MULTIPLE REPRESENTATIONS, COGNITIVELY ACTIVATING TASKS AND THEIR ROLE IN UNDERSTANDING OF PHYSICS EXPERIMENTS

UPGRADE

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1st Cohort

THEORETICAL BACKGROUND AND AIMS

Mental representations and their interplay

Essential for science learning in general and for the understanding of experiments in particular (Gilbert &Treagust, 2009)

Representational Competence

Ability to generate and use different specific descriptional and depictional representations of a subject or a problem in a skilled way (Dolin, 2007)

Obviously, students' representational coherence ability (**RCA**) is an essential part of representational competence. For this study, representations are seen as *coherent* if they correspond in conjoint information.

Learning problems related to representations and experiments

- Students' representational competence was found wanting even at physics' university level (Saniter, 2003)
- Students remember and understand too little from own (Novak, 1990) and lecture experiments (Crouch et al., 2004)

There is help: Learning about and from experiments can be enhanced by cognitively activating tasks as the predict-observe-explain sequence (Kearney et al., 2001, Crouch et al., 2004)

Instructional approach to overcome the problems

The experiment related RCA of students and their understanding of experiments based on it can possibly be fostered by cognitively activating tasks, explicitly asking for analysis of domain specific representations and their interplay (Representation Analysis Tasks, RATs).

Aims of the study

- Development and validation of an instrument for assessment of RCA for ray optics
- Development of a set of field-tested, experiment related Representation Analysis Tasks (**RATs**) fitting in regular classroom instruction of the topic
- Investigation of the development of student's RCA through the RAT-approach and influences of control variables (research topic)

METHODS

Sample: 342 students (age = 13; *SD*= .68; German grammar school)

Design: quasi-experimental, one-factorial design with/without RATs (otherwise identical lesson plan, same teacher)

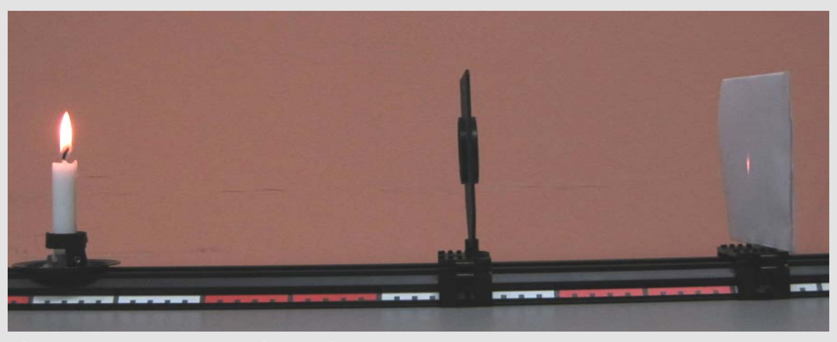
- Dependent variables: student's RCA, broader conceptual understanding
- Moderator variables: intelligence (Liepmann, 2010), possibly relevant school grades (German language, physics and mathematics), motivation

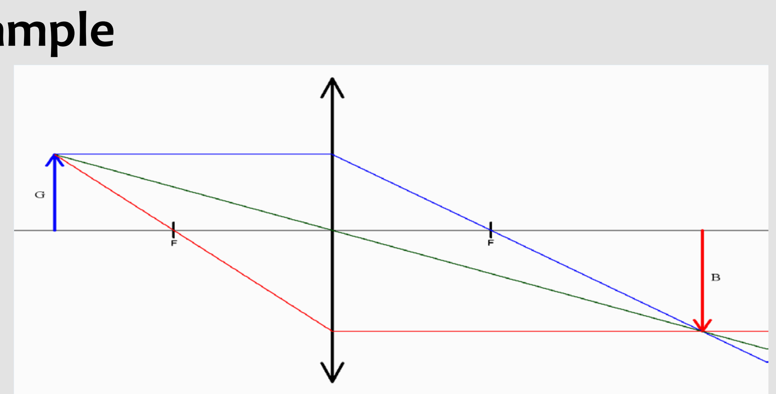
Statistics: Item analyses & multilevel-analyses for measuring changes (Göllner et al., 2010)

Design features of RATs

Ask for completing, correcting, adapting, comparing, & mapping of ≥ 2 involved representations. Explicit analysis of several connected representations (traditional tasks work typically with only 1 representation).

RATs: An Example





Students are asked to

- Analyze: Fitting of conditions of optical elements in photograph & ray diagram
- Mark: differences between the representations in the ray diagram
- Correct: ray diagram
- Explain verbally: how and why they have corrected the images.

➔ Activate cognitive processing with three types of representations

SELECTED RESULTS

Item analysis: Reliability and validity of the RCA-test

- α_{Cron} = .8 (n = 488)
- curricularly validated by expert-rating: ICC = .64, n = 11)

Inference statistics

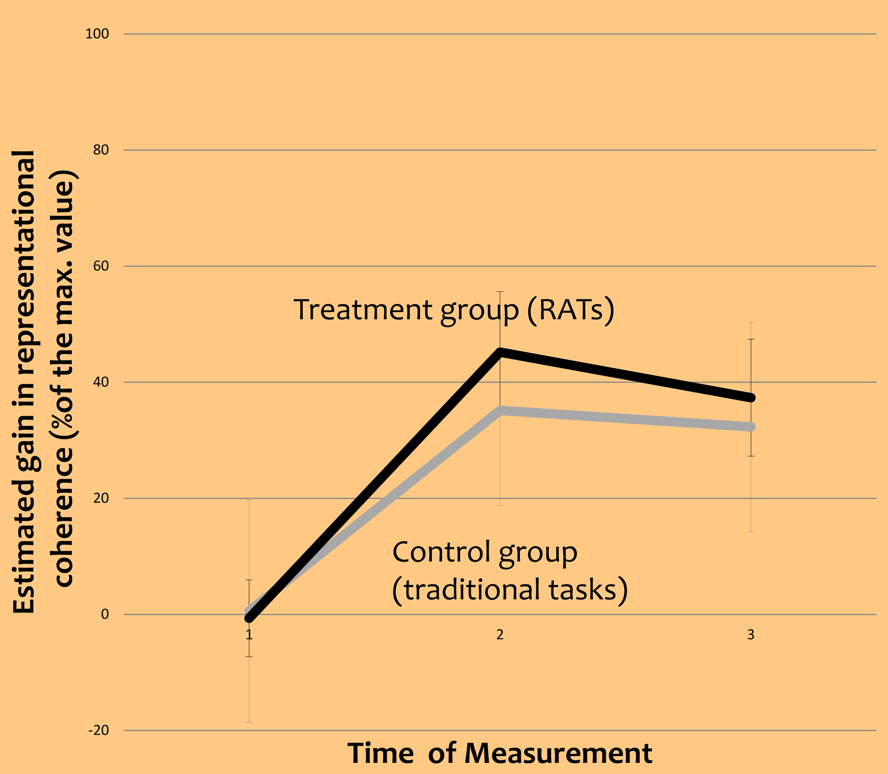
RCA of TG and CG are influenced by the following factors

(n = 302)

- Grade_{maths}: $\omega^2 = .072$, $p < .001$ (medium effect)
- $\text{IQ}_{figural\ reasoning}$: $\omega^2 = .035$, $p < .001$ (small effect)
- $\text{Grade}_{physics}$: $\omega^2 = .018$, $p < .012$ (small effect)
- Conceptual understanding (pretest): $\omega^2 = .013$, $p < .026$ (small effect)

(Results below are adjusted for these influences)

RAT-effect on representational coherence



Task type (RAT vs. traditional) has a highly significant influence on RCA
$p < .001$; $\omega^2 = .085$ (medium effect size)

6 weeks after intervention the RAT-effect stays significant
$p < .01$; $\omega^2 = .024$ (small effect size)

➔RAT-effect is lasting!
(at least at medium term)

However, no effect on broader conceptual understanding in ray optics

CONCLUSIONS & OUTLOOK

A relatively short intervention (6 x 45 min) targeted at experiment-related representations in ray optics and coherence between them, can lead to a significant and practically important improvement of student's representational coherence ability and therefore student's experiment related understanding (domain specific for image formation). The concept test targeted at a broader area of ray optics, it is probably therefore to unspecific to show effects in the researched area. Detailed analyses of subdimensions are in progress.

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PROGRESS OF THE WORK