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Disruption of task-specific strategies promotes strategic thinking

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Summary

An experimental study with the *n*-back task is described. The results suggest that disrupting the formation of a task-specific strategy by a concurrent irrelevant task promotes the development of a task-independent strategy. A computational cognitive model demonstrates how this task-independent strategy might be implemented in our brain.

Background

Juvina and Taatgen (2007) suggested that people might employ different strategies in *n*-back. We also proposed a behavioral metric that indicate the strategy that participants are using. This behavioral metric refers to how performance varies with the inter-repetition interval (IRI).

Jaeggy, Buschkuehl, Jonides, and Perrig (2008) showed that extensive practice at *n*-back produces performance improvements that transfer to other tasks. They claim that their version of the task discourages the development of task-specific strategies.

The most common task-specific strategy in *n*-back is a rehearsal strategy. A cognitive model for the rehearsal strategy in *n*-back based on the phonological loop has previously been described (Juvina & Taatgen, 2007).

Questions / Hypotheses

Discouraging rehearsal should allow the development of a task-independent strategy.

In contrast, encouraging rehearsal should hinder the development of a task-independent strategy.

Experiment

An experiment with the *n*-back task (Fig. 1) was conducted. Ninety-nine participants from Carnegie Mellon University were randomly assigned to three groups (33 per group).

	N=2	N=3
N back (target)	M B **M**	M B C **M**
N-1 back (foil)	**M M**	M B **M**
N+1 back (foil)	M B C **M**	M B C D **M**

Table 1. The *n*-back task. Participants have to press the SHIFT key when the current letter matches the letter presented *n* letters back. The stream of letters contains targets, distractors, and foils. Participants must explicitly discard foils and distractors by pressing the ALT key. The stream contains as many targets as foils and they are randomly interspersed.

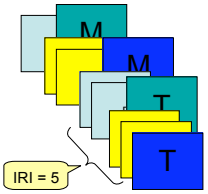

Figure 1. The inter-repetition interval (IRI) is the distance between two repetitions. Repetitions are occurrences of targets and foils. In this study IRI ranges from 2 to 7. In this example, there are 5 stimuli between the repetition of M and the repetition of T, thus IRI=5. Variations in performance with IRI have been shown to indicate the use of certain strategies. For instance, the rehearsal strategy is associated with a decrease in performance with IRI (Juvina & Taatgen, 2007).

Between-subjects	Within-subjects
Control (No shadowing)	Treatment
Rehearsal (Attracting shadowing)	Post-treatment
No-rehearsal (Distracting shadowing)	Transfer

Table 2. Experiment design. Participants in the control group did the *n*-back task only. Participants in the rehearsal group, while doing *n*-back, had to repeat (shadow) the last 2 letters from the *n*-back stream. Participants in the no-rehearsal group had to shadow a random digit that was played back to them in earphones.
All participants went through a treatment condition in which the manipulation described above was administered in the 2-back task. Then, in the post-treatment condition all participants did the 2-back task only. Lastly, in the transfer condition, all participants did the 3-back task.

Results

Differences in performance between groups and across blocks are presented in Fig. 2. Fig. 3 shows variations in hit rates with IRI. Variations in false alarms with IRI are presented together with the modeling results (Fig. 4).

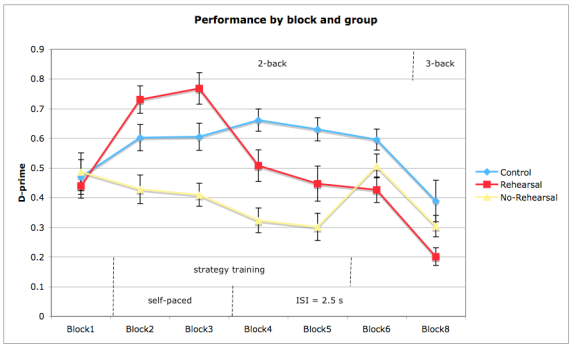

Figure 2. Performance for each block and group. In Block 1 participants receive instructions and practice with the 2-back task. Blocks 2 to 5 are treatment blocks (2-back), Block 6 is post-treatment (2-back), and Block 8 is transfer (3-back). Blocks 2 and 3 are self-paced whereas blocks 4 to 8 are time-limited (ISI = 2.5 s). In Blocks 2,3,and 4 participants have to do manual shadowing whereas in block 5 they do vocal shadowing. Vertical bars are standard errors. The three groups start at the same level of performance. The rehearsal group performs better at treatment and worse at post-treatment and transfer than the no-rehearsal group.

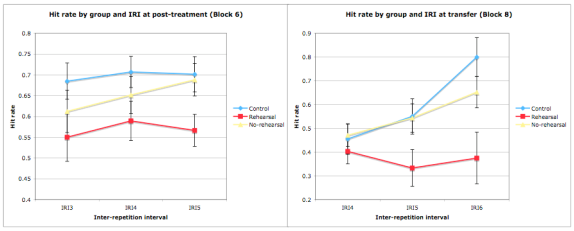

Figure 3. **Variations in performance with IRI**. Performance (hit rate) increases with IRI for the no-rehearsal group at post-treatment (Block 6) and for both the control and the no-rehearsal groups at transfer (Block 8).

Bayesian analysis

Table 3 shows how the probability to find a target increases as one advances through the stream of stimuli in the 3-back task.

	IRI=1	IRI=2	IRI=3	IRI=4	IRI=5	IRI=6
Prior probabilities	0	0	0	0.166	0.166	0.166
After IRI4	0	0	0	0	0.25	0.25
After IRI5	0	0	0	0	0	0.5
Posterior probabilities	0	0	0	0.166	0.25	0.5

Table 3. Updating probabilities. After a repetition (target or foil), the chance that the following repetition is a target is 0.5. By design, a target can occur at IRI4, IRI5, and IRI6 with equal probability. If no repetition was observed at IRI4, the probabilities at IRI5 and IRI6 must be updated. If no repetition was observed at IRI5, the probability of a target at IRI6 increases to 0.5.

A cognitive model of a task-independent strategy

The model learns from experience that the target probabilities increase with IRI. When a repetition is encountered, if the model cannot use its task-specific strategy to distinguish a target from a foil, it tries to guess based on previous experiences stored in memory. Then it reacts based on what experience is retrieved ("target" or "no-target"). As the model encounters more and more stimuli, it becomes more likely that a "no-target" experience is retrieved at lower IRIs and a "target" experience is retrieved at higher IRIs. Assumptions (not modeled): the model knows IRIs and it has a task-specific strategy (e.g., rehearsal). Free parameter: the amount of trials solved by a task-specific strategy (non-guessing) is decreased at block 8, reflecting the novelty of the 3-back task.

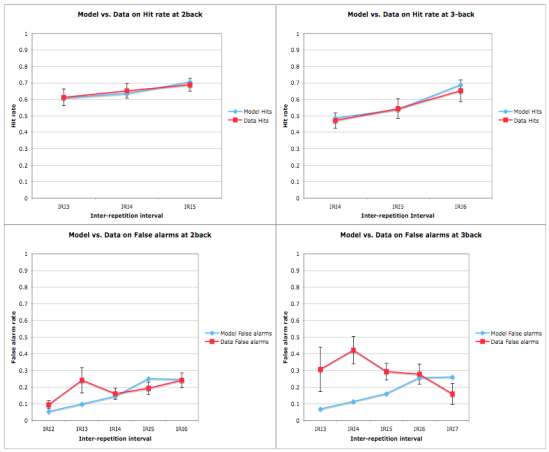

Figure 4. **Fit of the model to the data**. The model captures the increased bending-up at 3-back because it relies less on the task-specific strategy, and consequently it has more guessing experiences to learn from. The model does not account well for false alarms at 3-back. A higher number of false alarms at lower IRIs in 3-back reflects cases of carry-over from 2-back to 3-back.

Conclusions

As shown by the analysis of IRIs and the subsequent modeling, the disruption of rehearsal by a concurrent digit-shadowing task facilitated the development of a task-independent strategy. When rehearsal was encouraged by a concurrent letter-shadowing task no evidence of such task-independent strategy was observed.

The model of the task-independent strategy is agnostic with regard to what task is being performed. It only learns from experience to anticipate when a target is likely to occur. This simple memory-based mechanism is probably involved when humans lack task-specific knowledge and strategies and have to rely on their test-taking and strategic thinking skills.

References

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Jaeggi, S. M., Buschkuehl, M., Jonides, J., & Perrig, W. J. (2008). Improving fluid intelligence with training on working memory. *Proceedings of the National Academy of Sciences U.S.A., 105*(19), 6829-6833.