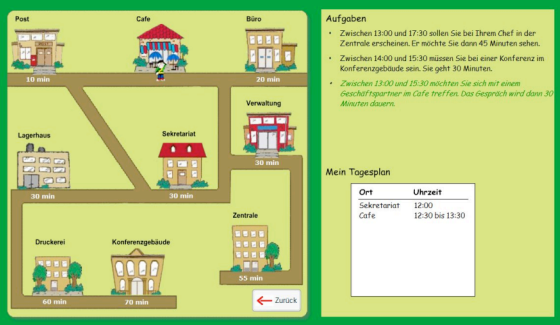
Cognitive modeling of planning processes within 'Plan-A-Day'

Joachim Funke, Sven Brüssow & Daniel Holt

Department of Psychology, Heidelberg University

1 The task: „Plan-A-Day“ (PAD)

PAD is a computer-based interactive task in which subjects have to coordinate several errands of different priority, date and duration during a fictitious day. The program is implemented in Macromedia Flash and controlled with the mouse. The difficulty of Plan-a-Day problems can be varied by the number of errands, overlap of time windows, and consideration of way times. Task completion time and number of planning errors are measured as performance indicators.



2 Aims

Our goal is to model decision making in the context of planning processes on a microgenetic level using the ACT-R framework (Anderson et al, 2004). The reason to work on the microgenetic level of planning lies in the better explanation of data due to a better resolution level of ongoing processes, in contrast to staying at the level of broad constructs, such as working memory or inhibitory control. We aim to provide a detailed model of subjects' cognitive processes and resulting behavioural performance.

Recently, Gobet and Ritter (2000) proposed an approach they called “individual data analysis” (IDA). IDA is not a totally new approach – on the contrary, many important developments in psychology have their foundation in single cases (see Dukes, 1968). Instead of looking for averaged effects (Gobet & Ritter, 2000, p. 153, speak from the ”obsession of modern psychology with statistical testing”), IDA might be a solution for microgenetic process modeling. Through the close interaction between theory building (modeling) and experimentation (data), IDA promises to gap the gulf between theories on a macro-level with microgenetic assumptions about processes.

3 Methods

- Five subjects received four Plan-a-Day problems in two difficulty levels (four errands and six errands).
- Detailed thinking aloud protocols were recorded using a screen capture software with a microphone.
- Recordings of verbalizations (audio) and behavior (video) were transcribed and further formalized by extracting actions (read text, move to location, etc.), goal statements, logical inferences, and implied working memory content.
- Possible heuristics used by subjects were deduced from the formalised protocols.
- These heuristics were compared to ACT-R cognitive models that solve Plan-a-Day with a minimal heuristics approach.

4 Results

- The additional behavioral data allowed a validation and extension of verbal protocols, as they contained non-verbalized information and made it possible to control the consistency of verbalizations and actions.
- The typical behavior of subjects could be modeled with surprisingly few heuristic rules.
- These heuristics correspond in large parts to the ACT-R cognitive models of the planning process using minimal heuristics.

Goal / Action	Description
Read tasks (initially)	Reading of tasks, write to memory
Rehearse property of a task	Recall of certain task properties (start time, end time, duration etc.) from memory
heuristics	
Use previously infeasible task heuristic	
Use starttime heuristic	A task is chosen on the basis of its start time
Use endtime heuristic	A task is chosen on the basis of its end time
Use distance heuristic	A task is chosen on the basis of its closeness to the preceding task
Use duration heuristic	A task is chosen on the basis of ist duration
Execute task	A task is executed
Undo execute task	An executed task is revoked
Evaluate status	An executed task or future steps are evaluated

Line(s)	Time		Goal/Action	Analysis (Verbal)	Analysis (Video)	Memory
3	00:00:00	VL: Gut, dann gehn's mal der ersten Aufgabe los. Genau so wie eben. Es sind auch ähnliche Aufgaben so vorn				
4						
5		VL: Genau.				
6		Ja, ok. Also Zeit gibt's hier nicht, nee (fragend)	Get information about time	Intuit		
7		VL: Nein, du hast soviel Zeit wie du willst				
	00:00:04			**Problem 1**		
8-9		Ja, ok. (Intuit:) Dann les ich mir das erstmal durch. (Intuit lustlos, Stille) (almost tief ein und aus)	Read tasks	Read(T1-CAF) Read(T2-STO) Read(T3-OFC) Read(T4-ADM)		T1-caf t2-sto t3-ofc t4-adm
	00:00:24	Mhm. (Stille)				
9-10	00:00:35	ok, also ich versuch das erst mal mit dem Lager weil das eben schon früher anfängt, ups	Use starttime heuristic Execute task	start(T2-STO) start(T3- >Eval*(T2-STO) Add(T2-STO)	InKey(T2-STO)	schedule=<t2-sto>
11	00:01:02	VL: Ja die Mann braucht immer ein bisschen lang				
12-13	00:01:07	Ok, ja. Oh nee, das geht dann nicht weil ich das nicht mit der Cafeteria schaff (murmelt unverständlich)	Evaluate status Undo execute task	T2-STO(T1-CAF->Eval(T1-CAF)	Restart ? Undo(T2-STO)	schedule=<>
13-14	00:01:20	Ok, dann geh ich jetzt zur Cafeteria erstmal, weil es sonst nicht gegangen wär	Use previously infeasible task heuristic Execute task	Eval(T1-CAF)&Alt(set(schedule)-<Eval*(T1-CAF) Add(T1-CAF)	InKey(T1-CAF)	schedule=<t1-caf>

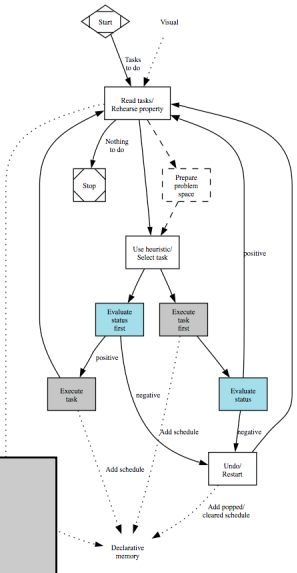
```
;; evaluate status

(p spot-too-late
    =goal>
    isa                 task
    state               spotting
    too-late            yes
==>
    =goal>
    state               skipping
)
```

```
;; executing/moving

(p execute-task
    =goal>
    isa                 task
    state               moving
    arrival-time        =arrival-time
    next-location       =next-location
    duration            =duration

    !bind! =time (+ =arrival-time =duration)
==>
    =goal>
    state               reading
    location            =next-location
    time                =time
)
```



References

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Contact

http://atp.uni-hd.de/forschun/planaday/index.html

5 Discussion

Individual data analysis of subjects who are solving planning tasks within PAD gives insight into strategic thinking processes and reasoning under constraints. Models for individual subjects are a promising starting point for a more general perspective on cognitive modeling of planning processes. Interactions between model and environment are implemented as abstract LISP functions and should be replaced by more sophisticated naturalistic modeling of perceptual processes in ACT-R. The same holds for modeling memory processes, which at present are implemented with perfect recall. In order to pursue the IDA approach more rigorously, selected subjects should be tested again with revised PAD problems.