Learning and Individual Differences 51 (2016) 59–68

Contents lists available at ScienceDirect

Learning and Individual Differences

journal homepage: www.elsevier.com/locate/lindif

Learner characteristics and information processing in multimedia learning: A moderated mediation of the seductive details effect

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ARTICLE INFO

Article history:
Received 18 November 2015
Received in revised form 22 July 2016
Accepted 19 August 2016
Available online xxxx

ABSTRACT

The present study examines whether the seductive details effect is mediated by perceptual processing and whether this mediation as well as the direct effect is moderated by multiple moderators. The Aptitude-Treatment-Interaction Design ($N = 108$) considers prior knowledge and spatial ability as continuous aptitude variables and seductive details (with vs. without) and task condition (cognitive low-loading single vs. cognitive high-loading dual task) as treatment variables. Two separate models of moderated mediation are focused including task condition as a first moderator and prior knowledge or spatial ability as a second moderator. Results show a full mediation by picture fixation duration with a moderating influence of task condition and prior knowledge on the mediator and a moderating influence of task condition and spatial ability on the direct path for learning success. Especially the low capacity learners were affected under cognitive high-loading conditions. A discussion of these results leads to different theoretical and practical implications.

1. Introduction

Computer-based multimedia learning instructions offer many options concerning the integration of additional, non-redundant and interesting but irrelevant learning material in form of pictures, text, animated sequences, videos or audio commentaries. The idea behind these forms of additional information is to enrich the original learning content in order to foster situational interest (Park, Flowerday, & Brünken, 2015) and to evoke learning-conducive affective processing in multimedia learning (Knörzer, Brünken, & Park, 2016; Park, Knörzer, Plass, & Brünken, 2015; Park, Plass, & Brünken, 2014; Plass, Heidig, Hayward, Homer, & Um, 2014; Um, Plass, Hayward, & Homer, 2012). This kind of additional, non-redundant and interesting but irrelevant information is called seductive details and is often used to make the learning material more interesting and attractive to learners of all age and every type of school including higher education at universities (Park, Flowerday, & Brünken, 2015). However, in fact seductive details can decrease the learning performance and this negative effect of seductive details on learning performance is called seductive details effect. Research on the seductive details effect is somehow contradicting. Several studies have shown a detrimental effect of seductive details (Garner, Gillingham, & White, 1989; Harp & Maslich, 2005; Harp & Mayer, 1998; Lehman, Schraw, McCrudden, & Hartley, 2007; McCrudden & Corkill, 2010), whereas others have shown non-significant results (Garner & Gillingham, 1991; Hidi & Baird, 1988; Mayer, Bove, Bryman, Mars, & Tapangco, 1996; Mayer, Griffith, Jurkowitz, & Rothman, 2008; Schraw, 1998). One difference between some of the studies that show or do not show a detrimental effect is probably the difficulty of the learning content. Several studies that found a seductive details effect were using scientific texts that explain for example detailed differences between insects or the lightning process step by step. In contrast, some of the studies that could not show the detrimental effect of seductive details were using non-scientific text (description of Stephen Hawking and his theories, originally written in a newspaper; episodes on three specific inventors and their discoveries; biography of Horatio Nelson). As task difficulty is closely related to the theories of cognitive load and the usage of cognitive capacities, the assumption is close that the learners' cognitive load plays a crucial role for the impact of seductive details. Moreover, task difficulty depends on learner characteristics such as prior knowledge (Kalyuga, Ayres, Chandler, & Sweller, 2003). Participants with high prior knowledge can be assumed to experience a lower task difficulty in contrast to participants with low prior knowledge. A study by Park, Moreno, Seufert, and Brünken (2011) showed that controversial results in seductive details research can be explained by an effect on cognitive load. They found that students' learning performance was significantly higher when seductive details were presented under the low load condition (narration) as compared to all other conditions. Another study by Park, Korbach, and Brünken (2015) further confirmed these assumptions for the learner characteristics prior knowledge and spatial ability that are relevant for cognitive load (Kalyuga et al., 2003) and multimedia learning (Mayer, 2001). Results showed a moderating influence on

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http://dx.doi.org/10.1016/j.lindif.2016.08.030
1041-6080/

the seductive details effect for the learners' prior knowledge and spatial ability not only on learning success but also on perceptual processing.

The goal of the present study was to test this hypothesis again in a 2×2 factorial design including the variation of cognitive load by task condition (low-loading single task vs. high-loading dual task version) and the variation of seductive details (with vs. without). The relevant learner characteristics prior knowledge and spatial ability were again considered as moderators for learning success but this time in an integrated model of moderated mediation with perceptual processing as mediator for the seductive details effect.

2. Theoretical framework and predictions

The seductive details effect can be explained within the Cognitive Load Theory (CLT) (Choi, Van Merrienboer, & Paas, 2014; Kalyuga, 2011; Plass, Moreno, & Brünken, 2010; Sweller, Ayres, & Kalyuga, 2011). CLT assumes that the total cognitive capacity is limited and the amount of total cognitive load is determined by three components. First, extraneous cognitive load is directly caused by the format and design of the information presentation. The more optimal the learning material is presented, considering the cognitive architecture and empirically proved instructional design principles, the lower the extraneous cognitive load. Therefore, an optimal instructional design saves cognitive resources by minimizing extraneous cognitive load. Second, intrinsic cognitive load depends on element interactivity. Element interactivity is determined by the number of elements that must be processed simultaneously in working memory and their relation to each other. The larger the number of elements and the more complex their relation, the higher the intrinsic load. Third, germane cognitive load is the load that results from engaging in learning activities that foster schema acquisition. Whereas extraneous sources of load hinder learning, intrinsic sources of load reflect the complexity of the given learning task in relation to the learners´ level of expertise, and germane sources of load promote learning by helping students engage in the process of schema formation and automation.

Because of the close relation of intrinsic and germane cognitive load and difficulties to differ unique construct relevant cognitive processes, the updated model of cognitive load theory (Choi et al., 2014; Kalyuga, 2011) considers only the two components intrinsic and extraneous load to cause the total amount of cognitive load and to consume working memory capacity. Germane cognitive load was excluded from the working memory equation and considered as germane resources that reflect the amount of working memory capacity dedicated to learning relevant information processing that is intrinsic cognitive load. However, the former concept of germane cognitive load is not finally discarded for the present study. Both concepts are considered and discussed according to the reported results.

CLT further assumes that the two respectively three components are additively composed to the total cognitive load (Moreno & Park, 2010). If the total amount of cognitive load in a learning situation is too high the learning process will be impaired. Seductive details are part of the instructional design but they are not relevant for the learning process, so they can be allocated to the extraneous load factor. Thus, adding seductive details to a learning content causes additional extraneous load that might overstrain the learners' cognitive capacity especially under cognitive high loading conditions.

2.1. Theoretical explanations for the seductive details effect

Seductive details consist of additional, non-redundant and interesting but irrelevant information. For the present study the seductive details provide for example information that is somehow related to the topic synthesis of adenosine triphosphate (ATP) in form of practical examples for the usage of ATP in humans' or animals' life. That information is interesting but not related to the learning concern of ATP synthesis in the ATP synthase. Even though there is some inconsistence in literature, research on seductive details provides four explanations for the negative effect of seductive details: (1) cognitive overload, (2) diversion, (3) disruption or (4) distraction. A meta-analysis by Rey (2012) compares 39 experimental effects concerning these explanations. The result suggests that a simple cognitive overload assumption might be insufficient and that the seductive details effect cannot be fully explained by one single explanation. A study by Harp and Mayer (1998) supports nevertheless the diversion hypothesis that assumes that seductive details activate inappropriate prior knowledge and that new information is organized around these inappropriate schemata. Some studies tested the effect of schema interference by manipulating the presentation order of seductive details in the way that seductive details were presented at the beginning, interspersed, or at the end of the learning material (Harp & Mayer, 1998). As seductive details only affect learning in a negative way, when presented before or within the learning session, the results support the diversion hypothesis and the assumption of schema interference. On the other hand, the results do not necessarily exclude the alternative explanations of disruption and distraction. The activation of inappropriate prior knowledge may further lead to a disruption or a distraction in the learning process. This assumption is supported by studies that could show a disruption and a distraction of the learning process (Lehman et al., 2007; Park, Korbach, & Brünken, 2015; Sanchez & Wiley, 2006). The disruption hypothesis assumes a coherence disruption of the relevant information processing by seductive details and the distraction hypothesis assumes an attention distraction of the relevant information processing. A study by Lehman et al. (2007) supports the disruption hypothesis, as the results show that seductive details reduce reading time of relevant sentences in scientific text and decrease the recall of main ideas. A study by Sanchez and Wiley (2006) gives support for the distraction hypothesis, as the results show that the learners' attention control is a crucial factor for the detrimental effect of seductive details. A study by Park, Korbach, and Brünken (2015) supports the disruption hypothesis as well as the distraction hypothesis. Results show that seductive details distract the learners' attention of the first fixation and cause a perfunctory processing of the relevant pictorial information that indicates a disruption of the relevant information processing and the learning process. The results of these studies suggest a combination of cognitive load, disruption and distraction explanation of the seductive details effect with an increase in extraneous cognitive load due to the processing of the additional information and a distraction or disruption of relevant information processing. The impact of the increased extraneous cognitive load due to additional irrelevant information processing relies on individual cognitive capacity and so individual learner characteristics seem to be of great importance to explain the seductive details effect, specifically concerning the distraction and the disruption hypothesis.

2.2. The moderator cognitive load manipulated via the dual-task method

Dual task means that participants have to perform two concurrent tasks at the same time. In educational studies using multimedia instruction, the participants' primary task is to work with a multimedia learning program and the secondary task is to execute a secondary task like for example to tap a previously presented rhythm with the foot. As cognitive capacity is required for both tasks in order to process them and both tasks rely on the same cognitive resources, more cognitive capacities are available for the participants in the single task condition to process the primary task. This is true for the rhythmic foot-tapping task that was chosen to manipulate cognitive load in the present study. The task is called rhythm method and was already successfully used by Park and Brünken (2015) to measure cognitive load while learning with a multimedia learning program.

2.3. Eye-movements: a relevant mediator for the seductive details effect?

Several studies show that seductive details not only affect learning performance but also the learners' perceptual processing indicated by