Chapter 4.12
The Influence of Visual and Temporal Dynamics on Split Attention:
Evidences from Eye Tracking

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ABSTRACT

This chapter introduces eye tracking as a method to observe how the split of visual attention is managed in multimedia learning. The chapter reviews eye tracking literature on multirepresentational material. A special emphasis is devoted to recent studies conducted to explore viewing behavior in learning from dynamic vs. static visualizations and the matter of pacing of presentation. A presented argument is that the learners' viewing behavior is affected by design characteristics of the learning material. Characteristics like the dynamics of visualization or the pace of presentation only slightly influence the learners' visual strategy, while user interaction (i.e., learner controlled pace of presentation) leads to a different visual strategy compared to system-paced presentation. Taking viewing behavior as an indicator of how split attention is managed the harms of a split source format in multimedia learning can be overcome by implementing a user interaction that allows the learner to adapt the material to perceptual and individual characteristics.

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INTRODUCTION

"Before information can be stored (…), it must be extracted and manipulated in working memory." (Paas, Tuovinen, Tabbers, & Van Gerven, 2003, p. 64).

In multimedia learning environments, a learner often has to extract and integrate information from different sources of information like words and pictures. Empirical evidences as well as theoretical considerations led to various instructional design principles to present those different sources of information in a learner supporting fashion (e.g. Mayer, 2001, 2005; Sweller, van Merrienboer, & Paas, 1998). The attentional, perceptual, and cognitive demands of multimedia instruction, however, are mostly *inferred* from learners' performance on subsequent tasks or self-reported difficulties with the materials at hand. In order to advance theoretical approaches and to refine instructional design principles process-related but subjective measures (e.g. cognitive load) and objective but product-related measures (e.g. learning outcomes) need to be complemented with more objective *and* process-related measures (Brünken, Plass, & Leutner, 2003; Paas et al., 2003). An often suggested, well suited, albeit – in multimedia learning – seldom-used process-related observation is the learner's viewing behavior during acquisition.

The absence of studies applying, for example, eye tracking methodology in this area may at least partly be explained by a lack of satisfying theoretical understanding of how the presumably complex cognitive processes involved in multimedia learning correspond to viewing behavior. The chapter tries to take a step towards an understanding of such viewing behavior in multimedia learning environments. Before we can discuss and further investigate how a particular viewing behavior may correspond to a particular learning outcome it is necessary to explore, if and how multimedia design actually affects viewing behavior. Reviewing the eye tracking research on combined presentation of text and pictures and providing recent research results of eye tracking studies in multimedia learning the chapter aims to answer the following questions:

1. How do learners split their visual attention during learning from a multimedia instruction? And
2. Which attributes of a multimedia instruction *moderate* a learner's viewing behavior?

BACKGROUND

Currently, research on multimedia learning and instructional design is influenced by two theoretical frameworks, cognitive load theory (Sweller et al. 1998) and Mayer's (2001) cognitive theory of multimedia learning. The main aim of these theoretical approaches is to base instructional design on "how the human mind works" (Mayer, 2001, p. 41). The most central concept of human cognitive architecture in both, the cognitive load theory and the cognitive theory of multimedia learning, is working memory. The central role of working memory for the matter of understanding and learning stems from the assumption that, simply stated, working memory is the gateway between the external world and the internal cognitive entities. Meaningful learning requires the learner to select relevant information, to organize that information in a coherent structure, and to integrate this structure into existing knowledge. Working memory plays an essential role since it is here, where the selection, organization, and integration processes are assumed to take place.

Among the various models and theories of working memory (for an overview, see Miyake & Shah, 1999) consensus exists on two aspects that are relevant to multimedia learning. First, most theorists agree that working memory resources are limited, and second, in most models of working memory there are, apart from a central regulation system, two or more separate subsystems. The notion of separate subsystems comes into play whenever information is presented in different codes (e.g. words, pictures, etc.) and/or different modalities (eye, ear, etc.) as it is the case in multimedia learning. In accordance with Baddeley's (1986) working memory model cognitive load theory and the cognitive theory of multimedia learning assume different subsystems or processing channels for visual and auditory information. Visual information is processed in a visuo-spatial sketchpad; auditory information is processed in an auditory loop. The limited