Using performance discontinuities to estimate individual Working-Memory Capacities in serial recall tasks

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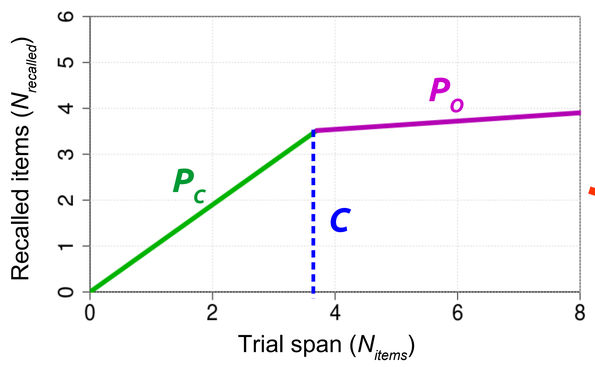
Introduction

Complex Span tasks and other serial recall tasks are typically scored using **simple indices**, such as the proportion of correctly recalled items (e.g., Conway, 2005). These indices **are not interpretable** as Working Memory Capacity.

The performance discontinuity model

… consists of **just three informative parameters: C_i**, the subject's capacity, P_C, a high proportion of correct-ly recalled items within C_i, and P_O, a lower proportion for further presented items. For a given trial with $N_{recalled}$ correctly recalled out of N_{items} presented items:



$$N_{recalled_{i,j}} = \begin{cases} P_C N_{items_{i,j}} & if\ N_{items_{i,j}} \leq C_i \\ P_C C_i + P_O (N_{items_{i,j}} - C_i) & if\ N_{items_{i,j}} > C_i \end{cases}$$

Method

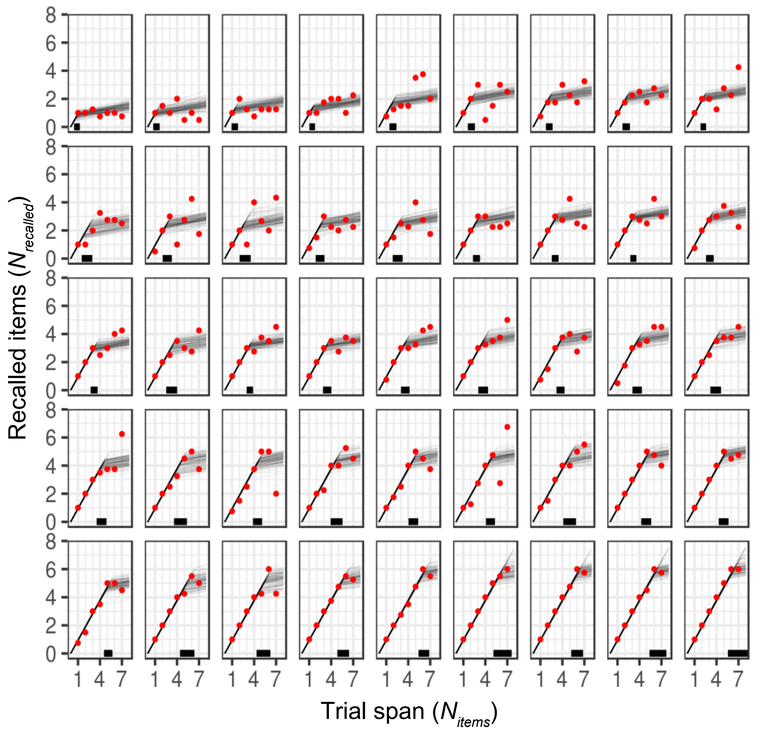
We estimated the parameters using JAGS for Bayesian inference (Plummer, 2003) on **Operation Span data from 46 subjects** who did four repetitions of spans one through seven, i.e., 28 trials.

Results: parameter estimates

The population C is 3.7, congruent with previous estimates (Cowan, 2001). C marks a sharp discontinuity between an almost perfect rate of recall in working memory and barely any recalled items when C is exceeded.

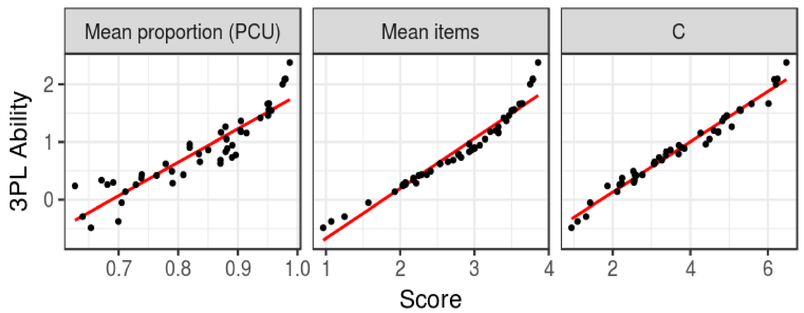
Estimate	95% CI (N = 46)
C = 3.7 chunks	3.2 – 4.2 chunks
P_C = 94.5 %	93.2 – 96.1 %
P_O = 9.1 %	3.9 – 15.0 %

For individuals (panels), the model has a good fit (slopes) to actual recall (dots) and C is identifiable (black horizontal 95% CI):

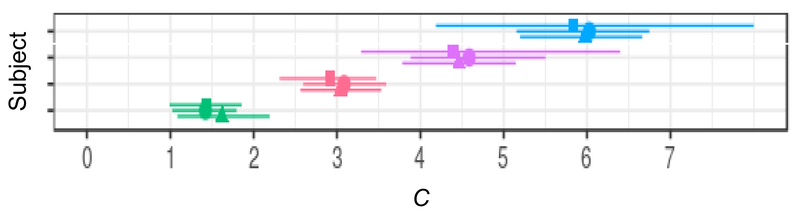


Results: validity and robustness

Compared to conventional scoring methods, Cs **scales linearly with the underlying ability** (r = .987), as estimated using a three-parameter logistic model (3PL):



Contrary to conventional indices, C **remains stable when some N_{items} are omitted**. Here are estimates of C based on N_{items} = 1-7, 3-7, and 1-5 for each of four example subjects (colors):



Discussion

The primary strength of the performance discontinuity score of C is the **low model complexity high interpretability.** It requires super- and supra-C trials and the non-zero P_O slope would be inaccurate for large N_{items}, so the model has a **restricted domain of applicability.** Within this domain, it outperforms classical scoring of Complex Span tasks.