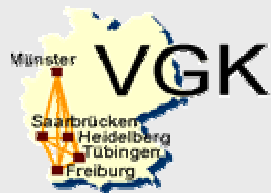


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Volitional Action Control in Multiple-Task Performance:

Modeling Effects of Goal Competition and Task Difficulty in ACT-R



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Overview

A. Elementary executive control processes

B. Volitional action control

PART: A framework

Hypotheses

Empirical findings on goal-conflicts

C. Modeling volitional action control in ACT-R

An ACT-R model

Comparing data and model

D. Summary and conclusions

A. The issue of scaling up

Promising insights by research on action control in multiple-task situations in the fields of experimental psychology and cognitive modeling

But

Focus on the microscopic world of simple choice reaction time tasks

Every-day multiple-task behavior

- Comprising the coordination of more complex actions
- Analyzed on a coarser temporal grain size
- Additional executive functions may be important

Question

Are theoretical constructs and computational mechanisms that have been useful in thinking about elementary control processes also applicable to everyday multiple-task behavior?

B. Hypothesis 1

PART-hypothesis 1: Distraction due to competing goals

The performance of a current goal will be impaired in case of a conflict with a pending goal regardless which goal will be pursued further

Explanation based on the Cognitive Load Theory (Sweller, van Merriënboer, & Paas, 1998)

Opportunity for implementing a pending goal

- Activating information in memory that is related to the pending goal
- Task-unrelated (extraneous) workload for the current goal
- Selecting simpler processing strategies for accomplishing the current goal, i.e., less resource-demanding and less effective (Schunn & Reder, 2001)

B. Empirical findings on goal-conflicts (1)

Materials

Complex hypertext-based learning and problem-solving task:
Solving probability word problems after having learned with examples

- that illustrate different problem categories
- that consist of the example problem and a step-by-step solution
- that are couched in cover stories related to attractiveness and mate choice

Design

Difficulty of word problems (easy vs. difficult)
x goal competition (with vs. without): realized as successive question-answering task about attractiveness and mate choice

Dependent measures

Problem-solving errors, time on task-relevant and task-irrelevant information pages

B. Empirical findings on goal-conflicts (2)

Results: Confirmation of both hypotheses

Hypothesis 1: Distraction due to competing goals

Distraction effects in terms of increased problem-solving errors together with a speed-up in the conditions with goal competition
→ Regardless of active distraction behavior

Hypothesis 2: Difficulty-related volitional protection

Performance impairments only for easy but not for difficult problems
→ Resource-adaptive strategy shift for easy problems under goal competition: selecting simpler example-processing strategies

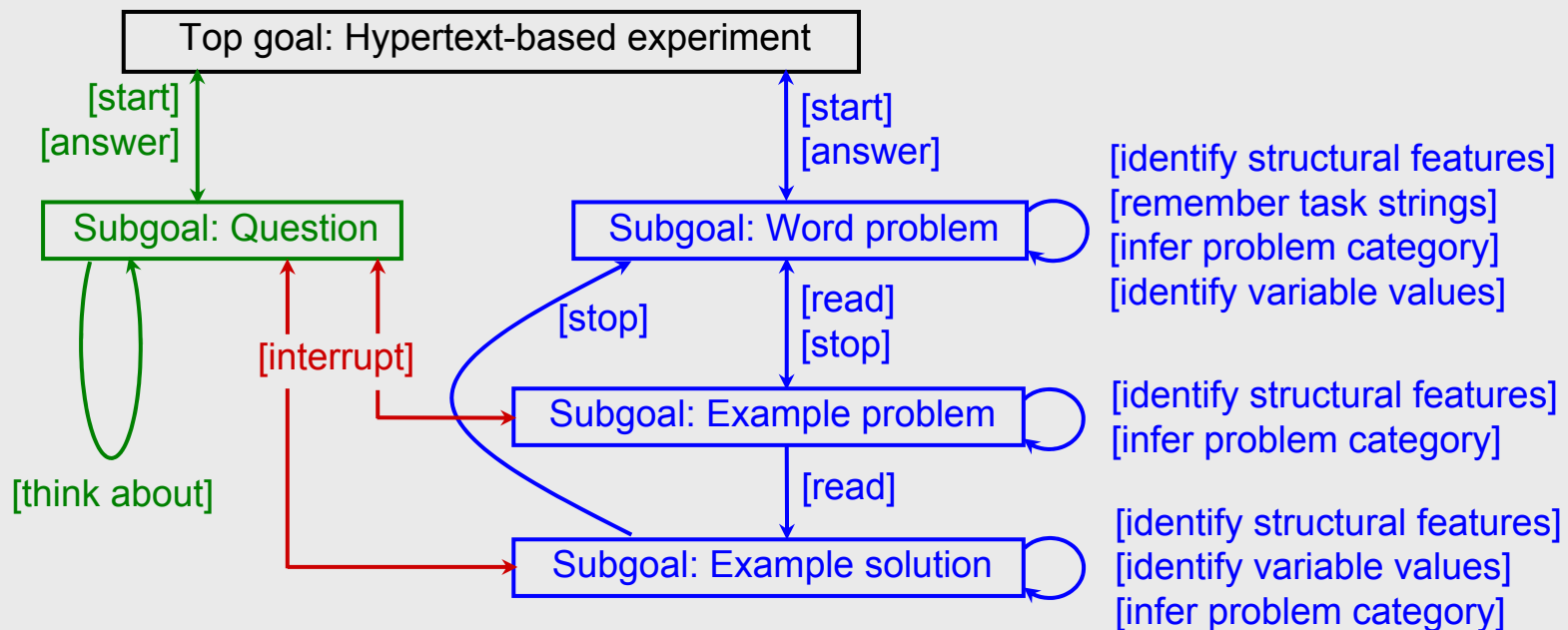
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C. An ACT-R model: Overall structure

Using the same materials and tasks for the model as in the experiments

Overall structure

Components simulating the **problem-solving task**, the **question-answering task**, or **volitional action control**



C. An ACT-R model: Tasks

Problem-solving task

Initial task representation:

- *Condensed for easy problems*: small number of activated chunks in working memory → low workload: free resources
- *Complex for difficult problems*: increased number of activated chunks in working memory → high workload: no free resources

Example-processing strategy:

- *Sophisticated*: studying all example problems and their solutions; implemented by complex resource-demanding production rules
- *Simple*: studying only the example problems; modeled by rather simple production rules that are applicable even in case of restricted cognitive resources or time

Question-answering task: only simplified and superficial simulation

C. An ACT-R model: Volitional action control (1)

Volitional action control

1. Situational cueing of pending goals

Spreading activation based on cues in an example problem in the case of free resources (i.e., condensed initial task representation)

2. Executive production rule

'Interrupt'-production for task interruption and goal management:

- firing in the case of multiple activated goals
- selecting the highest activated goal for further processing
- storing the conflict situation → increased (extraneous) workload

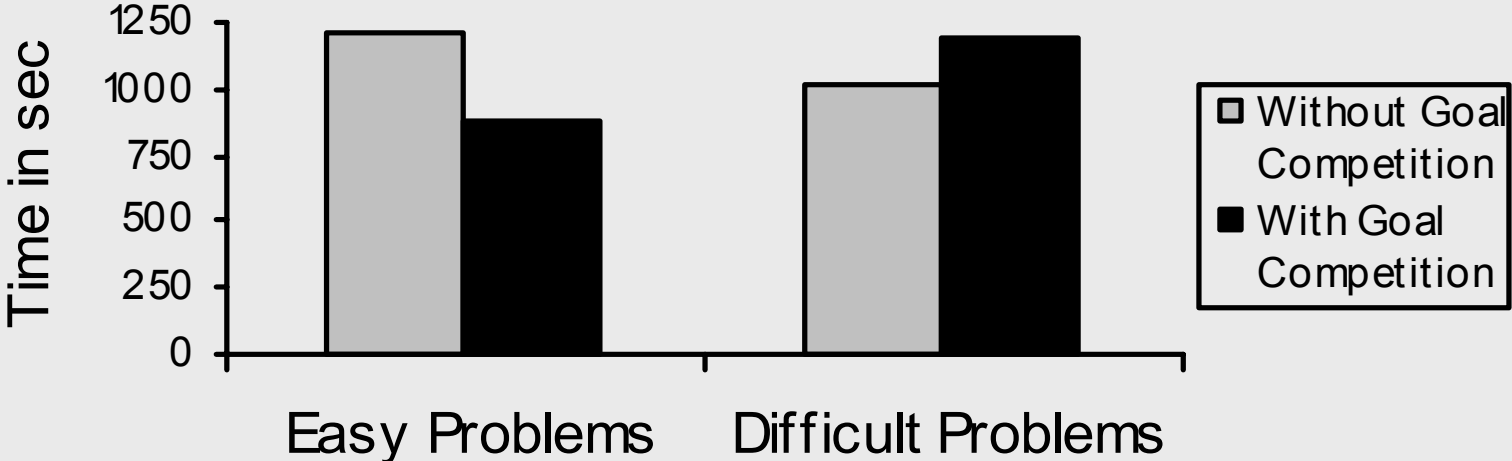
3. Specific goal representation

Chunk-type 'intention' that enables task-superordinated processes: representing a goal's status and information about goal conflicts

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C. Comparing data and model: Results (2)

Pattern of results for time demands
(independent of actual goal shifting)



Strategy shift for easy problems with goal competition (cf. empirical results): speed-up and increased number of processing cycles
 → more cursory processing based on rather simple production rules (i.e., the interrupt-production and productions implementing a simple example-processing strategy)

D. Summary and conclusions

Successful simulation of *effects of goal competition and task difficulty on processing strategies and performance for a complex learning and problem-solving task*

based on *activation mechanisms and executive control productions* which have proven useful for modeling elementary control processes in multiple-task performance

Filling the conceptual and explanatory gap between high-level volitional control demands in real-world multi-tasking and low-level experimental task-switching and PRP effects and their respective simulations

Acknowledgments and references

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