Cognitive Models of Transfer of Cognitive Skill (full day)

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Keywords: Cognitive Architectures; Cognitive Modeling; Skill Acquisition; Cognitive Transfer.

Transfer in Cognitive Skills

If you learn mathematics in school, but then proceed to become a lawyer, will you have any benefit from mathematics, for example in terms of abstract reasoning? Very little is know about the cognitive mechanisms behind such transfer of knowledge, and most psychological theories assume that very little transfer exists (Singley & Anderson, 1989, Thorndike & Woodworth, 1901). Nevertheless it is undisputable that many of our cognitive skills build upon each other, and have benefits beyond just the skill itself. Moreover, the new controversial industry of Brain Training games has emerged where spectacular improvements on various cognitive measures is promised, even though empirical evidence for such improvements is rather weak (Chein & Morrison, 2010, Jaeggi et al, 2008, Karbach & Kray, 2009, Owen et al., 2010).

A problem with most models and experiments in cognitive science is their focus on the experiment, and therefore take the particular task for granted. As a consequence, there is very little theory on how cognitive skills are interconnected, and how one skill can build on another. For this purpose, the PRIMs cognitive architecture (Taatgen, 2013) was developed, which will be the central topic of this tutorial. PRIMs is derived from the well-known ACT-R theory (Anderson, 2007), and inherits most of its principles (and therefore benefits) from that architecture. However, whereas one of the basic units of knowledge in ACT-R is the production rule, a fairly complex knowledge representation, the PRIMs theory starts with much smaller primitive information processing units (the PRIMs). PRIMs can be clustered into mental operators that perform tasks. However, many of these clusters are task-general, and can be used for different tasks.

The novel aspect of PRIMs is that cognitive modelers

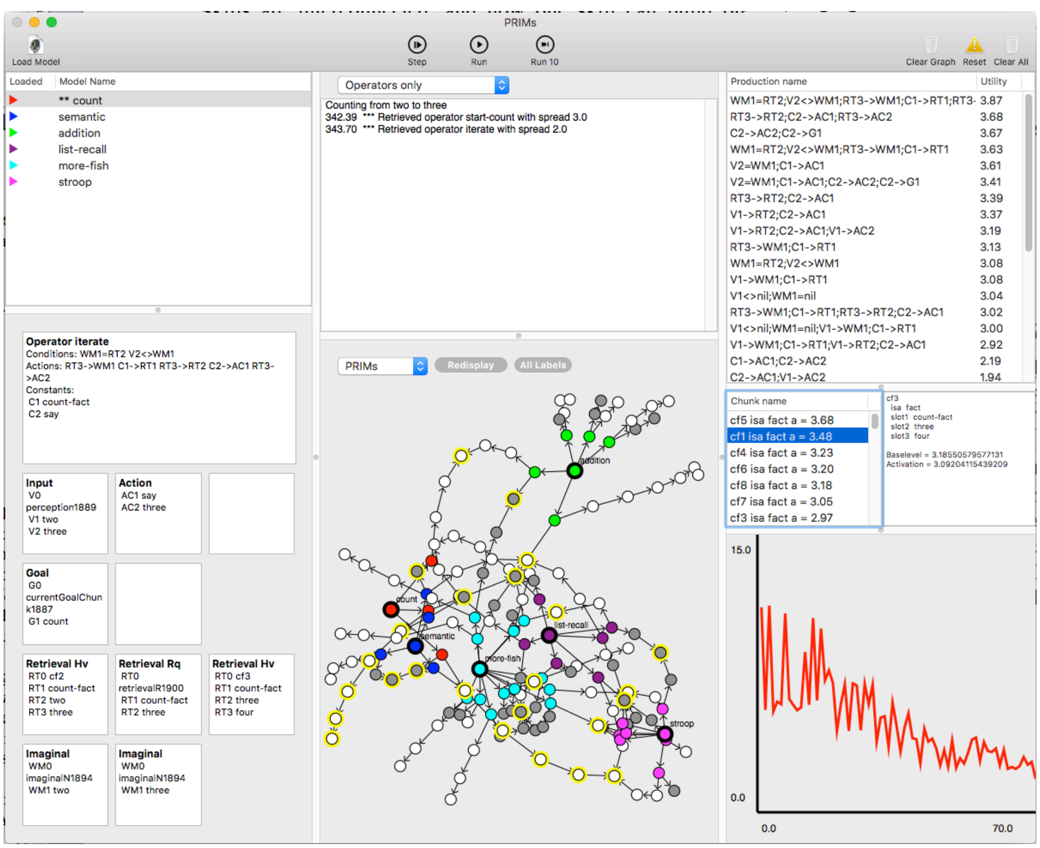

Figure 1. Screenshot of the PRIMs application. Six tasks (top-left corner), have been loaded into the system. The bottom-center panels shows how the knowledge for these tasks is interconnected.

can now move beyond the focus on individual tasks, and start building large-scale models that incorporate knowledge of many different tasks. This means that the modeler typically only has to supply a limited amount of new knowledge for a new task, because the system can use knowledge from other tasks.

Tutorial Structure

The chief goal of the tutorial is to give participants some hands-on experience with the architecture. The PRIMs application is easy to use, and gives a good overview of what happens in the model, how knowledge is interconnected and what the results of running models are. It will therefore start with a relatively brief theoretical overview, followed by a small exercise in which participants have to construct a small model that performs addition by counting, in order to investigate the transfer between regular counting and counting as part of doing addition.

The afternoon session will focus at an example of how PRIMs can model a case of *far transfer*, in which training on task switching improves the model's performance on the Stroop task (we will look at data from Karbach & Kray, 2009, for this). In the subsequent exercise, participants will extend that model with a working memory task.

We will end the session with some discussion about how PRIMs can discover its own knowledge, and future directions of the architecture.

Materials

Participants will be provided with a tutorial reader that has the instructions on how to use the software and build models. They can download and run the software themselves from https://github.com/ntaatgen/ACTransfer (it has both the source code and a precompiled application). Participants will also be provided with the Powerpoint presentations and other relevant files for the tutorial. The current limitation is that it only runs on a Macintosh computer, so participants may have to share machines for the exercises.

The tutorial assumes no prior knowledge apart from a general cognitive science audience. It may be helpful for participants to read the article that outlines the theory (Taatgen, 2013).

Credentials of the Organizer

Taatgen has given tutorials on ACT-R during CogSci 2004, and Taatgen and van Rijn during CogSci 2005-2008, and in 2011 with Jelmer Borst. In addition, Taatgen has organized the ACT-R summer school at CMU in the past, and presently co-hosts the yearly European cognitive modeling Spring School in Groningen that has run from 2009 until present. He has given the present tutorial to a smaller audience in 2015 at Rensselaer Polytechnic University, and will give the tutorial during the upcoming Spring School in Groningen.

Acknowledgements

This research was funded by ERC-StG grant 283597 awarded to Niels Taatgen.

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