What’s a chunk? And what’s working memory got to do with it?

Gobet et al. & Solopchuk et al.

Eric Schulz
MPI for Biological Cybernetics

Definition

- "A thick, more or less cuboidal, lump, cut off anything"
- Typically refers to a single unit built from several smaller elements
- "A collection of elements having strong associations with one another, but weak associations with elements within other chunks"
- Memory vs. motor actions
- Automatic vs. deliberate

Memory

- Deliberate chunking is conscious, explicit, intermittent, goal-directed, and strategically intended to structure the material to memorize

- Deliberate chunking is mostly used in the literature on short-term memory, e.g. Miller (1956)

- Automatic chunking is unconscious, implicit, and continuous

- Automatic chunking deals with processes occurring in long-term memory

- Grouping: (a a a b b b a a a) $\longrightarrow$ (a a a), (b b b), and (a a a)
- Categorization: (apple car plane orange boat banana) $\longrightarrow$ (apple orange banana) and (car plane boat)
- Recoding: 0000011110010011 $\longrightarrow$ start of second world war

Differences in processes

- Deliberate chunking leads to chunks that are fairly easy to identify, since they are explicitly defined by the chunker and can be readily illustrated or explained
- Identifying chunks created by automatic chunking is more problematic, and various methods have been designed for that purpose
- Compression is present in both processes
- Many studies mix the two and so do several cognitive architectures

Chunking and working memory

- Chunking is used to circumvent the limited capacity of working memory
- Most measures of chunking have failed to correlate with indexes of performance or learning rate
- Chunking relies on WM gating, i.e., the process that controls the access of new information to WM
- Imaging studies show an overlap between the different brain structures involved in WM and chunking
- Correlate individual estimates of chunking strategy in a sequence-learning task with task performance, cognitive workload (as indexed by pupil size), and performance in a WM updating task

Experiment (N=25)

- symbolic sequence-learning task with a sequence of 16 symbolic items (digits)
- Twenty-five right-handed individuals
- In each display, the “target” (the digit belonging to the sequence) and a distractor were shown simultaneously on the computer screen and the participants had to identify and to designate the “target” by clicking on the corresponding mouse button

Experimental Design

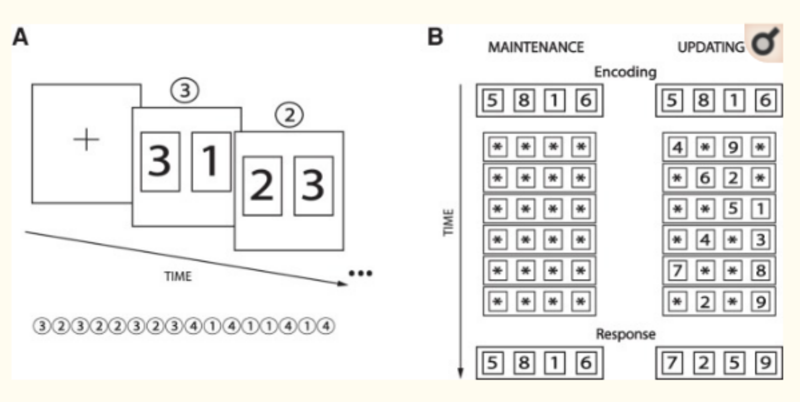

Figure: A: Pressing the correct button corresponding to the sequence below. B: Working memory (WM) task.

RT results

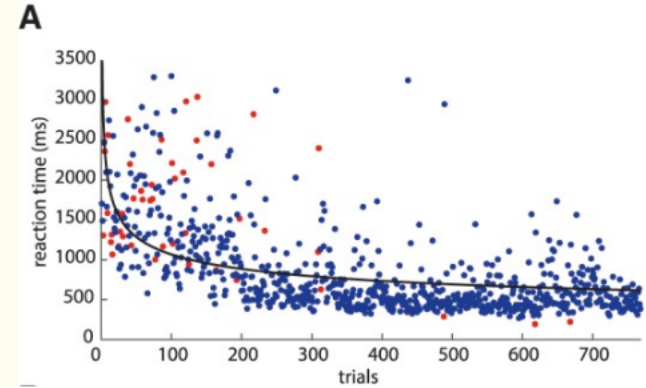

Figure: Reaction times over trials.

Defining chunks

- “chunk carryover” index (Ci): computed by averaging the RT for each sequence element within each block, then by computing pairwise Pearson correlations between item-wise averaged RT in all the valid blocks and finally by averaging all the obtained correlation coefficients
- mean chunk length: identify the first element of each chunk by using the log-RT for each sequence item computed for the last block (Block 8); then perform a one-tail t-test to evaluate whether RT for each sequence item, n was significantly longer than for the neighboring positions

Chunk carry-over

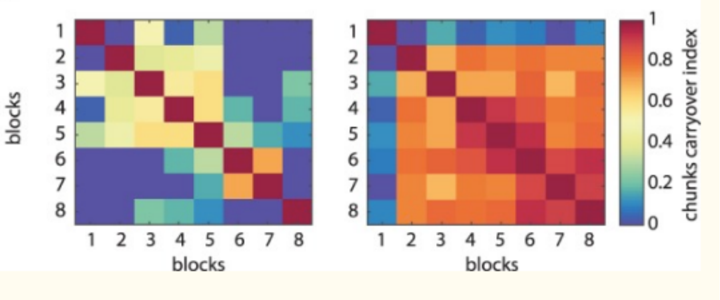

Figure: RT correlations and chunk carry-over by blocks.

Pupil diameter as a measure of effort

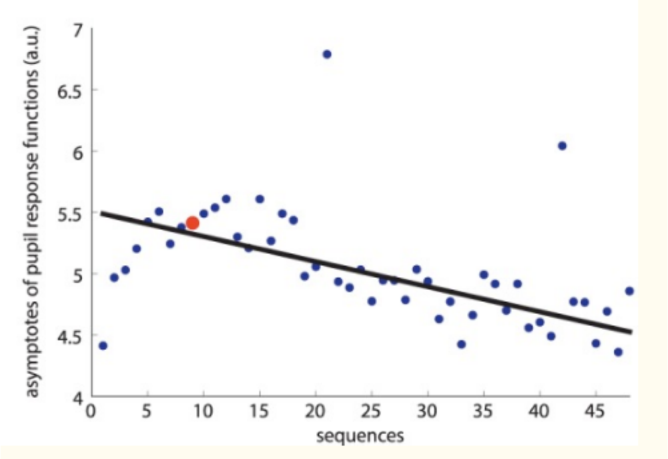

Figure: Asymptote goes down with number of sequence repetitions.

Correlational results

- Ci correlated negatively with learning rate (power function): consistent chunking benefits performance in terms of RT improvement
- Chunk length did not correlate with sequence-learning rate
- Ci correlated negatively with the slopes of the change in phasic pupil response: chunking led to a decrease in cognitive workload across sequence repetitions
- A significant positive correlation was found between the Ci and WM updating performance: better performance in the updating task was associated with more reliable chunking.
- No significant correlation between Ci and WM maintenance performance
- Chunk length and WM measurements did not correlate