Short-Term Effects of Animated versus Static Visualisation of Operations on Program Perception

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Outline

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- Background
- Visualization and Cognition
- Previous work
- Experiment
- Discussion
- Conclusion

Background

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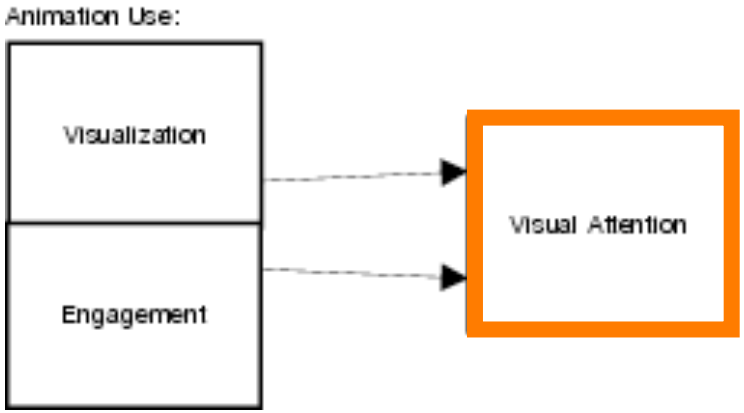
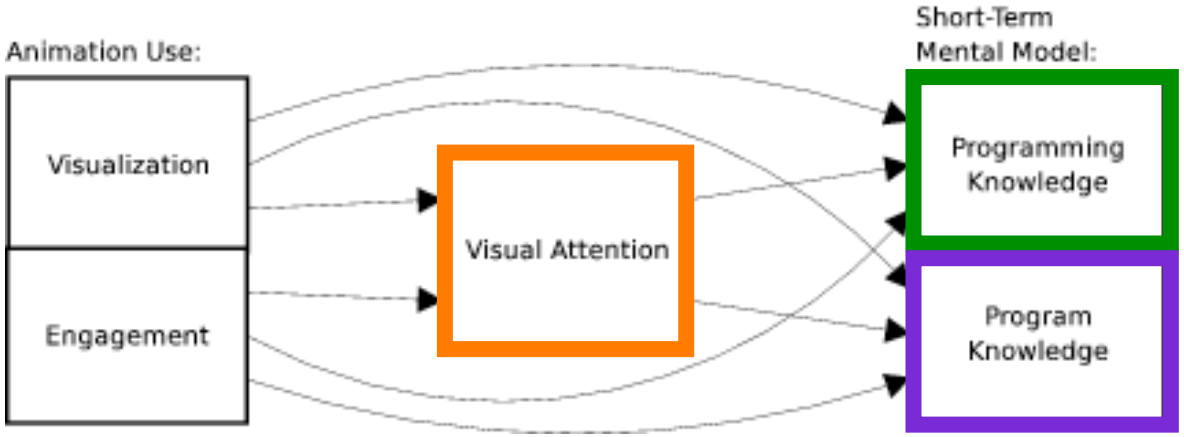
- Numerous visualization and animation tools to assist teaching of computer programming
- Empirical evaluation of visualization tools based mostly on long-term effects, ignoring immediate effects of visualizations
- A series of experiments studying immediate and short-term effects and their relation to long-term effects based on our model of cognitive phenomena that take place during viewing

Cognitive Phenomena behind Visualizations



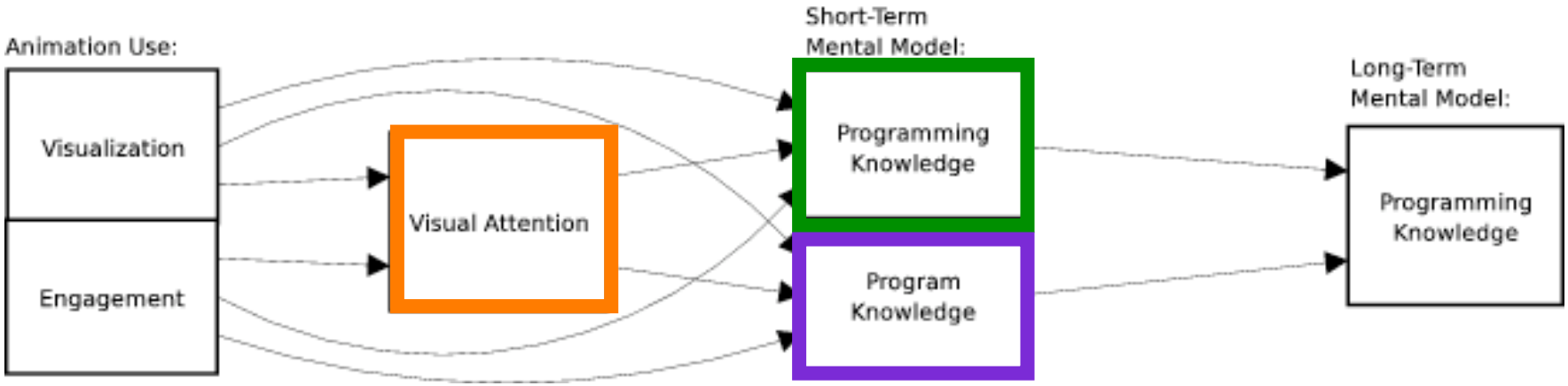
- Locations of participant's gaze (**visual attention**)
  - Gathered with eye-tracking equipment

Cognitive Phenomena behind Visualizations



- Locations of participant's gaze (**visual attention**)
  - Gathered with eye-tracking equipment
- Knowledge of variable roles (**programming knowledge**)
  - Measured with post-tests (Stützle and Sajaniemi 2005)
- Summaries of studied programs (**program knowledge**)
  - Analyzed with Good's scheme (Good 1999)

Cognitive Phenomena behind Visualizations



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PlanAni Visualization Tool (Sajaniemi and Kuittinen 2005)

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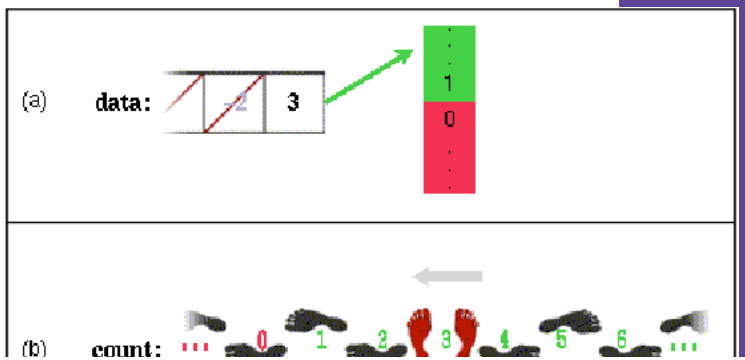
- Visualizes variable roles
- Role of a variable = behavior of a variable, e.g.,
  - Stepper = a variable stepping through a systematic, predictable succession of values
  - Gatherer = a variable accumulating the effect of individual values

- Facilitates learning introductory programming
- Eleven roles cover 99% of all variables in novice-level programs
- Role image represents the salient stereotypical features of variable´s behavior
- Role image also used for the animation of operations on a variable



Previous Work on Roles of Variables

- Beneficial long-term effects on programming skills (Byckling and Sajaniemi 2006, Sajaniemi and Kuittinen 2005)
- Use of original role images enhanced learning of roles when compared to neutral control images (Stützle and Sajaniemi 2005)
- PlanAni compared to Turbo Pascal debugger (Nevalainen and Sajaniemi 2005):
  - Use of PlanAni → increase in targeting of visual attention on variable visualizations
  - Increase of visual attention to variables →

    increase of high-level information,

    and decrease of low-level code-related information in program summaries

Experiment: Design

- Between-subject design
- Independent variable: version of PlanAni (smoothly animated (“animation group”) or immediate update (“static group”))
- Dependent variables:
  - Locations of participant's gaze
  - Participant's post-test score on role knowledge
  - Program summary provided by the participant
- Participants:
  - Eleven male and five female (n=16)
  - Had taken a first-year programming course in last eighteen months and continued their studies thereafter

Experiment: Procedure

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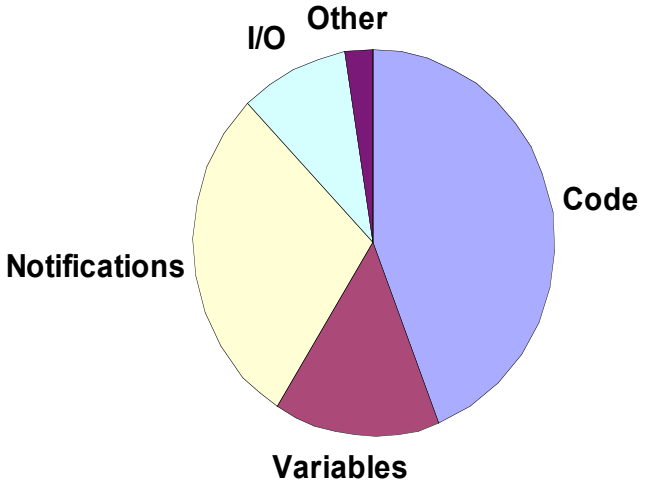
- A video presentation introducing roles
- Pre-test on role knowledge
- A practice program with PlanAni
- An actual program with PlanAni
- Post-test on role knowledge
- Tool evaluation form

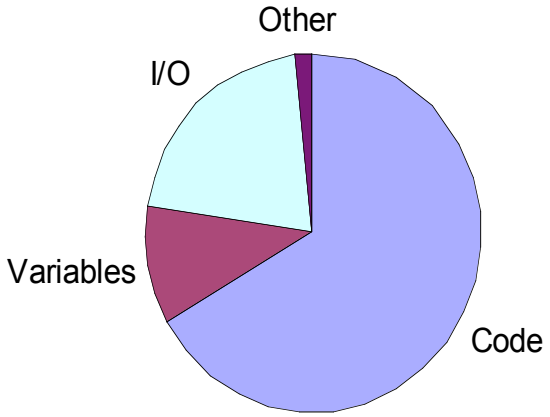
Results: Role Knowledge and Visual Attention

- Post-test scores on role knowledge (max score 13)
  - Animation group: 12.00
  - Static group: 11.25 Difference N.S.
- Mean proportions of viewing times on different areas of the screen (difference between the groups significant in viewing code and I/O areas):

Animation group



Static group



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Results: Program Summaries

- Good´s program summary analysis scheme (Good 1999) was applied to participants' program summaries

- Information types divided into high-level and low-level types:

Code	Information Type	Group			
		Animation		Static	
		Mean	SD	Mean	SD
HIG	FUN+ACT+SHI+DAT	76.09	12.69	77.31	15.00
LOW	OPE+SLO+CON	15.58	8.09	15.20	14.19
OTH	100-HIG-LOW	8.30	9.07	7.49	9.72
HIP	HIG / (HIG+LOW) * 100	82.81	8.97	83.84	14.93

Differences N.S.

- Object description categories:

Code	Object Description Category	Group			
		Animation		Static	
		Mean	SD	Mean	SD
PON	Program only	0.00	0.00	0.00	0.00
PRO	Program	3.13	8.84	1.14	3.22
PRR	Program—real-world	5.55	11.87	11.14	11.51
PRD	Program—domain	0.00	0.00	0.00	0.00
DOM	Domain	88.54	12.63	80.74	17.73
IND	Indirect reference	2.79	5.95	6.99	8.04
UNO	Unclear	0.00	0.00	0.00	0.00

Differences

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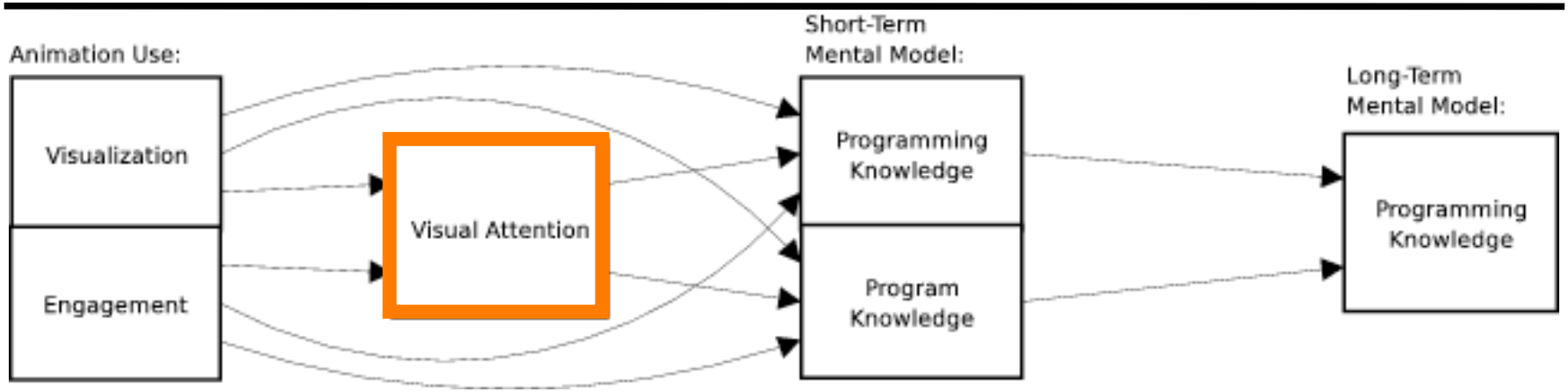
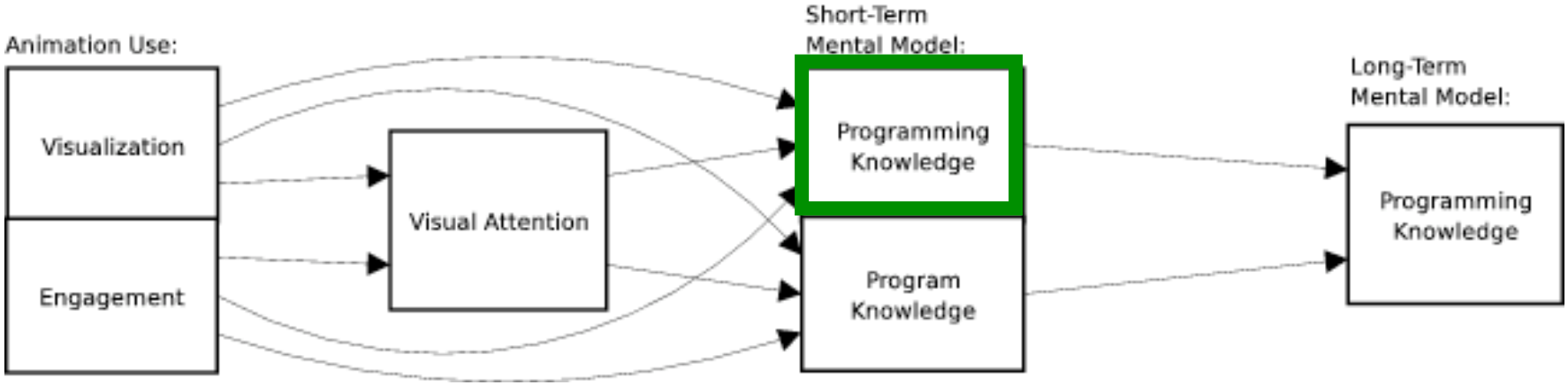
Discussion: Visual Attention



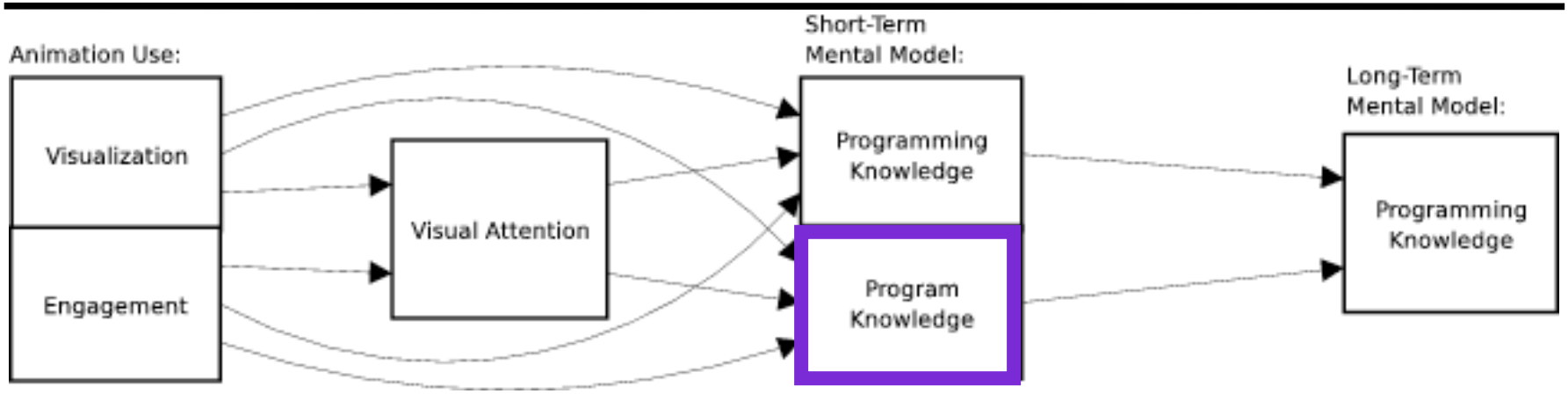
- Variation in the graphics, location and size of variable visualizations → clear influence on the distribution of visual attention (Nevalainen and Sajaniemi 2005)
- Presence or absence of a smooth animation → only subtle differences on the distribution of visual attention
- Even participants provided with rich pictorial information resorted heavily to the textual cues

Discussion: Role Knowledge



- Variation in the images of PlanAni → significant differences in development of role knowledge found in (Stützle and Sajaniemi 2005)
- Presence or absence of a smooth animation → differences non-significant
- One explanation: the role images, not the role animation, play central role in the development of role knowledge when PlanAni is used

Discussion: Program Summaries



- PlanAni has been found to have long-term effects on programming knowledge, that results in differences in program summaries (Sajaniemi and Kuittinen 2005)

- The effects do not seem to manifest themselves in program summaries collected after viewing visualization (Nevalainen and Sajaniemi 2005, this experiment)

Conclusions

- Research focus: how a person viewing visualizations targets her visual attention and what kind of a mental model she constructs concerning a computer program

- Research based on a model of cognitive phenomena that take place during viewing

Experiments on visualizing variable roles	**Dependent Variables:**	Visual attention on visualization	Programming knowledge	Program knowledge
Varied factors:				
Content of images used in visualization (Stützle & Sajaniemi 2005)		*Not measured*	***Significant differences***	*Not measured*
Graphics, location, and size of visualization (Nevalainen & Sajaniemi 2005)		***Significant differences***	*Not measured*	*No significant differences*
Animation style used in visualization (Nevalainen & Sajaniemi 2006)		*No significant differences*	*No significant differences*	*No significant differences*

- Future experiments: use of style of engagement as a varied factor

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