Abstract in ICLTC Handbook 2016

The present studies were designed according to the study of Hu, Ginns, and Bobis (2015) that showed beneficial effects of finger tracing on learning success and the study of Macken, and Ginns (2014) that showed beneficial effects of tracing gestures on anatomy and physiological learning about the human heart. Cognitive load theory and theories of embodied cognition provide explanations for the beneficial effects of tracing gestures. One explanation is that the finger functions like a cue to focus attention for visual processing, similar to the effects of hand gestures and position on attention direction (Cosman & Vecera, 2010). The goal of a pilot study was to combine eye tracking and finger tracing within one experimental setup and to analyse eye movements as an indicator for changes to visual information processing. The original paper-based learning instruction about the human heart (Macken & Ginns, 2014) was converted to a digital version and adapted for eye tracking on a 1280x1024 screen presentation. In addition, the instruction was shortened from 12 to 7 pages that focused on the anatomical structures and cut off the information about function and blood flow. The multiple-choice tests for prior knowledge and learning success were adapted, too. Participants (N = 13) were randomly assigned to one of two groups. The tracing group was instructed to use finger tracing while learning whereas the control group was instructed not to use their hands while learning. Preliminary results do not confirm the beneficial effect of tracing on learning success, however there was a significant increase in transitions between textual and related pictorial areas of interest for the tracing group ($M = 99.0$, $SD = 27.87$) in contrast to the control group ($M = 59.0$, $SD = 19.30$), $t(11) = -2.89$, $p < .05$. The present pilot study was conducted in order to solve several technological problems concerning the combination of eye tracking with tracing behaviour. These first results indicate that tracing has an effect on eye movements and information processing, as a recent study by Park, Korbach, and Brünken (2015) found the text-picture transitions to be positively correlated to learning success. The missing effect in the present pilot study on learning success may be due to the shortening of the learning instruction and the changes concerning the tests for prior knowledge and learning success. The main study is already running with the original learning instruction and focuses on eye-tracking analyses in combination with cognitive load measurement to investigate cognitive load explanations for the effects of tracing and pointing gestures. First results of the main study will be presented and discussed on the conference.

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Effects of Tracing Gestures on Eye Movements: An Eye-Tracking Study

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Aim of the pilot study:

(A) To combine the recording of eye movements and tracing gestures

(B) To analyze the eye movements as an indicator for changes to visual information processing as a function of tracing

How does Tracing affect multimedia learning?

(Hu, Ginns, & Bobis, 2015; Macken, & Ginns, 2014)

Macken and Ginns (2014):

- Paper-based learning instruction about the structure and function of the human heart (with/without tracing instruction)
- Increase in terminology test and comprehension performance
- No effect on subjective ratings of cognitive load (Cierniak, Scheiter, & Gerjets, 2009)

Hu, Ginns, and Bobis (2015):

- Paper-based learning instruction with geometry worked examples (with/without tracing instruction)
- Increase in test performance (Tracing on the paper > Tracing above the paper > No tracing)
- Lower ratings of test item difficulty for the tracing on the paper condition compared to the condition without tracing

Theoretical Explanations for Tracing effects

(Hu, Ginns, & Bobis, 2015; Macken, & Ginns, 2014)

Embodied Cognition:

- Activation of haptic working memory resources
- Use of tactile and kinaesthetic modalities (Kaas, Stoeckel, & Goebel, 2008)
- Gestures as a form of biological primary knowledge that supports the acquisition of biological secondary knowledge (Hu et al., 2015)

Attention Direction:

- Gestures as attention-guiding cue (Hu et al., 2015)
- Visual attention and perception is guided by the hand position (Cosman & Vecera, 2010)
- Information near the hand will be scrutinised longer and deeper (Reed, Grubb, & Steele, 2006)

Measures of Eye Movements

- **Eye Movements:** provide information about the focus of attention
  (Eye-mind Hypothese, Just & Carpenter, 1980)

- **Interpretation:** Measures for information processing based on visual perception – Supposed to be an indicator for cognitive processing
  (Mayer, 2010)

- **Number of Fixations and Fixation Duration:**
  As an indicator for cognitive processing
  (Lowe & Boucheix, 2010; Canham & Hagarty, 2010; Meyer, Rasch & Schnotz, 2010)

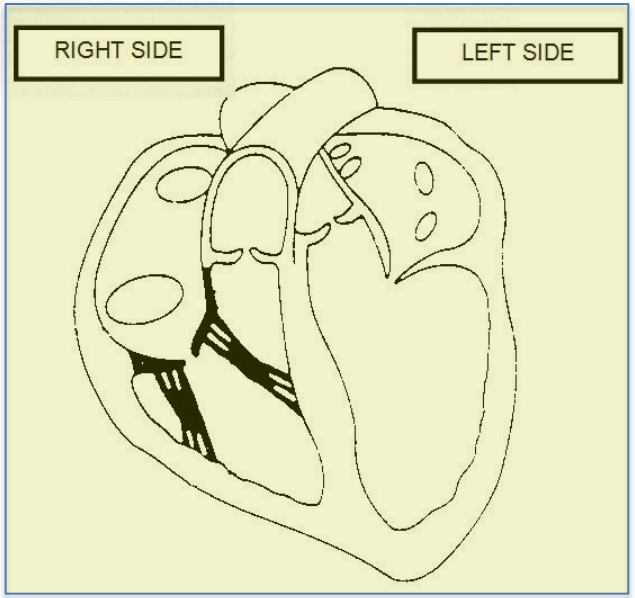
- **Transitions between different AOIs with related information:**
  As an indicator for cognitive integration processes
  (Holsanova, Holmberg, & Holmqvist 2009; Schmidt-Weigand, Kohnert, & Glowalla, 2010)

Areas of Interest (AOIs) and Measures of Eye Movements for the Pilot Study

- **Picture AOIs:** AOIs for relevant pictorial information
- **Text AOIs:** AOIs for relevant textual information
- **Fixations:** The total fixation duration on relevant text and picture AOIs
- **Transitions:** Number of Transitions from relevant text to relevant picture AOIs

The Heart And Its Functions

The human heart is a hollow, bluntly conical, muscular organ. Its pumping action provides the force that circulates the blood through the body. In the average adult, the heart is about 13 centimetres long and about 6 centimetres thick. A man's heart weighs about 300 grams and a woman's heart weighs about 250 grams. The heart lies toward the front of the body and is in a slanting position between the lungs, immediately below the breastbone. The wide end points toward the right shoulder. The small end of the heart points downward to the front of the chest and toward the left. In order to better comprehend the following instruction, it will be helpful to visualize a cross-section view of a human heart in a position as if facing the person. As it is visualised, the right side of the heart will be on the left side. To understand the functioning of the heart it is necessary to be able to identify the parts of the heart.



Research Questions and Hypotheses

How does Tracing affect learning success?

How does Tracing affect the focus of visual attention?

How does Tracing affect subjective ratings of cognitive load?

H1: Tracing leads to a higher performance in the terminology test

H2: Tracing leads to an increase in visual attention

H3: Tracing leads to a decrease in subjective ratings of task difficulty and to an increase in subjective ratings of concentration (mental effort)

Method

- System-paced multimedia instruction (Heart Structure & Function):
  7/12 screens with each of including a pictorial and a textual part (Macken & Ginns, 2014)

- *N* = 12 students of the Saarland University (6 with tracing/6 without tracing)

- Dependent variables:

  - Learning performance (terminology test)
  - Subjective Cognitive load ratings (7 point Likert scale):
    - How difficult was the learning content for you?
    - How difficult was it for you to learn with the material?
    - How much did you concentrate during learning?

  - Eye movements:
    - total fixation duration and transitions from text to picture AOIs

- Control variables:

  - Prior knowledge

Means and Standard Deviations for all Variables

	With Tracing (n = 6)	Without Tracing (n = 6)	
Prior Knowledge	2.00 (0.89)	3.16 (1.47)	
Learning Success	12.83 (4.11)	14.66 (2.66)	
Fixation Duration on Text AOIs	355.57 (187.187)	272.12 (87.90)	
Fixation Duration on Picture AOIs	176.97 (96.84)	198.47 (113.88)	
Transitions	95.6 (29.74)	59.0 (19.31)	$t(9)=-2.467$, $p<.05$
Difficulty of Content	4.0 (2.0)	3.5 (1.87)	
Difficulty of Learning	3.6 (1.97)	3.5 (1.22)	
Concentration	4.66 (1.03)	4.83 (1.72)	

Summary & Limitations of the Pilot Study

H1: No increase in learning performance

H2: Increase in visual attention for transitions

H3: No differences between the groups in the subjective ratings

- Learner characteristics were not controlled (e.g. age, gender, language skills, eye movements)
- Influence of language skills must be assumed
- Only a short version of the terminology test was used to measure learning performance

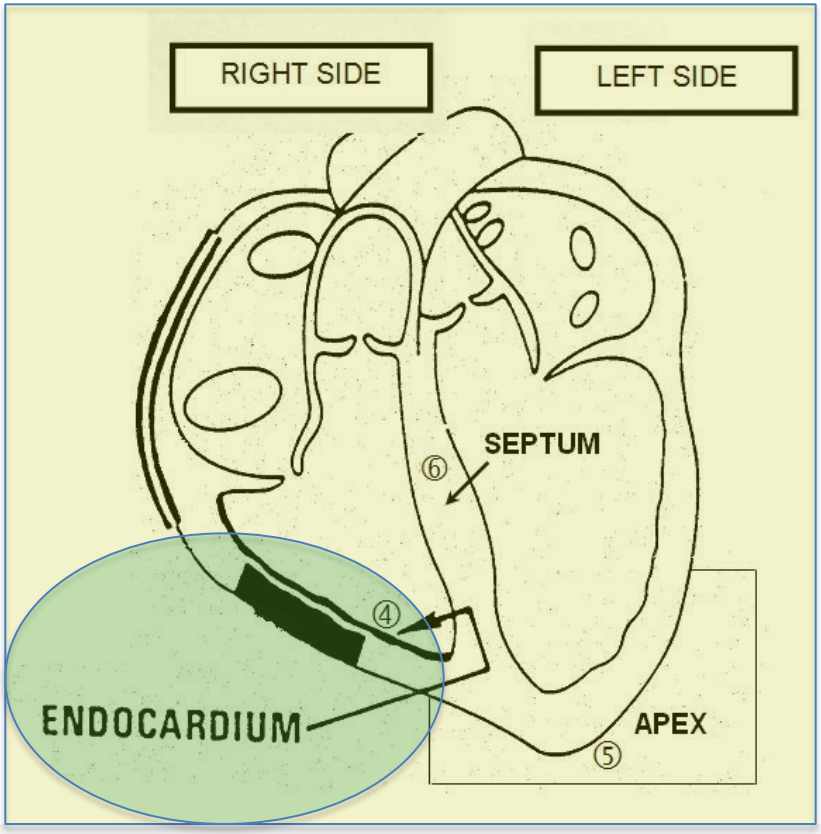
Improvements for the main study

- Learner characteristics will be controlled
- The original learning instruction will be translated into german language and only participants with mother tongue german will be evaluated
- The full length version of the learning instruction will be used
- Cognitive load will be measured with up to date rating scales (e.g. Leppink et al., 2013; Leppink et al., 2014)
- Detailed analysis of eye movements
- Detailed recording of tracing gestures (time, duration, position)

Analysis of Eye Movements for the Main Study

- **AOIs:** Local and global text and picture AOIs
- **Fixations:** Analysis of local fixations according to the areas of tracing gestures
- **Transitions:** Differentiated analysis of local and global transitions

The endocardium ④ is the name given to the inside lining of the heart. The human heart is really two pumps combined into a single organ which circulates blood to all parts of the body.
The lower portion of the heart is called the apex ⑤ and is the part that beats.
The heart is divided longitudinally into two halves by the septum ⑥. The two halves may be compared to a block of two houses which are independent of each other but have a common wall, the septum, between them.



Discussion

Increase in transitions – increase in visual attention – increase in cognitive activity?

- Results for transitions are in line with the theoretical assumptions of the studies of Hu et al. (2015) and Macken, and Ginns (2014)
- Increase in transitions indicates an increase in cognitive activity, however correlations to learning performance were missing

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Thank you for your attention!
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