A new statistic to detect segmentation or unequal variance in 2-Alternative Choice (2-AC) testing

Rune H B Christensen[1,*] John M Ennis[2] Daniel M Ennis[2]
Per B Brockhoff[1]

[1]DTU Informatics, IMM, Section for Statistics, Technical University of Denmark
[2]The Institute for Perception, Richmond, VA, USA

[*]Contact author: rhbc@imm.dtu.dk

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DTU Informatics
Department of Informatics and Mathematical Modelling

Paired preference testing

2 products :

- A Chocolate bar (standard)
- B Chocolate bar with darker chocolate

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2-Alternative Forced Choice (2-AFC):

- Do you prefer A or B?

Prefer A	Prefer B
☐	☐

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- A Chocolate bar (standard)
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2-Alternative Forced Choice (2-AFC):

- Do you prefer A or B?

Prefer A	Prefer B
☐	☐

2-Alternative ~~Forced~~ Choice (2-AC):

- Do you prefer A or B, or do you have no preference?

Prefer A	No Preference	Prefer B
☐	☐	☐

Paired preference with a *no preference* option

Terminology:

Paired preference with a *no preference* option

Terminology: *No preference* $\sim$ *No difference* $\sim$ Ties

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Why avoid a *no preference* option?

- Statistical methods less well-known

Placebo experiments and identicality norms

Consider the data:

	Prefer A	No Preference	Prefer B	Total
All counts	90	20	90	200

Placebo experiments and identicality norms

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- What if there are two opposing segments?

Placebo experiments and identicality norms

Consider the data:

	Prefer A	No Preference	Prefer B	Total
All counts	90	20	90	200
Segment 1	8	10	82	100
Segment 2	82	10	8	100

- Are there no differences wrt. preference in the population?
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Placebo experiments and identicality norms

Consider the data:

	Prefer A	No Preference	Prefer B	Total
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Segment 1	8	10	82	100
Segment 2	82	10	8	100

- Are there no differences wrt. preference in the population?
- What if there are two opposing segments?

Ennis and Ennis (2012) suggest:

1. Perform placebo experiment
2. Estimate the *identicality norm*:
   The expected proportion of counts for identical products

Ennis, D. M. and J. M. Ennis (2012). Accounting for no difference/preference responses or ties in choice experiments. *Food Quality and Preference 23*, 13-17.

Example: Comparing data with an identicality norm

Ennis' Approach:

	Prefer A	No Preference	Prefer B	Total
Data	25	15	60	100
Identicality norm	0.4	0.2	0.4	—

Example: Comparing data with an identicality norm

Ennis' Approach:

	Prefer A	No Preference	Prefer B	Total
Data	25	15	60	100
Identicality norm	0.4	0.2	0.4	—

$$\begin{aligned} X_2^2 &= (25-40)^2/40 + (15-20)^2/20 + (60-40)^2/40 \\ &= 5.625 + 1.250 + 10.00 = 16.875 \\ p\text{-value} &= 0.00022 \end{aligned}$$

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$$= 5.625 + 1.250 + 10.00 = 16.875$$
$$p\text{-value} = 0.00022$$

- Assumes identicality norm known without error
- Uncertainty in the placebo experiment not taken into account!

Example: Comparing data with an identicality norm

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Assume $n = 100$ in placebo experiment:

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Placebo data	40	20	40	100

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Assume $n = 100$ in placebo experiment:

	Prefer A	No Preference	Prefer B	Total
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Expected counts:

	Prefer A	No Preference	Prefer B	Total
Data	32.5	17.5	50	100
Placebo data	32.5	17.5	50	100

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	Prefer A	No Preference	Prefer B	Total
Data	32.5	17.5	50	100
Placebo data	32.5	17.5	50	100

The standard (genuine) Pearson χ^2 test:

$$X_2^2 = (25 - 32.5)^2/32.5 + (40 - 32.5)^2/32.5 + \ldots + (40 - 50)^2/50 = 8.18$$

p-value $= 0.0168$ (previous p-value $= 0.00022$)

Effect of sample size in placebo experiment

Standard Pearson test on 2×3 table:

$n_{placebo}$	χ^2_2 statistic	p-value
20	2.80	0.24619
50	5.50	0.06393
100	8.18	0.01677
1000	15.15	0.00051
10^9	16.87	0.00022

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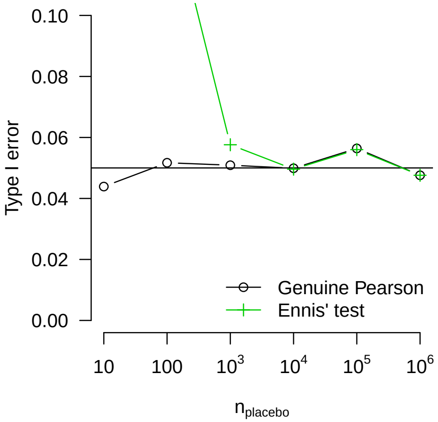

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- High power
- Insightful interpretation
- Easy to compute

Approach

1. Consider 5 test statistics
2. Compare the power of the 5 tests in a simulation study

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Parameterization and test statistics

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Placebo	$p_0(1 - s_0)$	s_0	$(1 - p_0)(1 - s_0)$

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Test statistics:

Test	Null Hypothesis	Alternative Hypothesis	df
Tie effects	$s_0 = s_1$	$s_0 \neq s_1$	1

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Tie effects	$s_0 = s_1$	$s_0 \neq s_1$	1
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Genuine Pearson	$s_0 = s_1$ and $p_0 = p_1$	$s_0 \neq s_1$ or $p_0 \neq p_1$	2

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Pooled Test	$s_0 = s_1$ and $p_1 = 0.5$	$s_0 \neq s_1$ or $p_1 \neq 0.5$	2

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Settings for power simulations

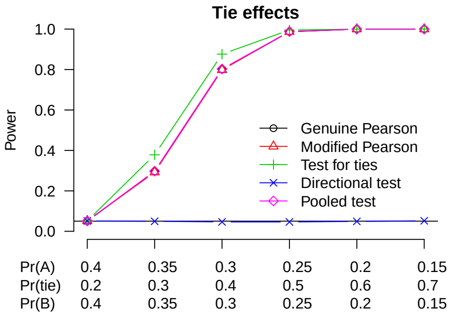
Placebo experiment (true identicality norm):

Prefer A	No Preference	Prefer B
0.4	0.2	0.4

Power simulations in 6 settings:

	Structures in preference data		
Placebo sample size	Tie effects	Directional effects	Joint effects
100	1A	1B	1C
1.000.000	2A	2B	2C

- $n_{preference} = 100$
- 10.000 simulations at each point


Tie effects
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1.0
0.8
0.6
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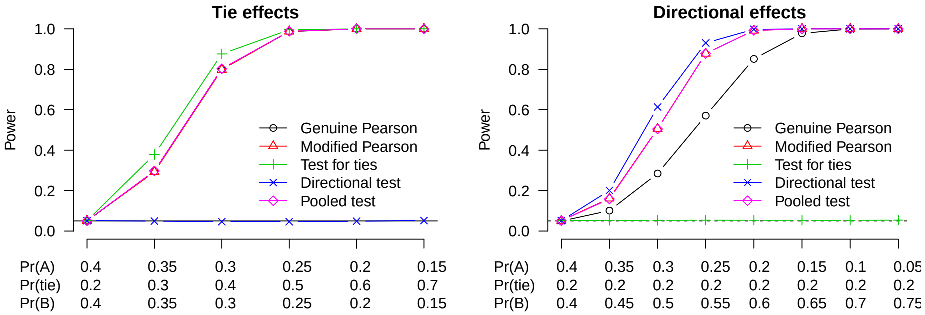
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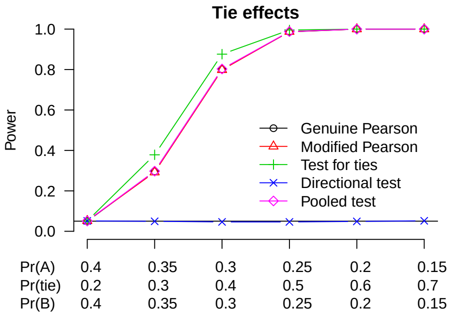
Pr(tie) 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2
Pr(B) 0.4 0.45 0.5 0.55 0.6 0.65 0.7 0.75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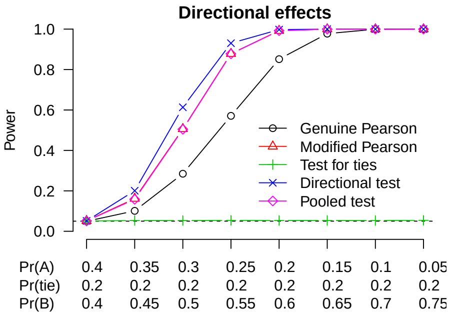
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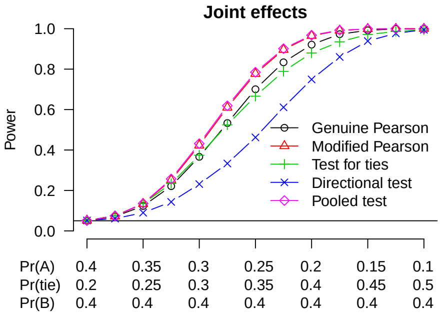
Joint effects
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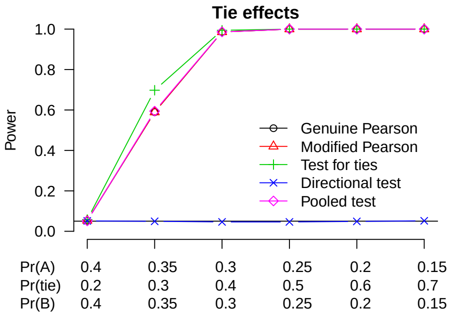
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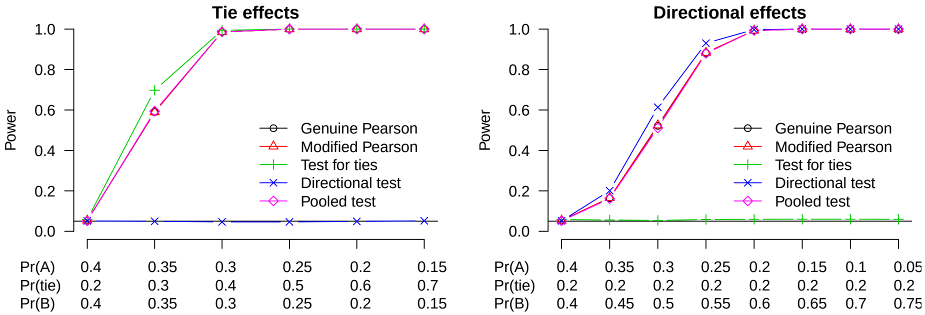
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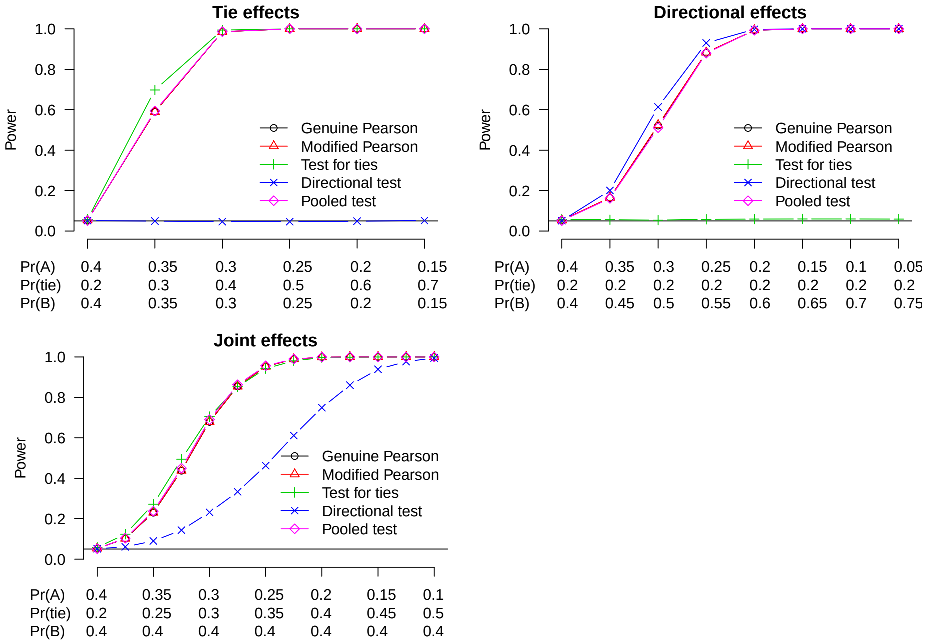

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Example — new insights

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Preference exp.	37	12	51	100

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ANOVA-like analysis:

Test	χ^2	df	p-value
Pooled test	7.00	2	0.030
Tie effects	4.78	1	0.029
Directional effects	2.23	1	0.136

Example — new insights

Example data:

	Prefer A	No Preference	Prefer B	Total
Placebo exp.	81	45	74	200
Preference exp.	37	12	51	100

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Test	χ^2	df	p-value
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Tie effects	4.78	1	0.029
Directional effects	2.23	1	0.136
Modified Pearson	7.20	2	0.027

Final points

Conclusions and recommendations:

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- What may cause tie-effects?
  - Segmentation
  - Heterogeneity in preference
  - Unequal variances in the underlying perceptual distributions

A new statistic to detect segmentation or unequal variance in 2-Alternative Choice (2-AC) testing

Rune H B Christensen[1,*] John M Ennis[2] Daniel M Ennis[2]
Per B Brockhoff[1]

[1] DTU Informatics, IMM, Section for Statistics, Technical University of Denmark
[2] The Institute for Perception, Richmond, VA, USA

[*] Contact author: rhbc@imm.dtu.dk

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DTU Informatics
Department of Informatics and Mathematical Modelling