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Visualizers versus verbalizers: Effects of cognitive style on learning with texts and pictures – An eye-tracking study

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ABSTRACT

This study was conducted in order to examine the differences between visualizers and verbalizers in the way they gaze at pictures and texts while learning. Using a collection of questionnaires, college students were classified according to their visual or verbal cognitive style and were asked to learn about two different, in terms of subject and type of knowledge, topics by means of text-picture combinations. Eye-tracking was used to investigate their gaze behavior. The results show that visualizers spent significantly more time inspecting pictures than verbalizers, while verbalizers spent more time inspecting texts. Results also suggest that both visualizers' and verbalizers' way of learning is active but mostly within areas providing the source of information in line with their cognitive style (pictures or text). Verbalizers tended to enter non-informative, irrelevant areas of pictures sooner than visualizers. The comparison of learning outcomes showed that the group of visualizers achieved better results than the group of verbalizers on a comprehension test.

Issues of cognitive style and learning preferences have been an underlying topic of educational and psychological discussions for years (e.g., Mayer & Massa, 2003; Riding, 1997; Witkin, 1973). Sometimes the whole concept is disputed (e.g., Kirschner & van Merriënboer, 2013), sometimes endorsed (e.g., Cassidy, 2004). Regarding visual-verbal cognitive style and its influence on learning from text-picture combinations, relatively few studies have been conducted (e.g., Höffler, Prechtl, & Nerdel, 2010; Riding & Douglas, 1993). There are even fewer studies which try to examine actual differences between visualizers and verbalizers via a direct observational method like, for example, eye-tracking (e.g., Mehigan, Barry, Kehoe, & Pitt, 2011; Tsianos, Germanakos, Lekkas, Mourlas, & Samaras, 2009). Our study is therefore an attempt to directly examine verbal and visual learners' eye-movements in the context of multimedia learning. Some eye-tracking studies already indicated that visualizers and verbalizers might differ in the way they view pictorial and textual stimuli (Mehigan et al., 2011; Tsianos et al., 2009). Thus, when learning with texts and pictures, learners' visualizer-verbalizer cognitive style might have a direct influence on learning behavior and preferences. Such a finding would help to provide evidence for the existence or non-existence of different cognitive styles and their influence on learning behavior and, furthermore, learning outcome.

1. Theoretical background

1.1. Cognitive style, learning style, or learning preferences?

According to Messick (1984), cognitive style can be defined as an individual difference in the way of organizing and processing information. Sternberg and Grigorenko (1997) described cognitive style as a platform placed between cognition and personality. Often, studies on cognitive style focus on the visualizer-verbalizer dimension, which originally derives from dual-coding theory (Paivio, 1986). According to this theory, incoming information is processed and mentally represented in two ways: verbally and visually. Hence connecting these two mental representations should improve learning outcomes (e.g., Mayer, 2014). Although there is much evidence that some people tend to think in words

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and others in pictures (e.g., Mayer & Massa, 2003), there is some controversy as to the impact of this distinction on learning behavior and learning outcome (Kirschner & van Merriënboer, 2013; Massa & Mayer, 2006).

Furthermore, there is great inconsistency in the literature on how to refer to the distinction of visualizers and verbalizers: Some researchers refer to the term cognitive style (e.g., Richardson, 1977), others to learning style (e.g., Kirby, Moore, & Schofield, 1988), or learning preferences (e.g., Plass, Chun, Mayer, & Leutner, 1998). As a result of a factor analysis, Mayer and Massa (2003) identified cognitive style, learning preferences, and spatial ability as three different factors. They distinguished between these three constructs, defining spatial ability as a specific type of cognitive ability, visualizer-verbalizer cognitive style as thinking in pictures or words, and learning preferences as preferences in choosing graphics or text in instructional materials. Based on this distinction, the current study's focus is on cognitive style. We focus on differences between learners who think either more in pictures (visualizers) or in words (verbalizers). Learning preferences, as well as the correlated construct learning style, we understand as a predilection for specific kinds of learning materials (verbal, visual), that can be, but not necessarily has to be a consequence of cognitive style.

Research results are also inconsistent in terms of the structure of the visualizer-verbalizer distinction. Some studies describe this distinction as a one-scale dimension, which two endings correspond to either verbal or visual cognitive style (Mayer & Massa, 2003), others as two different scales (e.g., Paivio & Harshman, 1983). Kozhevnikov, Kosslyn, and Shephard (2005) even subdivided the visual scale into two subscales: Object and spatial. Object visualizers score poorly on spatial imagery tasks, whereas spatial visualizers score highly. The authors reported that many scientists and engineers seem to be spatial visualizers, while visual artists are usually rather be categorized as object visualizers. As the question on the number of scales does not seem to be fully answered yet, we used a large number of different established scales in our study to be able to satisfyingly characterize visualizers and verbalizers. Furthermore, we studied the learning behavior of visualizers and verbalizers in learning tasks which consist of visual (that is, pictorial) and verbal representations.

1.2. Learning with text and pictures

Many studies (Clark & Paivio, 1991; Mayer, 2014; Wittrock, 1989) show that a combination of text and pictures supports learning and deepens understanding and problem-solving processes. For example, in a study conducted by Plass et al. (1998) on visualizer and verbalizer learning preferences, a combination of text and pictures or text and animations led to better learning outcomes than text alone. However, simply combining text and pictures does not always lead to improvements of learning results. The effectiveness of the combination is highly dependent on such aspects as the form of visualization, the type of learning task, the number of referential connections between text and pictures, and personal characteristics of the learner (e.g., Mayer, 2014; Schnotz & Bannert, 2003). Thus, learning achievements differ with respect to individual differences, such as, for example, prior knowledge (e.g., Kalyuga, 2007), spatial ability (e.g., Hegarty, 2005; Höffler & Leutner, 2011; Höffler, 2010), or cognitive style (Höffler et al., 2010).

According to the cognitive theory of multimedia learning individuals process information using two channels: verbal for verbal or auditory representations and visual for visual or pictorial representations (Mayer & Moreno, 2003; Paivio, 1986). Verbal and visual processing is also reflected in the structure of working memory postulated by Baddeley (1998). The capacities of visual and verbal components of working memory (phonological loop and visuospatial sketchpad) are limited (Baddeley, 1998; Chandler & Sweller, 1991), differ strongly depending on individual differences such as intelligence (Baddeley, 2003), and are deeply connected with cognitive load experienced by an individual (cognitive load theory; Sweller, 1994). The more difficult the learning material, the higher the perception of intrinsic load (Plass, Moreno, & Brünken, 2010). Some studies show that working memory capacity and cognitive style (in this case, so called field dependence/independence cognitive style) are correlated (Mousavi, Radmehr, & Alamolhodaei, 2012). Referring to these findings, we make assumptions regarding the way in which visualizers and verbalizers might process information in multimedia learning differently. We assume that limited capacities of working memory's components and individual differences regarding cognitive style can result in favoring either the verbal or visual channel while processing information in multimedia learning (Mayer & Massa, 2003).

Visualizer-verbalizer cognitive style seems to have an impact on the learning process. Visualizers achieve better when learning from pictures and text and profit more from pictorial information, while verbalizers rely more on text (e.g., Plass et al., 1998). Additionally, Riding and Douglas (1993) showed that text-picture combinations are more beneficial to visualizers, whereas conditions providing only textual information result in better results for verbalizers. These findings can support our assumptions and also suggest that visualizers might be better in integrating information represented in both channels described in the cognitive theory of multimedia learning. Moreover, Plass et al. (1998) showed that the absence of the preferred mode of information presentation (e.g., pictorial for visualizers) resulted in poorer learning. On the other hand, Massa and Mayer (2006) could not replicate such an effect. The discrepancy between these findings might be a result of differences in defining visualizers and verbalizers in both studies, though. Massa and Mayer measured visual-verbal cognitive style as well as learning preference, while Plass et al. concentrated on learning preferences.

The inconsistencies of research results regarding advantages of instructional text and pictures for the learning of visualizers and verbalizers – and the predicted differences in processing information and learning outcomes between these groups – encouraged us to examine how visualizers and verbalizers learn from two different, in terms of topic and type of knowledge, combinations of pictures and texts.

1.3. Eye-tracking and learning

Eye-Tracking research revealed that people differ in their patterns of reading a text. Generally, the most effective strategy is to pay special attention to topic sentences and topic-relevant information in the text (Hyönä, Lorch, & Kaakinen, 2002). While dealing with stimuli containing text and pictures, research showed that learning is heavily driven by text (Hannus & Hyönä, 1999; Schmidt-Weigand, Kohnert, & Glowalla, 2010), and that learners tend to spend more time looking at the text than at the pictures (Rayner, Rotello, Stewart, Keir, & Duffy, 2001). However, best learning outcomes can generally be achieved when information from pictures and texts is integrated.

The way of looking at a stimulus depends on its construction. Some studies showed, in line with the *spatial contiguity principle* (Mayer, 2014) that shorter physical distance between textual and pictorial information facilitates the integration of information from these two sources by finding correspondences between them (e.g., Holsanova, Holmberg, & Holmqvist, 2008). Especially a serial layout of the information material, which organizes the material sequentially, enhances the integration (Holsanova et al., 2008). The