Replicated tetrad simulations for sensitivity quantification and panelist selection

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Purpose

Thurstonian-derived models are used widely for interpretation of sensory discrimination test results. True product effects δ_t, and estimates d_t', are signal-to-noise ratios, for which measurement sensitivity provides important context. **A discrimination panel's sensitivity is often defined descriptively (e.g. "employees").**

Our objective: **Define panel sensitivity quantitatively (e.g. "employees with sensitivity 1.2 ± 0.2 for samples in the product category").**

Method

In real-world data, true parameters remain unknown to the researcher. Simulation studies permit known values against which sensitivity and d' estimates can be evaluated. An extensive tetrad test simulation study was conducted. Details are provided in the right panel.

Results

- $Bias(d_t')$, $Var(d_t')$, and $MSE(d_t')$ comparable for the different panelist selection methods for reasonable power (>0.8).
- $\hat{\gamma}$ was low (rarely >0.3).
- Power increased with the number of observations. Increasing reps thus had the most profound impact on power.

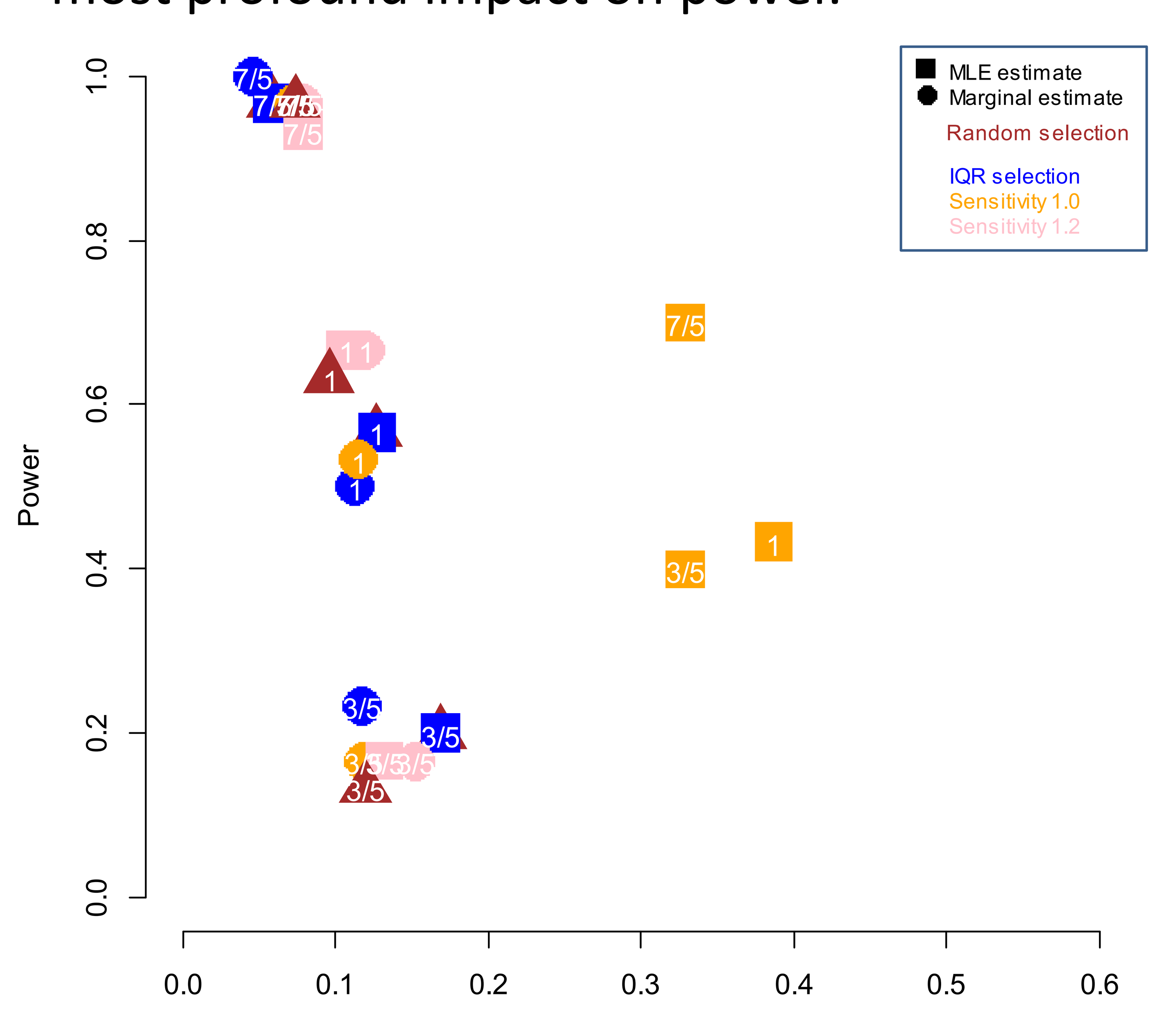

Fig. 1. Power and MSE estimates for 3 reps by panels (n=16) chosen using panelist selection criteria, which then evaluates samples with true differences $\delta_t = (0.6, 1.0, 1.4)$.

Acknowledgements

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Stage 1: Panelist Sensitivity Estimation

i) Experiment context

Panelists $i = 1, \ldots, 50$ have true sensitivity parameters $\zeta_i \sim \mathcal{U}(0, 2)$.
Products $t = 10$ with true product effects $\delta_t = \mathcal{U}(0, 2)$.
Reps $r = 5$.

ii) Estimate sensitivities from tetrad simulations

Simulations conducted to estimate product effects (d_i') and to estimate panelist sensitivities:

(i) a subject-specific sensitivity estimate ($\hat{\zeta}_{i\,\mathrm{SS}}$), and
(ii) a marginal sensitivity estimate from the Thurstonian model ($\hat{\zeta}_{i\,\mathrm{MAR}}$).

submitted to Stage 2 evaluations

Stage 2: Panelist Selection & Product Estimation

i) Panelist selection

Panelists $i = 1, \ldots, 50$ with sensitivity estimates $\hat{\zeta}_{i\,\mathrm{SS}}$ and $\hat{\zeta}_{i\,\mathrm{MAR}}$.

- Random
- IQR based on $\hat{\zeta}_{i\,\mathrm{SS}}$
- IQR based on $\hat{\zeta}_{i\,\mathrm{MAR}}$
- $|\hat{\zeta}_{i\,\mathrm{SS}} - 1|^{(1)}, \ldots, |\hat{\zeta}_{i\,\mathrm{SS}} - 1|^{(n^*)}$
- $|\hat{\zeta}_{i\,\mathrm{MAR}} - 1|^{(1)}, \ldots, |\hat{\zeta}_{i\,\mathrm{MAR}} - 1|^{(n^*)}$
- $|\hat{\zeta}_{i\,\mathrm{SS}} - 1.2|^{(1)}, \ldots, |\hat{\zeta}_{i\,\mathrm{SS}} - 1.2|^{(n^*)}$
- $|\hat{\zeta}_{i\,\mathrm{MAR}} - 1.2|^{(1)}, \ldots, |\hat{\zeta}_{i\,\mathrm{MAR}} - 1.2|^{(n^*)}$

where $(1), \ldots, (n^*)$ are sorted lowest to highest, where the panel size $n^* = 10, 12, \ldots, 20$.

ii) Products

In each simulation, the panel will evaluate pairs of products with discriminable differences in $\delta_t = (0.0, 0.2, \ldots, 2.0)$.

iii) Replication

Reps $r = 1, \ldots, 10$.

iv) Estimate product effects from tetrad simulations

For each of the 660 conditions, 30 simulations are conducted to obtain product effect estimates (d_t') for product:

- Based on marginal estimate of d_t' if panelist selection based on $\hat{\zeta}_{i\,\mathrm{MAR}}$.
- Based on ML-model incorporating $\hat{\zeta}_{i\,\mathrm{SS}}$ if selection based on $\hat{\zeta}_{i\,\mathrm{SS}}$.
- Both methods if selection of panelists is at random.

d_t' for panelist selection methods for 18,600 conditions

Stage 3: Evaluation

- $bias(d_t')$
- $Var(d_t')$
- $MSE(d_t')$
- $\hat{\gamma}$ (Panel Heterogeneity)
- Power

Conclusions

Results show no clear advantage for estimating assessor sensitivities on outcome. Additional simulations will be performed to confirm results.