Construction of a benchmark categorization algorithm for Comparative Judgement: a simulation study

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Paired Comparison

Although comparative judgement (CJ) proves a valid and reliable assessment method, it is characterized by a low efficiency. (Bramley, 2007)

Only a few proposals have been made to increase CJ's efficiency. The most frequently used method consists of some initial Swiss tournament rounds followed by Fisher information based matching (Pollitt, 2012).

Issue 1: Swiss tournament inflates the reliability (Bramley, 2015). The Fisher information based matching might suffer the same problem.

Issue 2: In the context of CJ, there appears a lack of simulation studies testing the efficiency and accuracy of selection algorithms.

Benchmark Categorization

Based on Computerized Categorization Testing (CCT; Spray & Reckase, 1994),

New representations are compared to a set of representations, *close to* one or more benchmarks, on an earlier ranking.

The new representations are classified using a version of SPRT (Reckase, 1983)

Based on Eggen (1999):

- Item selection criteria: Maximum Fisher Information (FI) and Maximum Kullback-Leibler Information (KLI).
- Information calculation reference points
  a. For FI:
     - estimated $\hat{\theta}_A$ (a, g)
     - nearest cutting point (NCP; b, h)
     - midpoint closest to $\hat{\theta}_A$ (c, i)
  b. For KLI:
     - fixed points (d, j)
     - midpoint of the decision interval, closest to $\hat{\theta}_A$ (e,k)
     - dependent on decision (f, l)
- Stopping criterion: all new representations are classified (variable length; g-l, n) and/or fixed length (Ncomp; a-f [n=100], m [n=500]).

Research questions

RQ1 Which information statistic results in more efficient pair construction and a higher accuracy?

RQ2 Per information statistic, which reference point results in more efficient pair construction, and accuracy?

RQ3 Does SPRT contribute to a higher efficiency and accuracy?

Method

Conditions

12 experimental conditions:

a. Ncomp – FI – estimated
b. Ncomp – FI – NCP
c. Ncomp – FI – midpoint
d. Ncomp – KLI – fixed
e. Ncomp – KLI – midpoint
f. Ncomp – KLI – decision
g. SPRT – FI – estimated
h. SPRT – FI – NCP
i. SPRT – FI – midpoint
j. SPRT – KLI– fixed
k. SPRT – KLI – midpoint
l. SPRT – KLI – decision

2 control conditions using random selection:

m. Ncomp – random
n. SPRT – random

Simulation details

The ranking from a CJ assessment on argumentative writing was used.

10 representations were randomly selected as new representations.

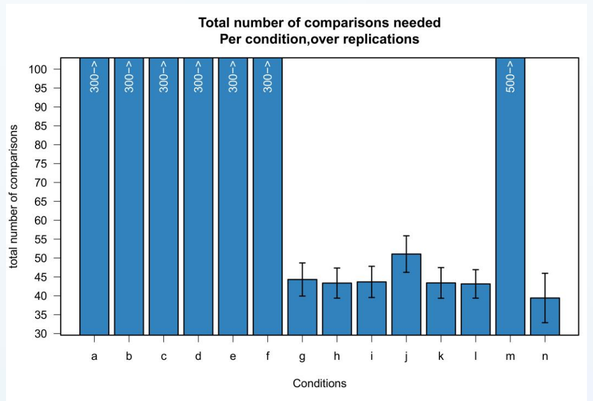
Benchmarks:

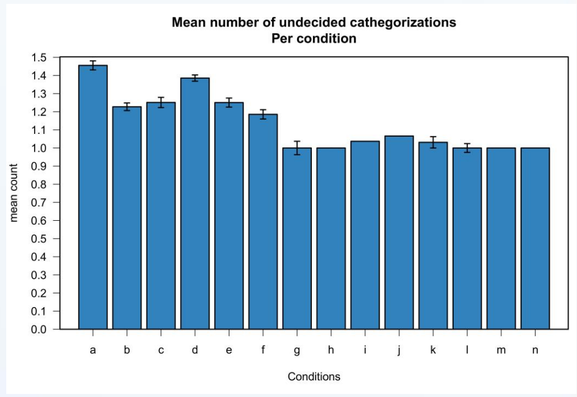
- BM1 at -2.29 , and 17 "close to" representations
- BM2 at -0.06, and 15 "close to" representations

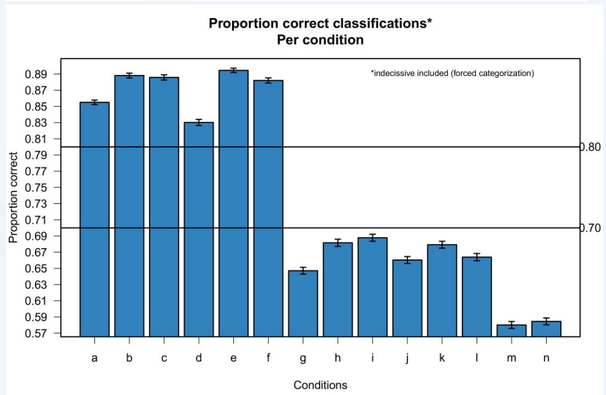
SPRT parameters:

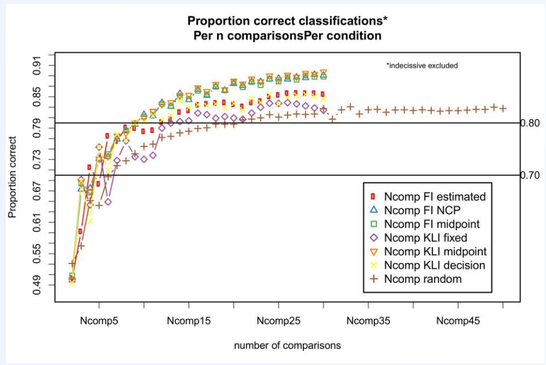
- δ = 3
- α = β = 0.05

- 1000 replications per condition









Results and preliminary conclusion

Information based selection (a-l) requires more comparisons but leads to a higher accuracy than random selection(m-n).

Fixed length CJs (a-f) lead to a much higher accuracy [but more undecided categorizations] compared to variable length CJ (g-l).

Accuracy rises with the number of comparisons. Between 9 and 12 comparisons all selection algorithms reach a proportion correct of 0,80

In fixed length as in variable length CJ the same four selection criteria appear most accurate:

- Ficher information on nearest cutting point
- Ficher information on the midpoint of the decision interval
- Kullback-Leibler information on the midpoint of the decision interval (less in variable length)
- Kullback-Leibler information on the decision (not in variable length)

Future directions

Applying the algorithm in a real assessment (preliminary results)

Looking into the SPRT parameters in the light of the most efficient and accurate selection criteria.

Testing the limits : how do the most efficient and accurate selection criteria behave under random judgements?

Extending the selection algorithm to more than three categories

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