Using the Attention Cascade Model to Computationally Account for the Age Differences in an Attentional Blink (AB) Task

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The Study

- The attention cascade model (Shih, 2008) is a general, mathematical model of attention and working memory. It is applied here to characterize cognitive aging.

Method

- Task: search for two targets (T1 and T2) in rapid serial visual presentation (SOA = 100 ms)
  - T1: 3, 5, 7, 9; T2: 2, 4, 6, 8; Distractor: black letters
- Design: T1 Salience (red/black) x T2 Salience (green/black) x T1-T2 Lag

Results

- Sensory processor (SP)
  - Interference process may scale down the stimulus strength
  - Mandatory output to LTM; output to the ACM only if bottom-up salient (e.g., with a distinct color)

- Long-term memory (LTM) traces
  - Some activation level assumed for well-learned items
  - Target salience subject to resource availability

- Preliminary representations (PRs) in the peripheral buffer
  - Each PR is described by a rectangular function
  - Width = SOA (i.e., perceptually available)
  - Suitable height (e.g., due to masking)

- Attention Control Mechanism (ACM)
  - Attention window (AW) transfers PRs into the WM buffer
    - The AW is described by a rectangular function
    - Width (interval) modulated by the task demand, etc.
  - Target templates (TTs) = task demands, behavioral goals
  - Two modes of triggering the AW
    - Controlled: by a top-down salient stimulus via TTs
    - Automatic: by a bottom-up salient stimulus via the SP
  - The AW triggering time distribution is a 2nd (automatic) or 4th (controlled) gamma function

- Gating
  - Resource: an input with greater $s$ is perceived as an exponential pdf with the time constant $\beta$

- Working memory (WM)
  - WM buffer
    - If % response threshold
    - Otherwise, hold the inputs
  - Strength $s$ decays exponentially while queuing — the greater the $s$, the slower the decay

Depictions of the Attention Cascade Model

- Sensory Processor (SP)
- Long-Term Memory (LTM)
- Resource
- Working Memory
- Response Buffer
- Guess
- Decision

Table 1. Parameter Estimates of 2.5, 50, and 97.5 Percentiles for Each Group

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Young</th>
<th>Older</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\theta$, initial masking factor (--)</td>
<td>0.49</td>
<td>0.91</td>
</tr>
<tr>
<td>$\beta$, time constant (ms) of pre-WM stages</td>
<td>11.0</td>
<td>13.8</td>
</tr>
<tr>
<td>$\gamma$, width of attention window (ms)</td>
<td>164</td>
<td>194</td>
</tr>
<tr>
<td>C, CP capacity (item per SOA unit)</td>
<td>1.01</td>
<td>0.92</td>
</tr>
<tr>
<td>$\pi$, CP duration (ms)</td>
<td>684</td>
<td>747</td>
</tr>
<tr>
<td>$\mu$, mean of CP noise (ms)</td>
<td>21</td>
<td>29</td>
</tr>
<tr>
<td>$\sigma$, SD of CP noise (ms)</td>
<td>61</td>
<td>70</td>
</tr>
<tr>
<td>Mean (SD) $R^2$</td>
<td>0.83</td>
<td>0.79</td>
</tr>
</tbody>
</table>

Note: CP = consolidation processor. The values for the 2.5 and 97.5 percentile respectively provide the lower and upper bounds of the 95% confidence interval for the distribution of 10,000 bootstrap samples. The value for the 50 percentile coincides with the optimum estimate. $R^2$ denotes the amount of variance in the data that is accounted for by the model corrected for the number of free parameters. The value of $R^2$ is between 0 and 1, with 1 denoting a perfect fit. In each round of simulations, there are 1000 Monte Carlo trials for each of the 32 conditions; each condition provides three dependent measures: $P(T1), P(T2)$, and $P(T1T2)$. The Mean (SD) $R^2$ are based on 100 rounds of Monte Carlo simulations using the optimum estimates.

Reference: