Mei:CogSci Conference Budapest

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The Role of Mental Representations in Problem Solving Process

Transcript of presentation

Each paragraph has a preceding number that marks the presentation slide (with the same number) that was displayed to the audience at the same time. Refer to those slides for clarity during reading. Paragraphs may have been worded differently that is written here, but the same thoughts, concepts and ideas were expressed (the important ones are marked bold as a reminder).

01)
Hello! My name is Nejc and today I will talk about **Problem Solving** in general and specifically about **mental representations** and their **role** in a problem solving process.
We will take a look at how they have been investigated until now and how we **plan** to investigate them in the future.

02)
First. Problem solving research field.
It's a very **broad field** and thus has been **widely studied** through many disciplines.
The two components that are mainly studied are **selection of strategy** (how an active agent selects or decides on a strategy) and **optimization of the said strategy** (how to squeeze the best result out of the strategy applied to the problem).
Each of these two is crucial in its own way and thus has great effect on the final result. But there is also a third component that is equally crucial, yet often very neglected

Shape and mental representation of the problem solving process.

03)
We study this phenomena because we believe it is crucial to the final result of a problem solving process.
A mental representation determines which strategies and optimizations can be used.
Some problems allow for the multiple representations and some don't. - Or. Alternative representations just haven't been discovered yet. This is a topic for later research.

04)
What we do know about mental representations is that they work like a **fork in the road**.
When we discover 2 or more mental representations, we can take any one of them. Some are **faster,** some are **easier**, some may provide other benefits and some can even **lead us astray**.
But we can take only **ONE AT A TIME** to tackle the problem. We can often return to the beginning and take the other one, but we can never combine them or go on both at the same time. **Only one at a time.**

05)
I like mathematics, so most of the examples in this presentation will be from this field. To get a certain Fibonacci number we can either take the commonly known formula, which is **simple, intuitive and easy to understand**, but it takes **a long time** to calculate higher numbers.
Alternatively, we can use the second, **linear equation**, which enables us to directly calculate any Fibonacci number, but just look at it… **we do not understand what us going on here** :)
In the end, they both bring us the same result, but they have different **features**.

06)
Now for a little participation task.
You have 60 seconds to tackle the problem on the screen.
Use them wisely. The fastest result gets a reward!

* Congratulations to Jan Honza for solving the task first.

07)
There are **many approaches to solve this problem**.
The **2 most notorious** are:

- Approach 1 uses the common **mentalization** of **acquiring all variables, one by one** by the common formula we were taught in school. It is a long process, but on the plus side, it acquires **all variables, one by one.**
- The second approach works on the **mentalization of combining the formulas .** In some cases the solution can be achieved much faster.
    - We combine all the equations and divide the result by the combined amount of all variables, in this case: 3. This is the **quickest solution**, but we do not get to know the individual variables.

08)
Sometimes it is hard to observe the underlying mental representations, especially since humans tend to **pick the first one that comes to mind and work with it.** We rarely take time to consciously investigate others. We pick one and go to incredible lengths to solve the problem with it.
But **once we have identified alternative representations**, we can **switch between them** like on the picture with a vase or 2 faces. But we can **never use them together at the same time.**

09)
Another concept worth mentioning at this point is **Transfer.**
It tells us **how well the subject** (after solving the first tasks) **solves subsequent similar tasks.** Transfer can be positive (subject performs better at subsequent tasks) or negative (subject performs worse).

10)
As said before, this aspect of problem solving has not been widely researched; and we base our work on the work of **Herbert Alexander Simon**, which was presented by Kotovsky and Fallside in the article **Representation & Transfer in Problem Solving.**

11)

* Invite Karina to help demonstrate solving of the tasks (which were prepared in the beginning)

In this article authors (among other tasks) investigated how subjects solve a **tower of Hanoi task** in various situations using **balls instead of common disks**.

- Subjects are asked to solve the task when balls are stacked on a pole and behave just like disks in comparison to a task where balls are placed on three plates, but rules still apply: subject can not move the bigger ball if a smaller one is on the same plate.

* Special thanks to Karina for solving the tasks so quickly

12)
This is very well studied by a task, where subjects are asked to solve **an isomorph of the Tower of Hanoi task,** but are presented by such balls on an **interactive computer screen**.
They are told either:

- that balls are **in a box** and are **small, medium and large**

or

- that balls are **in a tunnel** and are **far, middle and near.**

The same stimulus is used, so the only difference is in **subjects' mental representations**. And they have determined (among other things) that **independently of the stimulus features, internal representation determines transfer and how fast the solution is achieved.**

13)
Following Simon's steps I have created an experiment under **the mentorship** of Dr. Paolo Petta, where subjects were asked to **write a program** that will solve the **tower of Hanoi task** under **object oriented** or **logic paradigm**.
We have concluded that participants solved the task faster and produced better solutions under the logic paradigm, but the code was much easier to understand under the object oriented paradigm.
And the differences are mainly attributed to mental representation of the problem.

14)
Just a quick glance for better understanding.
On the left is an avereage code produced to create a programm under **object-oriented representation** and on the right the code required for a program under **logic representation.**

15)
Lastly, I will present you my **master thesis project** (at this moment, **unfinished**), where I am going to do 2 experiments under the mentorship of Dr. Matus Grezo.

A matchstick experiment and a programming experiment.

(We like to include programming tasks in our research and in this way bring computer science and psychology a little bit closer)

16)
On the first experiment, called the **matchstick experiment**, we will use tasks – like the one presented on the picture (where, by the way, 4 solutions are possible with only one move) to investigate whether creating a mental representation and learning effective strategies leads to a negative (unwanted) transfer in an isomorphic task, so that other representations and strategies are overlooked.

Basically, if the subject would be better off not learning and training before solving a task.

17)
The second experiment will examine the effect of transfer in a more specific field of programming. Here, we will investigate whether manipulating the structure of information about the problem task induces creation of a certain mental representation and choosing of a particular strategy.
We will also investigate whether the transfer of strategy used also occurs in neutrally introduced isomorphic task that does not induce creation of a particular mental representation.

18)
We expect that

1. Mental representations lead to statistically significant effective (positive or negative) transfer. But that transfer is not solely dependent on mental representations.
2. That structure of information plays a significant role in construction of mental representations.
3. And that some mental representations are more available (easier to think of) than others.

(Most of these hypothesis follow from the works of H. A. Simon)

19)
Hopefully, our research will provide new findings about how mental representations affect the occurrence of transfer, which could create some base ground for further interdisciplinary research in psychology and computer science.

20)
Thank you for your attention.

Following slides are prepared to be used for certain expected questions at the end.