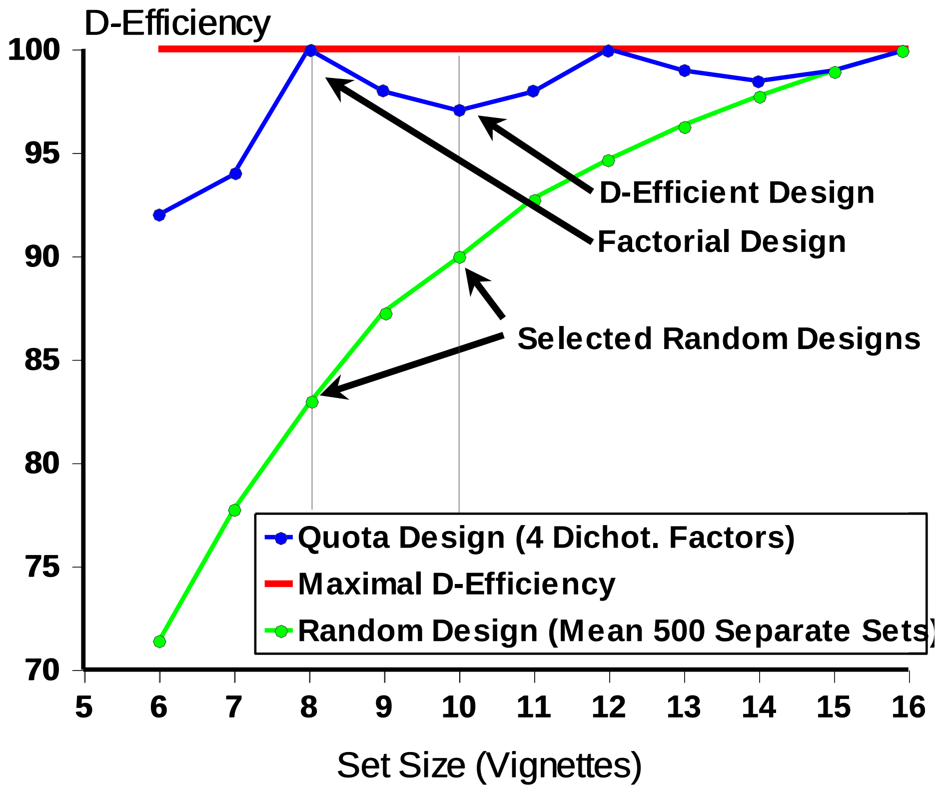
Balance: Relationship between the two levels "-1" and "+1";
Selected initial design: Design 1 (D1, D-Efficiency: 97,032):
D1: Set 1: Vignettes 1 to 8, Set 2: Vignettes 7 and 8, D5: Set 1: Vignettes 3 and 4, Set 2: Vignettes 1 to 8,
D2: Set 1: Vignettes 1 to 8, Set 2: Vignettes 3 and 4, D6: Set 1: Vignettes 5 and 6, Set 2: Vignettes 1 to 8,
D3: Set 1: Vignettes 1 to 8, Set 2: Vignettes 5 and 6, D7: Set 1: Vignettes 7 and 8, Set 2: Vignettes 1 to 8,
D4: Set 1: Vignettes 1 to 8, Set 2: Vignettes 1 and 2, D8: Set 1: Vignettes 1 and 2, Set 2: Vignettes 1 to 8.

Generating D2 to D8: Permuting (changing) the assignment between the levels of the vignette characteristics and the respective levels of the variables of the selected D-efficient design.

D-Efficiency of the confounded D-efficient Design (incl. all interaction terms: 100)
(main effect only model: D-Efficiency of 100 already reached by using D1 to D4 or D5 to D8)

Operationalizations and Data

Random Designs (without replacement):



D-Efficiency (qualitative factors):

- completely **heterogeneous** answer behavior: green line
- completely **homogeneous** answer behavior (OLS-regression): asymptotically approaching the red line (the same applies to the confounded D-efficient Design)

Operationalizations and Data

Design Comparison:

Set size of 8 vignettes:

- **Confounded Factorial Design**
  (2 balanced half fractional factorial Designs: D-Efficiency: 100)
- **Random Design** (without replacement)

Set size of 10 vignettes:

- **Confounded D-efficient Design**
  (D-Efficiency of each of each separate vignette set: 97.032)
- **Random Design** (without replacement)

Vignette sets (Quota Design) and vignettes (Random Design) were respectively assigned randomly to the respondents.
To get different assignments, this procedure was **repeated 49 times**.

Empirical Results

		Full Factorial Design	Simple Random Design (50 Samples)		Confounded Factorial Design (50 Samples)				Simple Random Design (50 Samples)		Confounded D-Efficient Design (50 Samples)	
Set Size	**n**	16	8		8				10		10	
Respondents	**n**	132	132		132				132		132	
Vignettes	**n**	2112	1056		1056				1320		1320	
			Mean	Std.-Dev.	Mean	Std.-Dev.	Mean: Set Effect	Std.-Dev.	Mean	Std.-Dev.	Mean	Std.-Dev.
γ Intercept		3.515	3.514	.029	3.514	.022	*-.110*	.082	3.511	.025	3.519	.014
γ Gender (Female)		.105	.109	.038	.114	.026			.113	.023	.109	.023
γ Order		.428	.430	.031	.430	.023	*-.095*	.065	.429	.032	.427	.022
γ Government		.668	.671	.027	.674	.026	*-.132*	.043	.671	.024	.668	.020
γ Price		.320	.321	.031	.321	.018	*-.078*	.038	.320	.028	.317	.019
γ Speech		1.107	1.113	.033	1.106	.025	*-.045*	.058	1.102	.023	1.104	.019
σ Intercept		.078	.085	.004	.081	.002	.081	.002	.082	.003	.080	.002
σ Gender (Female)		.077	.083	.004	.080	.003			.080	.003	.079	.002
σ Order		.068	.074	.003	.072	.002	.072	.002	.072	.002	.072	.002
σ Government		.049	.058	.002	.055	.003	.055	.003	.054	.002	.053	.002
σ Price		.044	.054	.002	.051	.002	.051	.002	.049	.002	.049	.002
σ Speech		.054	.062	.003	.058	.002	.058	.002	.059	.002	.058	.002
t Intercept		44.924	41.624	1.885	43.423	1.254	-1.357	1.016	43.027	1.322	43.861	1.137
t Gender (Female)		1.372	1.322	.482	1.424	.328			1.416	.297	1.384	.300
t Order		6.307	5.800	.518	5.960	.376	-1.318	.906	5.959	.490	5.971	.357
t Government		13.767	11.671	.554	12.327	.908	-2.419	.786	12.341	.675	12.561	.648
t Price		7.313	5.935	.589	6.362	.381	-1.552	.778	6.478	.579	6.547	.433
t Speech		20.646	18.038	1.118	19.021	.758	-.762	.991	18.777	.789	19.188	.732

Empirical Results

		Full Factorial Design	Simple Random Design (50 Samples)		Confounded Factorial Design (50 Samples)				Simple Random Design (50 Samples)		Confounded D-Efficient Design (50 Samples)	
Set Size	n	16	8		8				10		10	
Rspondents	n	132	132		132				132		132	
Vignettes	n	2112	1056		1056				1320		1320	
			Mean	Std.-Dev.	Mean	Std.-Dev.	Mean: Set-Effect	Std.-Dev.	Mean	Std.-Dev.	Mean	Std.-Dev.
τ_{00} Intercept		.708	.715	.088	.661	.049			.707	.056	.683	.045
τ_{11} Order		.513	.504	.059	.491	.040			.517	.038	.515	.042
τ_{22} Government		.218	.209	.031	.200	.038			.222	.030	.212	.029
τ_{33} Price		.159	.157	.033	.139	.026			.152	.023	.154	.023
τ_{44} Speech		.286	.278	.046	.250	.027			.287	.034	.282	.027
σ^2		1.492	1.494	.117	1.590	.091			1.484	.059	1.537	.060
χ^2_{U00} Intercept		1117.399	480.779	62.105	561.470	46.023			631.731	58.515	670.856	44.576
χ^2_{U11} Order		852.117	372.845	35.095	452.881	33.059			496.000	35.679	541.872	40.957
χ^2_{U22} Government		436.589	228.891	18.550	261.856	27.865			289.293	27.840	300.424	26.114
χ^2_{U33} Price		354.125	207.711	22.790	221.675	18.980			240.638	20.305	254.795	21.400
χ^2_{U44} Speech		532.550	267.545	33.554	294.477	22.641			333.976	34.769	358.390	25.550
R_1^2		.368	.372	.018	.378	.014			.368	.016	.366	.011
R_2^2		.013	.132	.050	.025	.024			.097	.035	.033	.028
Iterations		5.000	26.880	11.508	6.320	2.938			16.820	4.241	13.080	2.656

Conclusion

Confounded Factorial Design (balanced, orthogonal):

- highest D-Efficiency: most reliable design with highest internal validity (independent of the heterogeneity of the answer behavior of the respondents)
- *however*: for more complex research questions such a design rarely exists within the limits of a reasonable set size

Confounded D-efficient Design:

- completely **heterogeneous** answer behavior:
  - same D-Efficiency as a simple Quota Design,
  - higher D-Efficiency as a simple Random Design
- increasingly **homogeneous** answer behavior:
  - increasingly higher D-Efficiency as a simple Quota Design,
  - Random Design comes closer to the D-Efficiency of a Confounded D-Efficient Design
- *however*: constructing such a Design for more complex research questions is rather time-consuming

Not applicable: in cases where *logically impossible combinations* have to be excluded (for instance, a physician with only an eighth-grade education)

Conclusion

Random Design (without replacement):

- completely **homogeneous** answer behavior (very unlikely):
  - very high D-efficiency: highly reliable design with very high internal validity
- increasingly **heterogeneous** answer behavior (likely)
  - especially for small set sizes: low D-efficiency and for that reason lower internal validity as Quota Designs (*no systematic bias*)

Simple Quota Designs (Factional Factorial Designs, D-Efficient Designs):

- *Applicable*: **small vignette sets a**nd **heterogeneous answer behavior** (representative surveys)
- *Predisposition*: the aliased interaction effects are negligible in comparison to the affected b-coefficients included in the multilevel model
- *however*: in contrast to other designs it is impossible to test afterwards whether non-negligible interaction effects exist which were not included when the design was constructed.

Thank You for Your Attention!

Dülmer, Hermann (forthcoming): The Factorial Survey. Design Selection and its Impact on Reliability and Internal Validity. Sociological Methods and Research.

Empirical Results

		Full Factorial Design		Simple Random Design (50 Samples)		Confounded Factorial Design (50 Samples)		Simple Random Design (50 Samples)		Confounded D-Efficient Design (50 Samples)	
Set Size	n	16		8		8		10		10	
Respondents	n	132		132		132		132		132	
Vignettes	n	2112		1056		1056		1320		1320	
		b	t	b Mean	t Mean	b Mean	t Mean	b Mean	t Mean	b Mean	t Mean
Intercept		3.515	44.924**	3.516	41.601	3.515	43.222	3.509	43.020	3.519	43.932
Gender (Female)		.105	1.372	.109	1.322	.113	1.412	.113	1.416	.109	1.385
Or (Order)		.428	6.307**	.429	5.769	.432	5.945	.427	5.950	.427	6.000
Go (Government)		.668	13.766**	.670	11.600	.674	12.247	.669	12.323	.668	12.714
Pr (Prise)		.320	7.311**	.322	5.952	.321	6.319	.319	6.496	.317	6.589
Sp (Speech)		1.107	20.645**	1.115	18.040	1.106	18.913	1.102	18.847	1.105	19.286
Or x Go		-.033	-1.271	-.038	-.899	-.031	-.832	-.036	-1.015	-.026	-0.748
Or x Pr		.022	.866	.031	.736	.019	.487	.024	.673	.024	.700
Or x Sp		.120	4.661**	.122	2.898	.118	3.093	.120	3.375	.122	3.601
Go x Pr		-.099	-3.851**	-.097	-2.446	-.099 [1)]	-2.604	-.108	-3.022	-.094	-2.768
Go x Sp		.027	1.050	.022	.546	.029 [1)]	.750	.027	.775	.033	.972
Pr x Sp		-.030	-1.087	-.032	-.756	-.029 [1)]	-.760	-.025	-.703	-.029	-.852
Or x Go x Pr		.053	2.045*	.054	1.274	.047 [1)]	.775	.048	1.358	.056	1.449
Or x Go x Sp		.080	3.114**	.073	1.748	.077 [1)]	1.531	.085	2.361	.079	2.105
Or x Pr x Sp		.129	5.030**	.128	3.049	.132 [1)]	2.397	.131	3.686	.129	3.222
Go x Pr x Sp		.107	4.145**	.108	2.579	.093 [1)]	1.293	.105	2.957	.106	2.491
Or x Go x Pr x Sp		.099	3.851**	.097	2.325	.109 [1)]	1.347	.099	2.805	.093	2.166

Note: *: $p \leq 0.05$, **: $p \leq 0.05$; 1) Set effects; only the intercept and slope of all main effects are estimated with their own variance component (variance components of all interaction effects turned out to be insignificant for the Full Factorial Design); consequence: t-values of the set effects are underestimated since they cannot be fixed independently of the intercept/main effect with which they are confounded. This explains why the t-values for the three- and four-way interaction effects are on average lower for the Confounded Factorial Design than for the Simple Random Design of set size 8.

Random and Quota Designs

Formula for Calculating the D-Efficiency:

$$\text{D-Efficency} = 100 \cdot \frac{1}{N_D \cdot \left|(X' \cdot X)^{-1}\right|^{\frac{1}{p}}} = 100 \cdot \left(\frac{1}{N_D} \cdot \left|X' \cdot X\right|^{\frac{1}{p}} \right)$$

N_D: Set Size

X‘•X: Information Matrix (X-Variables Including the Intercept)

p: Number of Estimated β-Coefficients (Including the Intercept)

SPSS Syntax-File for Calculating D-Efficiency

Half Fractional Factorial Design (Set 1):

```
MATRIX.
comp des_x={
 1 , -1  , -1 ,  -1 ,  -1  ;
 1 , -1  , -1 ,   1 ,   1  ;
 1 , -1  ,  1 ,  -1 ,   1  ;
 1 , -1  ,  1 ,   1 ,  -1  ;
 1 ,  1  , -1 ,  -1 ,   1  ;
 1 ,  1  , -1 ,   1 ,  -1  ;
 1 ,  1  ,  1 ,  -1 ,  -1  ;
 1 ,  1  ,  1 ,   1 ,   1
}.
comp des_xi={
  1  ,  1 ,  1 ,  1 ,  1 ,  1 ,  1  , 1 ;
 -1  , -1 , -1 , -1 ,  1 ,  1 ,  1  , 1 ;
 -1  , -1 ,  1 ,  1 , -1 , -1 ,  1  , 1 ;
 -1  ,  1 , -1 ,  1 , -1 ,  1 , -1  , 1 ;
 -1  ,  1 ,  1 , -1 ,  1 , -1 , -1  , 1
 }.
comp info_xx= des_xi * des_x.
print info_xx.
end matrix.
```

```
MATRIX.
comp covm={
 8 , 0 , 0 , 0 , 0 ;
 0 , 8 , 0 , 0 , 0 ;
 0 , 0 , 8 , 0 , 0 ;
 0 , 0 , 0 , 8 , 0 ;
 0 , 0 , 0 , 0 , 8
}.
comp fpeff=Det(covm).
comp deffic=100*((1/8)*(fpeff**(1/5))).
print deffic.
end matrix.
```

Random and Quota Designs

Orthogonal Contrast Coding:

	Number of Levels of a Factor					
	2	3		4		
a	1	1	-1	1	-1	-1
b	-1	0	2	0	2	-1
c		-1	-1	0	0	3
d				-1	-1	-1

Standardized Orthogonal Contrast Coding:

	Number of Levels of a Factor					
	2	3		4		
a	1.00	1.22	-.71	1.41	-.82	-.58
b	-1.00	.00	1.41	.00	1.63	-.58
c		-1.22	-.71	.00	.00	1.73
d				-1.41	.82	-.58

Random and Quota Designs

Empirical Bayes Estimator (EB) for the ANOVA-Model:

$$\hat{\beta}_{0j}^{EB} = \lambda_j \cdot \hat{\beta}_{0j}^{OLS} + (1 - \lambda_j) \cdot \hat{\gamma}_{00}$$

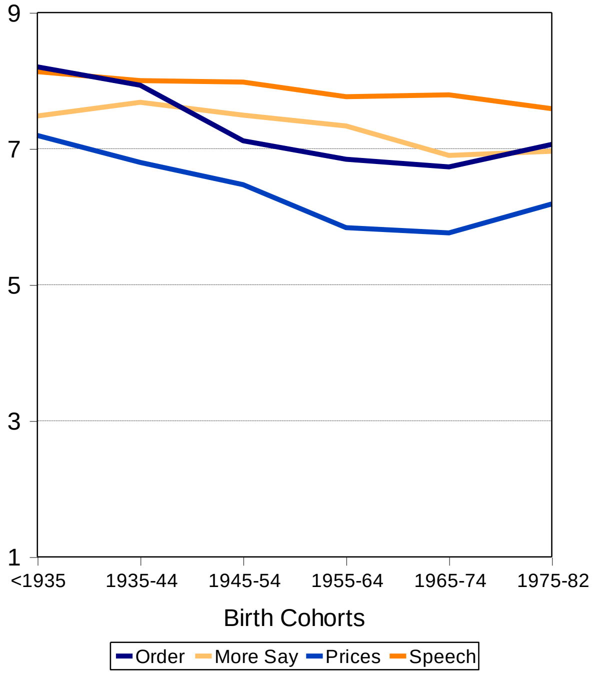
$$\lambda_j = \frac{\tau_{00}}{\tau_{00} + (\sigma^2 / n_j)}$$

Random and Quota Designs

Empirical Comparison: Rating and Ranking (Representative Survey, Cologne 2001)

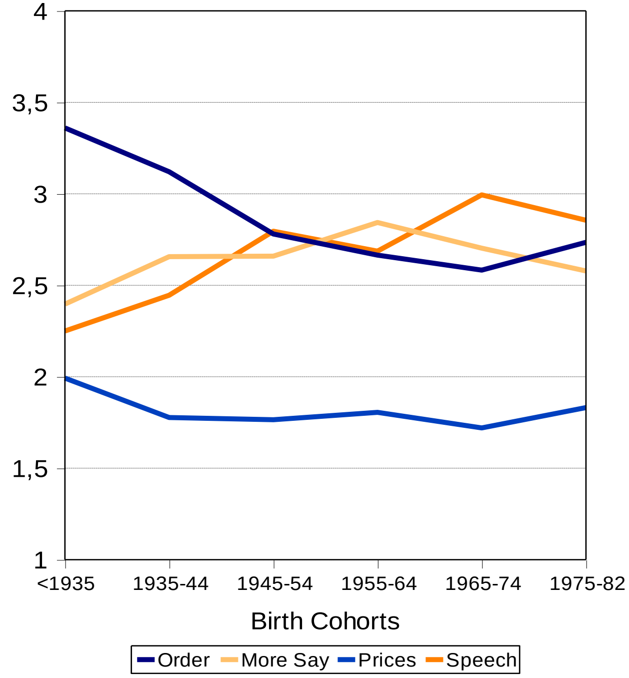
Rating

(n=897 of 980, 91.5%)



Ranking (reversed scale)

(n=915 of 980, 93.4%)



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Empirical Comparison: Rating and Ranking (Representative Survey, Cologne 2001)

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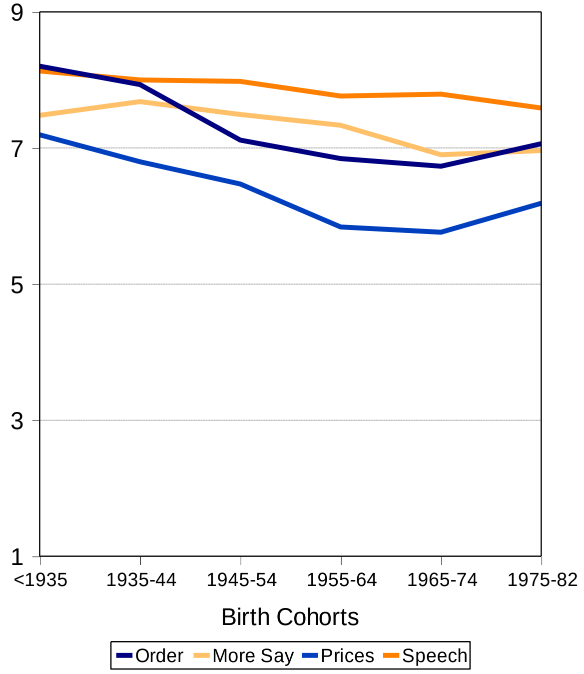
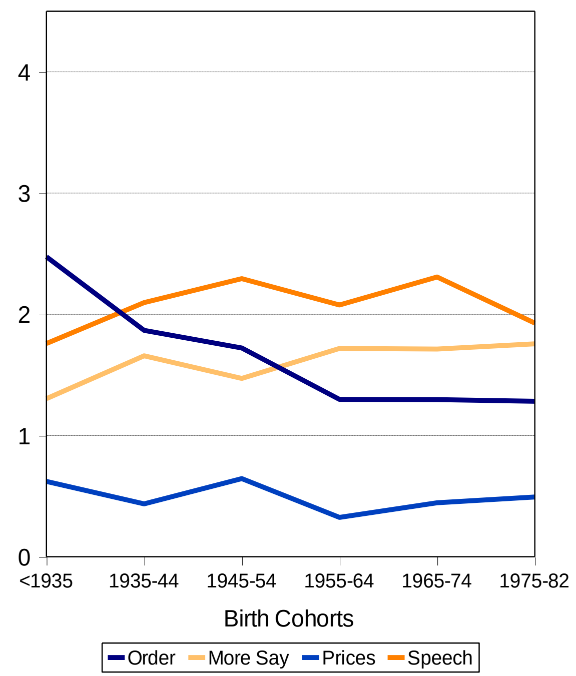


Vignette-Method

(n=415 of 478, 86.8%)



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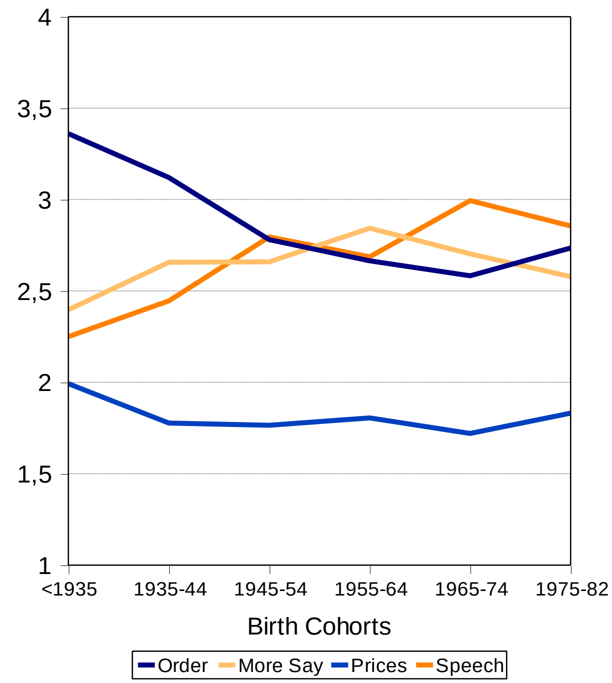

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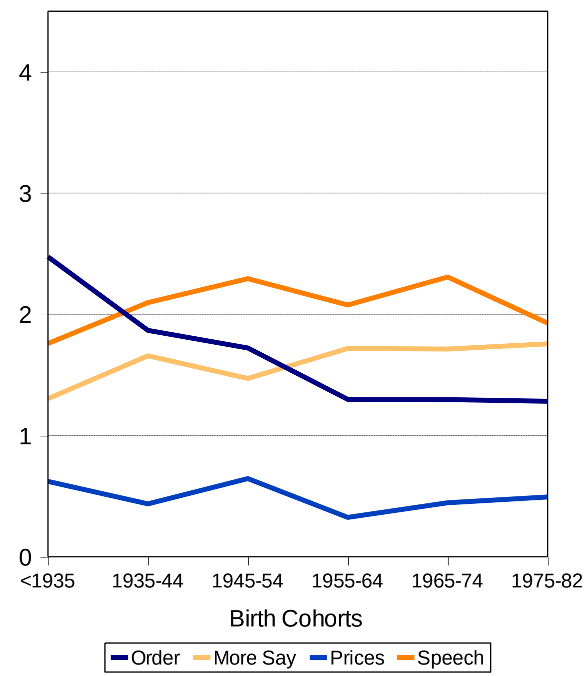

Empirical Results

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Vignettes	n	2112		1056		1056		1320		1320	
		b	t	b Mean	t Mean	b Mean	t Mean	b Mean	t Mean	b Mean	t Mean
Intercept		3.515	44.924**	3.516	41.601	3.515	43.222	3.509	43.020	3.519	43.932
Gender (Female)		.105	1.372	.109	1.322	.113	1.412	.113	1.416	.109	1.385
Or (Order)		.428	6.307**	.429	5.769	.432	5.945	.427	5.950	.427	6.000
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Or x Go		-.033	-1.271	-.038	-.899	-.031	-.832	-.036	-1.015	-.026	-0.748
Or x Pr		.022	.866	.031	.736	.019	.487	.024	.673	.024	.700
Or x Sp		.120	4.661**	.122	2.898	.118	3.093	.120	3.375	.122	3.601
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Or x Go x Pr x Sp		.099	3.851**	.097	2.325	.109 1)	1.347	.099	2.805	.093	2.166

Note: *: $p \leq 0.05$, **: $p \leq 0.01$; 1) Set effects; only the intercept and slope of all main effects are estimated with their own variance component (variance components of all interaction effects turned out to be insignificant for the Full Factorial Design); consequence: t-values of the set effects are underestimated since they cannot be fixed independently of the intercept/main effect with which they are confounded. This explains why the t-values for the three- and four-way interaction effects are on average lower for the Confounded Factorial Design than for the Simple Random Design of set size 8.

Empirical Results

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Set Size	n	16	8		8				10		10	
Respondents	n	132	132		132				132		132	
Vignettes	n	2112	1056		1056				1320		1320	
			Mean	Std.-Dev.	Mean	Std.-Dev.	Mean: Set Effect	Std.-Dev.	Mean	Std.-Dev.	Mean	Std.-Dev.
γ Intercept		3.515	3.514	.029	3.514	.022	*-.110*	.082	3.511	.025	3.519	.014
γ Gender (Female)		.105	.109	.038	.114	.026			.113	.023	.109	.023
γ Order		.428	.430	.031	.430	.023	*-.095*	.065	.429	.032	.427	.022
γ Government		.668	.671	.027	.674	.026	*-.132*	.043	.671	.024	.668	.020
γ Price		.320	.321	.031	.321	.018	*-.078*	.038	.320	.028	.317	.019
γ Speech		1.107	1.113	.033	1.106	.025	*-.045*	.058	1.102	.023	1.104	.019
σ Intercept		.078	.085	.004	.081	.002	.081	.002	.082	.003	.080	.002
σ Gender (Female)		.077	.083	.004	.080	.003			.080	.003	.079	.002
σ Order		.068	.074	.003	.072	.002	.072	.002	.072	.002	.072	.002
σ Government		.049	.058	.002	.055	.003	.055	.003	.054	.002	.053	.002
σ Price		.044	.054	.002	.051	.002	.051	.002	.049	.002	.049	.002
σ Speech		.054	.062	.003	.058	.002	.058	.002	.059	.002	.058	.002
t Intercept		44.924	41.624	1.885	43.423	1.254	-1.357	1.016	43.027	1.322	43.861	1.137
t Gender (Female)		1.372	1.322	.482	1.424	.328			1.416	.297	1.384	.300
t Order		6.307	5.800	.518	5.960	.376	-1.318	.906	5.959	.490	5.971	.357
t Government		13.767	11.671	.554	12.327	.908	-2.419	.786	12.341	.675	12.561	.648
t Price		7.313	5.935	.589	6.362	.381	-1.552	.778	6.478	.579	6.547	.433
t Speech		20.646	18.038	1.118	19.021	.758	-.762	.991	18.777	.789	19.188	.732

Empirical Results

		Full Factorial Design	Simple Random Design (50 Samples)		Confounded Factorial Design (50 Samples)				Simple Random Design (50 Samples)		Confounded D-Efficient Design (50 Samples)	
Set Size	n	16	8		8				10		10	
Rspondents	n	132	132		132				132		132	
Vignettes	n	2112	1056		1056				1320		1320	
			Mean	Std.-Dev.	Mean	Std.-Dev.	Mean: Set-Effect	Std.-Dev.	Mean	Std.-Dev.	Mean	Std.-Dev.
τ_{00} Intercept		.708	.715	.088	.661	.049			.707	.056	.683	.045
τ_{11} Order		.513	.504	.059	.491	.040			.517	.038	.515	.042
τ_{22} Government		.218	.209	.031	.200	.038			.222	.030	.212	.029
τ_{33} Price		.159	.157	.033	.139	.026			.152	.023	.154	.023
τ_{44} Speech		.286	.278	.046	.250	.027			.287	.034	.282	.027
σ^2		1.492	1.494	.117	1.590	.091			1.484	.059	1.537	.060
χ^2_{U00} Intercept		1117.399	480.779	62.105	561.470	46.023			631.731	58.515	670.856	44.576
χ^2_{U11} Order		852.117	372.845	35.095	452.881	33.059			496.000	35.679	541.872	40.957
χ^2_{U22} Government		436.589	228.891	18.550	261.856	27.865			289.293	27.840	300.424	26.114
χ^2_{U33} Price		354.125	207.711	22.790	221.675	18.980			240.638	20.305	254.795	21.400
χ^2_{U44} Speech		532.550	267.545	33.554	294.477	22.641			333.976	34.769	358.390	25.550
R_1^2		.368	.372	.018	.378	.014			.368	.016	.366	.011
R_2^2		.013	.132	.050	.025	.024			.097	.035	.033	.028
Iterations		5.000	26.880	11.508	6.320	2.938			16.820	4.241	13.080	2.656

This report was presented at the training methodological workshop
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http://lcsr.hse.ru/en/seminar_m2015

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31 марта – 6 апреля 2015 года – Турция.

http://lcsr.hse.ru/seminar_m2015