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Slide presentations as speech suppressors: When and why learners miss oral information

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ABSTRACT

The objective of this study was to test whether information presented on slides during presentations is retained at the expense of information presented only orally, and to investigate part of the conditions under which this effect occurs, and how it can be avoided. Such an effect could be expected and explained either as a kind of redundancy effect due to excessive cognitive load caused by simultaneous presentation of oral and written information, or as a consequence of dysfunctional allocation of attention at the expense of oral information occurring in learners with a high subjective importance of slides. The hypothesized effect and these potential explanations were tested in an experimental study. In courses about literature search and access, 209 university students received a presentation accompanied either by no slides or by regular or concise PowerPoint slides. The retention of information presented orally and of information presented orally and on slides was measured separately in each condition and standardized for comparability. Cognitive load and subjective importance of slides were also measured. The results indicate a "speech suppression effect" of regular slides at the expense of oral information (within and across conditions), which cannot be explained by cognitive overload but rather by dysfunctional allocation of attention, and can be avoided by concise slides. It is concluded that theoretical approaches should account for the allocation of attention below the threshold of cognitive overload and its role for learning, and that a culture of presentations with concise slides should be established.

1. Introduction

Using presentation software such as PowerPoint or Keynote to support lectures and presentations has become ubiquitous in both university and continuing education. Typically, learners appreciate this widespread practice because they believe that they can follow, understand, and remember the content of the presentation more easily when presentation software is used as compared to no such support (Apperson, Laws, & Scepansky, 2006, pp. 120–123; Mantei, 2000, p. 303; Nouri & Shahid, 2005, p. 66; Nowaczyk, Santos, & Patron, 1998, study 2, p. 376 f.; Susskind, 2008, p. 1232 f.; Szabo & Hastings, 2000, pp. 179–181). Furthermore, they believe that the common practice of making presentation slides available before the lecture facilitates learning (Mantei, 2000, p. 303) because it reduces the need to take notes (Daniels, 1999, p. 45).

On the other hand, concerns about negative effects of the ubiquitous use of PowerPoint have been raised in the wider public, often in the form of such lurid slogans as "PowerPoint makes us stupid" (Gralla, 2010), which have led to extensive discussions (for an overview see Craig & Amernic, 2006, p. 147 f.; Levasseur & Sawyer, 2006, p. 101 f.). In fact, from time to time teachers and trainers in university or continuing education may observe new patterns of learning outcomes when using presentation software. For example, they may get the impression that in the presence of slides participants missed what was only said but not shown in written form on a slide more often than learners miss information either in other settings or if presented on a slide. This article deals with the question whether this particular occasional impression is valid, and if so, why such an effect occurs and how it can be avoided.

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2. Prior research and theoretical background

2.1. Research about effects of the use of presentation software on knowledge acquisition

The use of presentation software in teaching has been investigated for about one and a half decades or so. Most of this work has focused on the global effectiveness of using presentation software with respect to learning and was guided by the assumption that it should have a beneficial effect (e. g. Lowry, 1999, p. 18; Mantei, 2000, p. 301; Nouri & Shahid, 2005, p. 58; Susskind, 2008, p. 1230; Szabo & Hastings, 2000, p. 178; 182).

As has been pointed out in review articles, some of these studies suffer from considerable methodological shortcomings (Craig & Amernic, 2006, p. 149 f.; Shapiro, Kerssen-Griep, Gayle, & Allen, 2006, p. 71). In the following, the ones that used only subjective criterion measures (e. g. Hopkins, Mohundro & Sayre, 1998, p. 6; Nowaczyk et al., 1998, study 1, p. 371 f.; study 2, p. 375 f.) will not be considered because they do not provide any information about actual effectiveness. Others confound the use of presentation software with cohorts of students (Daniels, 1999, p. 50; Kunkel, 2004, p. 189; Lowry, 1999, p. 18 f.; Mantei, 2000, p. 301; Szabo & Hastings, 2000, study 1, p. 179), with the distribution of slides to the participants prior to the lesson (Kunkel, 2004, p. 191; Mantei, 2000, p. 301), or with the tests used to compare the conditions (Bartlett & Strough, 2003, p. 336). Because these studies provide at least partial, albeit ambiguous, information about the effectiveness of using presentation software in teaching, they are included in the following overview of this research.

One study found a positive effect of lectures supported by presentation software compared to lectures supported by overhead slides: Although this study used different tests to compare the different conditions (Szabo & Hastings, 2000, study 2, p. 182), there was a large difference between the conditions without PowerPoint slides and with PowerPoint slides with respect to the scores in the knowledge test (49% vs. 78%, Szabo & Hastings, 2000, p. 183), which is unlikely to reflect merely a difference in test difficulty. Another study compared a PowerPoint presentation accompanied by an audio recording of a lecture to the actual lecture without slides as well as to a video recording without slides. This study also found a significant difference between the three conditions, with the highest learning outcomes in the condition with slides (Carrell & Menzel, 2001, study 2, p. 238).

In contrast, a number of studies found no effect of lectures supported by presentation software as compared to lectures without such media support (Beets & Lobingier, 2001, p. 234; Bushong, 1998, p. 20 f.; Carrell & Menzel, 2001, study 1, p. 234; Hardin, 2007, p. 55; Larson, 2001, p. 20) or to lectures supported by overhead transparencies (Ahmed, 1998, p. 4 f.; Apperson et al., 2006, p. 124; Avila, Biner, Bink, & Dean, 1995, p. 41; Bartsch & Cobern, 2003, study 1, p. 81; Beets & Lobingier, 2001, p. 234; Nouri & Shahid, 2005, p. 62; Rankin & Hoaas, 2001, p. 113; Susskind, 2008, p. 1234; Szabo & Hastings, 2000, study 3, p. 185). The overall picture from this research still is in line with a meta-analysis published in 2006. It integrated 16 comparisons from twelve publications until 2001 and reported the mean effect of using presentation software in teaching as a correlation of $r = .128$, without providing any inferential statistics for this estimate (Shapiro et al., 2006, p. 69). More than five years later, a corresponding meta-analysis including about 25 studies would still be unlikely to demonstrate an effect that is both substantial and significant. Consequently, the assumption that simply using presentation software compared to using overhead transparencies or no media support would have a positive effect on learning can hardly be defended. Concerning the comparison to teaching without media support, even in the first place, such an effect would have been only plausible for specific situations to which specific theoretically derived assumptions about cognitive advantages of concurrent written text or graphics on slides apply. Concerning the comparison to overhead transparencies, it even seems implausible that information that can actually look almost identical when projected from overhead transparencies and when projected from presentation software (including colours and “animation” by sliding down a covering sheet of paper, cf. Yates & Orlikowski, 2007, p. 74) should be remembered to a different extent (cf. Clark, 1983, p. 448 f.; 1994, p. 22 f.; 25 f.). At this level of generality, the driving question of many of these studies seems to be overly general, and more specific research questions seem to be appropriate.

Fortunately, some of the studies already discussed also focus on limiting conditions for the effectiveness of using presentation software in teaching, for example in courses differing according to the kinds of their topics (Kunkel, 2004, p. 192), with learners differing according to learning prerequisites such as “learning styles” (Nouri & Shahid, 2005, pp. 62–65), “cognitive styles” (Carrell & Menzel, 2001, study 1, p. 236; study 2, p. 238) or learners’ preferred modes of presentation (Beets & Lobingier, 2001, p. 234; for an overview of these aptitude–treatment interaction studies see Levasseur & Sawyer, 2006, p. 113 f.), with slideshows differing according to their multimedia design aspects (Bartsch & Cobern, 2003, study 1, p. 81; study 2, p. 83; Hallett & Faria, 2006, p. 173 f.), or with tests tapping different kinds or levels of knowledge (Stephenson, Brown, & Griffin, 2008, p. 646 f.) or retention of information differentiated according to the mode in which it was presented (e. g. graphically or orally; Lanir, Booth, & Hawkey, 2010, p. 897; Savoy, Proctor, & Salvendy, 2009, p. 862). One of these studies with a more specific focus demonstrated a negative effect of the use of PowerPoint on the recall of information that was presented only orally (Savoy et al., 2009, p. 863), which is in line with the occasional impression mentioned above.

This finding raises the question whether information presented both on slides and orally is learnt to a greater extent at the expense of information from speech, and if so, why this is the case. In the following section, two theoretical accounts that would imply and explain such an effect are discussed.

2.2. Explanations for inferior retention of oral information when using presentation software

2.2.1. Inferior retention of oral information as a redundancy effect due to cognitive load

Inferior recall of oral information with presentation software has some structural similarity to a variant of the so-called redundancy effect. This variant is constituted by inferior learning outcomes if pictorial information is presented along with oral and written text as compared to pictures presented along with only oral text (Mayer, 2005b, p. 184; Mayer, Heiser, & Lonn, 2001, p. 187; 195; Sweller, 2005b, p. 160). It occurs if the content is presented rapidly and the pace cannot be controlled by the learners (Kalyuga, Chandler, & Sweller, 2004, p. 579 f.; Mayer et al., 2001, p. 191). More generally, a negative effect on learning is called a ”redundancy effect” if it occurs when further information is added to information that can be understood in isolation (Kalyuga, Chandler, & Sweller, 1999, p. 369; Leahy, Chandler, & Sweller, 2003, p. 405; Sweller, 2005b, p. 160; 163; Sweller, van Merrienboer, & Paas, 1998, p. 283 f.).

The inferior recall of oral information with presentation software has two things in common with the particular variant of the redundancy effect characterized above: First, there is a multimedia learning situation. In particular, written text is presented along with oral text (Kalyuga et al., 2004, p. 567). Second, this constellation impairs learning compared to only oral text. Studies yielded evidence for this type of redundancy effect in situations in which the pictorial information was constituted by a diagram (Kalyuga et al., 1999, exp. 1, p. 358) or by an animation (Mayer et al., 2001, exp. 1, p. 192; exp. 2, p. 193; Moreno & Mayer, 2002, exp. 2, p. 160).

The redundancy effect has been explained as a consequence of cognitive demands that exceed the learners' processing capacity. Both the Cognitive Theory of Multimedia Learning (CTML) and Cognitive Load Theory (CLT) assume two channels or processing systems for auditory and visual information (Mayer, 2005a, pp. 33–35; Sweller, 2005a, p. 23; Sweller et al., 1998, p. 252) with limited processing capacity (Mayer, 2005a, p. 35 f.; Sweller, 2005a, p. 21 f.; Sweller et al., 1998, p. 252). It is assumed that in situations in which a redundancy effect can be observed when more information is presented, cognitive overload occurs (Kalyuga et al., 2004, p. 568; 578; Mayer et al., 2001, p. 192; Sweller, 2005b, p. 160; Sweller et al., 1998, p. 284) or extraneous processing takes place at the expense of essential and generative processing (Mayer et al., 2001, p. 190 f.; Mayer & Johnson, 2008, p. 381; Moreno & Mayer, 2002, p. 157; 160 f.).

Evidence for this explanation of the redundancy effect comes in many forms: When the content to be mastered required many elements of information to be processed simultaneously (high "element interactivity") and thereby produced high intrinsic cognitive load, the redundancy effect was found to be stronger than when the content required fewer elements of information to be processed simultaneously (low "element interactivity") and thereby produced low intrinsic cognitive load (Leahy et al., 2003, p. 405; exp. 2, p. 413). Furthermore, there was a "reversed redundancy effect" if the on-screen text was no longer than three words and placed immediately next to the corresponding portions of the pictures presented and therefore required less extraneous processing for selecting relevant content. In such a situation, the retention (but not transfer) of information was higher with the combination of oral and written text than with oral text alone (Mayer & Johnson, 2008, p. 381; exp. 1, p. 383; exp. 2, p. 384). In another study, learning outcomes were found to be higher if written text was not presented simultaneously with pictures and oral text, but shown after the oral text had been finished (Kalyuga et al., 2004, exp. 2, p. 575), but only if the time to study the material was limited (Kalyuga et al., 2004, exp. 1, p. 573). In all these studies, the redundancy effect disappeared or even reversed when processing demands were reduced.

In other studies, measurements of cognitive load were obtained by asking learners how difficult it was to understand the instruction on either a seven-point (Kalyuga et al., 1999, p. 357 f.; Kalyuga et al., 2004, p. 571) or a nine-point rating scale (Kalyuga et al., 2004, p. 575). In line with the explanation of the redundancy effect described above, cognitive load was rated higher in the conditions associated with lower learning outcomes (Kalyuga et al., 1999, exp. 1, p. 358; 368; Kalyuga et al., 2004, exp. 1, p. 573; exp. 2, p. 575).

More specifically, it has been argued that the redundancy effect does not occur as a consequence of overload in the auditory processing channel due to the need to integrate the oral and the written text, but as a consequence of overload in the visual channel due to the presentation of two kinds of visual information, that is pictorial material and written text (Mayer, 2005b, p. 186; Mayer et al., 2001, p. 193; 195; Moreno & Mayer, 2002, p. 157). If overload would occur in the auditory channel, learning outcomes should be lower if the written text is a summary of the oral text than if it is identical to the oral text because in the former case the integration taking place in the auditory channel should be more difficult (Mayer et al., 2001, p. 192). In an experiment testing this prediction, learning outcomes were not inferior if the written text was a summary than if it was identical to the oral text (Mayer et al., 2001, exp. 2, p. 193), which is consistent with the explanation based on overload in the visual channel. Further evidence for this explanation comes from a study in which it was shown that if there is no concurrent pictorial information (in particular animations), learning outcomes are higher when both written and oral text is presented than when only oral text is presented (Moreno & Mayer, 2002, exp. 1, p. 159; exp. 2, p. 160; exp. 3, p. 161 f.).

Although there is a substantive body of evidence supporting the explanation of the redundancy effect as a consequence of cognitive demands that exceed the learners' processing capacity, there are several reasons why this explanation may not apply to the inferior recall of oral information in the presence of slides. The first group of them refers to certain dissimilarities between the respective learning situations: Typically, presentation slides do not contain written text that is identical even with part of the oral text spoken by the presenter, as opposed to most of the studies about the redundancy effect. Besides, presentation slides need not contain pictorial information such as diagrams or photographs along with written text, which was an important boundary condition for the redundancy effect to occur. In contrast to the view that slide presentations cover the whole gamut of multimedia, many slide presentations consist mainly of bulleted lists.

The second group of reasons against this explanation is theoretical. First, the predictions of different researchers derived from the explanation on the basis of cognitive demands for learning situations without pictorial information and the corresponding findings are contradictory. On the one hand, it has been argued that in the absence of pictures, oral and written text allow for "dual processing" and the creation of connections between these two kinds of information, thereby leading to higher learning outcomes (Moreno & Mayer, 2002, p. 157; 162). This was actually found in one experiment (Moreno & Mayer, 2002, exp. 3, p. 161 f.). On the other hand, it was argued that if no pictures but both oral and written text are presented, inevitably learners will try to integrate these two sources of information, which produces unnecessary cognitive load and leads to lower learning outcomes (Kalyuga et al., 2004, p. 576; 579). In one experiment, this effect on learning outcomes was actually found, but the corresponding effect on cognitive load was not observed (Kalyuga et al., 2004, exp. 3, p. 577). A third position from this literature is that written text on presentation slides may potentially be innocuous because slides are typically presented at a sufficiently slow pace to avoid cognitive overload (Mayer et al., 2001, p. 196).

This explanation based on cognitive load furthermore presupposes that the cognitive demands actually exceed the learners' processing capacities. Regular slides that follow widespread recommendations will hardly contain an amount of information that leads to cognitive overload. However, this assumption can and should be empirically tested. A minimal empirical criterion for accepting the explanation based on cognitive load would be that cognitive load is higher when typical slides accompany the presentation than when no slides are shown.

Finally, this account provides no explanation why particularly the information presented orally should be remembered to a lesser extent when presentation software is used, rather than the information presented in written form on the slides, or both of them. The current explanations of the redundancy effect contain no assumptions about the specific cognitive consequences of cognitive overload. This does not play a role in research on the redundancy effect because the written and the oral information are usually identical and therefore the information remembered cannot be differentiated according to its source.

These arguments need to be tested in an empirical study. Furthermore, the theoretical reasons against this explanation require an alternative account of the inferior retention of information from speech that needs to be tested empirically as well.

2.2.2. Inferior retention of oral information as a consequence of dysfunctional allocation of attention

It has been described as a quite general cultural fact that in many contexts presentations that are not accompanied by slides are not a real option. Appearing at a meeting without PowerPoint slides has even been compared to wearing no shoes (cf. Craig & Amernic, 2006, p. 147). A concomitant shift concerns the role that presentation slides play in the context of a presentation: Slides are no longer regarded as a means to support the oral presentation, but rather the oral presentation is regarded as an explanatory commentary about the slides. Thereby, the slides become the actual message instead of supplementing it (Craig & Amernic, 2006, p. 151; cf. also Yates & Orlikowski, 2007, p. 72), whereas the role of the presenter is reduced to that of a "stagehand" or a "disembodied voice" that mediates between the slides and the audience by explaining them (Craig & Amernic, 2006, p. 151; 155). This mutated role of slides is exemplified by the fact that "slide decks" have replaced written documents as final project reports in consulting firms and are often presented by one person who sits at a table among a group of people and walks the others through these printed handouts (Yates & Orlikowski, 2007, p. 79; 82).

This change in the "genre" of the presentation is accompanied by a change in the participants' expectations concerning content and aspects of the situation (Yates & Orlikowski, 2007, p. 69 f.). By these mechanisms, media are claimed to change "human attention-structures" (Craig & Amernic, 2006, p. 149). In particular, providing a piece of information on a slide is likely to be understood as a conventional signal for highlighting important content, and thereby reduce the audience's attention for listening (Carrell & Menzel, 2001, p. 239; cf. also Craig & Amernic, 2006, p. 155; Mayer & Johnson, 2008, p. 384).

Although these changes have been described as general cultural phenomena, learners may differ with respect to the corresponding beliefs and expectations: Some people may be more prone than others to focus on information presented on slides at the expense of information from speech because they regard slides as important means of support for understanding and remembering content. These people are also likely to prefer presentations accompanied by slides to presentations without such media support. In fact, a negative correlation between preference for PowerPoint and learning outcomes has been found in prior research (Sugahara & Boland, 2006, p. 398). This provides some initial support for the assumption that regarding slides as important may be dysfunctional for learning, and – as argued – in particular with respect to information from speech alone.

Based on these considerations, inferior retention of oral information when slides are used should occur mainly in learners with high subjective importance of slides. Such a pattern of findings would provide evidence for the explanation of this effect based on a dysfunctional allocation of attention to information presented in written form on slides.

2.3. A potential method for avoiding inferior retention of oral information

If presentation slides "suppress" information from speech as far as the learners' attention is concerned, the question arises whether there is a remedy for this negative effect. Otherwise – given the lack of evidence for beneficial effects of using slides on learning outcomes – their use should rather be abandoned.

If the proposed alternative explanation based on a dysfunctional allocation of attention is veridical, a method for avoiding this negative effect could be using concise slides. In contrast to regular slides as they are widely in use, these can be characterized by at least two properties: First, they contain only very limited information on each slide (e. g. the "skeleton" of the exposition of the topic of the slide, but no details such as definitions of concepts and examples). Second, parts of the presentation are not accompanied by projected text, in particular parts that cover content that can be followed quite easily without a need for representing the structure or any details in written form. Instead, a "black slide" is inserted at each of these positions in the presentation and "projected" during these parts. In an experiment that tested these assumptions, a positive effect of concise slides compared to no slides could in fact be demonstrated (Wecker & Hetmanek, submitted for publication, p. 10 f.).

It can be hypothesized that this kind of slides avoids inferior retention of information from speech in two ways: First, they provide less occasions to focus one's attention exclusively on written information on slides because at each point in time either no written text is projected on a slide or the written text on the slide actually projected is obviously not the whole story. Second, this kind of slides may convey the general message that there is important information to be attended to that is not written on slides. Because these assumptions are derived from the untested alternative explanation described above, they need to be tested empirically as well.

3. Research goals and hypotheses

The first purpose of this study was to demonstrate the existence of the aforementioned negative effect of regular slides with respect to the retention of oral information. Three hypotheses related to this purpose were tested:

(1a) Retention of information on slides is higher with regular slides than without slides.
(1b) Retention of oral information is lower with regular slides than without slides.
(1c) With regular slides, retention of oral information is lower than retention of information on slides.

Hypothesis 1a is directed at testing, in a face-to-face setting, the counterpart of an effect observed in multimedia research (Moreno & Mayer, 2002, exp. 3, p. 161 f.), and 1c is an immediate consequence of the "dual processing" explanation offered by the authors of this study (Moreno & Mayer, 2002, p. 157; 162). Hypothesis 1b is directed at a replication of the negative effect of slides on the retention of oral information (Savoy et al., 2009, p. 863). Together, these hypotheses specify the assumed effect that regular slides foster the retention of information on slides at the expense of information from speech.

Furthermore, two hypotheses corresponding to the two competing explanations for the negative effect outlined above are tested:

(2) Cognitive load is higher with regular slides than without slides.
(3) In contrast to persons with low subjective importance of slides, the retention of oral information of persons with high subjective importance of slides is lower with regular slides than without slides.

If hypothesis 2 is supported, this provides evidence for the view that the negative effect of regular slides on the retention of oral information is a kind of redundancy effect and that it can be explained as a consequence of cognitive demands that exceed the learners' processing capacity. If hypothesis 3 is supported, this favours the explanation that this effect occurs as a consequence of dysfunctional allocation of attention to slides at the expense of oral information.

Another set of hypotheses refers to the way of avoiding this effect suggested above:

(4a) Overall retention of information is higher with concise slides than without slides or with regular slides.
(4b) Retention of information on slides is higher with concise slides or regular slides than without slides.
(4c) Retention of oral information is higher with concise slides or without slides than with regular slides.

Hypothesis 4a is a consequence of the assumptions that information on slides is better remembered than purely oral information and that concise slides do not negatively affect the retention of oral information, which are the focus of hypotheses 4b and 4c, respectively.

The two rival accounts described above also apply to the effect of concise slides as the suggested remedy for the negative effect of regular slides on the retention of oral information. Accordingly, the two final hypotheses addressed direct tests of these explanations:

(5) Cognitive load is higher with regular slides than with concise slides.
(6) In contrast to persons with low subjective importance of slides, the retention of oral information of persons with high subjective importance of slides is higher with concise slides than with regular slides.

4. Method

4.1. Instructional setting and procedure

The study was conducted in the context of a course for university freshers about how to search for literature and how to access literature via libraries and electronic resources. Each course section was taught by one of three teaching assistants and scheduled for 90 min.

After welcoming the participants and introducing them to the topic, a 30-min presentation about background information was given based on a detailed protocol. This presentation covered the scientific publication system (including the functions and kinds of scientific literature as well as the basic principles of access to scientific publications), methods to search for scientific literature (by means of bibliographical databases or reference lists of publications already retrieved), and ways to access the publications found (such as online services as well as libraries and their online catalogues or the system of interlibrary lending). During this presentation, the learners were not allowed to take notes. This phase was captured on video in all course sections as the basis for checking the fidelity of the implementation of the presentation and the manipulation of the treatments.

Next, the learners answered a three-page quiz that served as a posttest for the retention of information. Furthermore, an instrument to measure cognitive load during the presentation was administered. All participants were granted the time they needed to complete these tasks. The extended phase following this initial section was not part of the experiment. In this phase, literature search and access to publications were demonstrated and the participants had the opportunity to practice these activities to the extent that time and technical possibilities allowed for it. At the end of the session, they completed an evaluation form that contained an instrument to measure the subjective importance of slides.

The equipment included a projector which was used to display slides on the wall in the conditions with slides. After the course, the participants received a four-page handout including all the information contained in the introductory presentation. They were informed about this in advance to secure acceptance for the fact that they were not allowed to take notes.

To assess the implementation fidelity of the introductory presentation, the video recordings of the course sections were analyzed with respect to the duration of the introductory presentation and coverage of 40 information units that were either necessary or helpful to answer the quiz. One of the three teaching assistants deviated from the protocol in an important respect in three of his four course sections. Therefore, all four course sections taught by this teaching assistant were excluded. The average duration of the introductory presentations in the three conditions varied in a rather narrow range from −4% to +6% around the overall average duration of 30 min and 46 s. More importantly, of the 320 content units coded (8 remaining course sections × 40 content units), only 12 were not found to be covered appropriately, indicating an implementation fidelity of 96%. On closer inspection it was found that content required to answer one item from the quiz was not covered appropriately in two course sections. Therefore this item was excluded from the analysis.

4.2. Design

A one-factorial between-subjects design was employed with a condition without slides, a condition with regular slides, and a condition with concise slides as the three values of the independent variable "presentation mode" (see Table 1). Within the constraints of their availability for the timeslots of the study, which depended on their minor subjects, students were assigned to the conditions at random and treated as the unit of analysis.

Table 1
Design of the experiment.

Presentation mode		
Without slides	With regular slides	With concise slides
89 students from 3 course sections taught by 2 teaching assistants	48 students from 2 course sections taught by 2 teaching assistants	72 students from 3 course sections taught by 2 teaching assistants

4.3. Manipulation of the presentation mode

The presentation mode was manipulated as follows:

4.3.1. Condition without slides

The content of the introductory presentation was delivered to the participants according to the protocol mentioned above without projected slides.

4.3.2. Condition with regular slides

Following a title slide and a slide with a structural outline, ten slides were projected during the introductory presentation in this condition. All topics of the presentation were accompanied by the projection of slides. Nevertheless, as typical in presentations supported by presentation software, not all content covered was written on the slides to allow for the assessment of the retention of oral information in this condition. The slides (see the left part of Fig. 1 for examples) contained lists of key points (such as four formal publication types, three disciplinary bibliographies along with rather general information about their content, three online resources for accessing literature and five local libraries). Frequently, these slides contained more detailed information such as definitions and examples. Furthermore, crucial principles (e. g.. "In principle, everything that has been ordinarily published can be accessed." or "With the reference list method one can only find literature that is older than the publication used as the starting point."). No slide in this condition contained more than eight lines (excluding the heading) or six bullet points.

4.3.3. Condition with concise slides

In this condition, four slides were projected during the introductory presentation following the title slide and the slide with the structural overview. Not all topics of the presentation were accompanied by the projection of slides; some of the eight topics accompanied by slides in the condition with regular slides were either completely (three topics) or partially (one topic) accompanied by a black screen in the condition with concise slides. The slides (see right part of Fig. 1 for examples) contained only lists of the key points mentioned above without more detailed information such as definitions or examples. No slide in this condition contained more than seven lines (excluding the heading) or five bullet points.

4.4. Measurement of variables

4.4.1. Retention of information

The quiz used as a posttest for the retention of information contained 18 multiple choice items with four options one of which was correct, and three items with an open answering format. As mentioned above, one of the multiple choice items was excluded due to insufficient coverage of the corresponding content in two course sections. A sample multiple choice item read "Which scientific text type is most likely to contain an overview about a whole area of research?", with "narrative review" as the correct and "article about an empirical

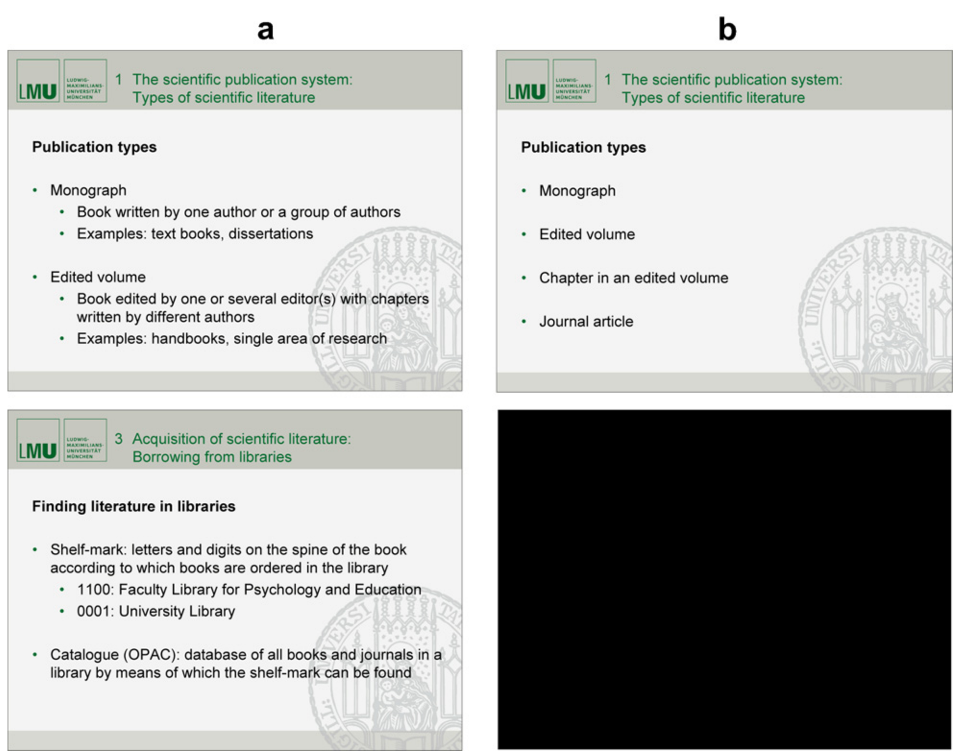

Fig. 1. Corresponding slides from (a) The condition with regular slides and (b) The condition with concise slides.

study" as one of the three incorrect options. An example of the items with an open answering items read "Enumerate in as much detail as possible all the places where you could get a journal article of which you have information about author, title, journal, year and pages (in the most efficient order)." The participants' answers to the items with an open answering format were coded for the occurrence of each of 18 single concepts from ideal solutions for these three items. Each of two coders analyzed half of the material from each course section. To determine the objectivity of this analysis, over 10% of the data were analyzed by both of them. Their agreement was highly satisfactory (83%–100%, $Mdn = 98\%$; Cohen's κ: .62 to 1.0, $Mdn = .96$).

The items were grouped in three subsets depending on the source of the corresponding information in the three conditions: One third of both the multiple choice items and the items with an open answering format tapped information that was presented orally in all three conditions and in written form on slides in the conditions with regular and concise slides. Another third covered information that was presented orally in all three conditions and in written form on slides in the condition with regular slides. The multiple choice item that was excluded was from this group of items. The final third captured information that was presented only orally in all three conditions.

For each of these three subsets of items, a separate score was computed as the sum of the number of multiple choice items answered correctly (potential maximum: 6) and the proportion of concepts from the ideal solutions mentioned in the answers to the items with an open answering format weighted by the factor four (potential maximum: 4). To compensate for differences in difficulty between these three sets of items, they were z-standardised using the means and standard deviations for each of the three subsets of items from the condition without slides (information presented in written form on slides in the conditions with regular and concise slides: $M = 3.51$; $SD = 1.46$; information presented in written form on slides in the condition with regular slides: $M = 3.53$; $SD = 1.35$; information presented only orally in all three conditions: $M = 4.28$; $SD = 1.66$). The descriptive statistics from the condition without slides were appropriate for this purpose because the information required to answer the items in all three subsets was presented orally without support by slides in this condition and therefore was delivered under equivalent circumstances.

The standardized scores for the three subsets of items were combined differently in the three conditions to construct three scales that were comparable across conditions: The scale for the retention of oral information was computed as (the average of) the score(s) of the subset(s) of items tapping information that was presented orally in the respective condition. The scale for the retention of information on slides was computed as (the average of) the score(s) of the subset(s) of items tapping information that was presented on slides in the respective condition (which does not exist in the condition without slides). The scale for the overall retention of information was computed as the average of the two other scales for oral information and information on slides.

To determine the reliability of these scales, Guttman's split-half coefficient was used. The different composition of the three scales in the three conditions did not allow for calculating one coefficient per scale based on the same set of items across all conditions. Instead, the reliability had to be determined separately for each condition (see Table 2). With the exception of two cases in the condition with concise slides, the scales had good reliability. It has to be kept in mind that high reliability means a low proportion of error variance in relation to the variance of the scores. Accordingly, the lower reliability for two scales in the condition with concise tends to lead to more conservative tests of hypotheses.

4.4.2. Cognitive load

A single item was included on the quiz sheets to measure cognitive load, which read as follows: "How difficult was it to follow the introductory presentation?" The answering format consisted of a seven-point rating scale labelled "extremely easy" and "extremely difficult" at its lower and higher endpoints with no labels in between. Accordingly, values could range from 1 to 7, indicating low to high cognitive load. Using one item asking for the difficulty of understanding a piece of instruction along with a seven-point answering scale labelled from "extremely easy" to "extremely difficult" constitutes a standard practice in the measurement of cognitive load (de Jong, 2010, p. 114 f.; Kalyuga et al., 1999, p. 358; 2004, p. 571).

4.4.3. Subjective importance of slides

Three items with a five-point rating scale as the answering format labelled from "is completely true" to "is not true at all" were included in the final evaluation form to measure the subjective importance of slides. These items read as follows: "I prefer presentations with PowerPoint to 'traditional' ones.", "PowerPoint slides are very helpful for following a presentation.", and "PowerPoint slides are necessary for memorizing the content of a presentation." The overall scale was calculated as the mean of the answers checked, with values ranging from 1 to 5 indicating low to high subjective importance of slides. The reliability of the scale was good (see Table 2).

Table 2
Reliability of the scales for the retention of information and the subjective importance of slides across and within the three conditions.

Scale	All conditions	Presentation mode		
		Without slides	With regular slides	With concise slides
Recall of information[a]				
Overall information	.72	.79	.73	.69
Oral information	–[b]	.79[c]	.68	.50
Information on slides	–[b]	–[d]	.61	.46
Subjective importance of slides[e]	.82	–[f]	–[f]	–[f]

[a] Guttman split-half coefficients.
[b] Cannot be calculated because the composition of the scale varies across conditions.
[c] Identical to overall information in this condition.
[d] Does not exist in the condition without slides.
[e] Cronbach's α.
[f] Not calculated separately for each condition because the composition of the scale is the same across conditions.

4.5. Participants

The participants were 209 university freshers from two subsequent cohorts of a Bachelor degree program in Education with students from both cohorts distributed across all three conditions. Of the participants, 85% were female and 15% were male. The distribution with respect to gender did not differ significantly between the conditions, $\chi^2(2) = 2.86$; $p = .24$ (two-sided); Cramer-$V = .12$. The most frequent minor subject was Sociology with 38% followed by Psychology with 31% and Communication Studies with 15% and other subjects (Philosophy, Computer Science, Law and Comparative Religious Studies) with 15% of the participants. Like gender, the distribution of the students' minors did not differ significantly between the three conditions, $\chi^2(6) = 8.06$; $p = .23$ (two-sided); Cramer-$V = .14$.

To the quizzes of six students no corresponding evaluation form could be matched. Therefore the number of participants included in analyses involving the subjective importance of slides was 203.

4.6. Statistical analysis

The level of significance was set to 5% for all statistical analyses.

Even when not explicitly mentioned and unless indicated otherwise, means were always compared using analyses of variance or covariance with presentation mode (if appropriate), teaching assistant and course section (nested within the combinations of presentation mode and teaching assistant) as independent factors. In none of these analyses, any main effect of teaching assistant or course section nor any interaction of these factors with any other variable was significant. Therefore, the test statistics for these effects are not reported when presenting the results.

5. Results

5.1. Demonstration of the negative effect of regular slides on the retention of oral information

The descriptive statistics pertinent to the demonstration of the effect that information on regular slides "suppresses" information from speech are displayed in Table 3 and Fig. 2. Overall retention of information was lower in the condition with regular slides than in the condition without slides. However, this difference was not significant, $F(1; 132) = 1.11$; $p = .30$; partial $\eta^2 = .01$.

To test the specific hypotheses concerning the existence of the aforementioned negative effect of regular slides, these conditions were compared separately with respect to the different information sources. Hypothesis 1a was that the retention of information on slides is higher with regular slides than without slides. The descriptive findings were in line with this assumption (see Table 3 and Fig. 2). However, the difference between the conditions without slides and with regular slides was not significant, $F(1; 132) = .53$; $p = .47$; partial $\eta^2 < .01$. Although the descriptive findings are consistent with hypothesis 1a, they are not safeguarded against chance and do not constitute supporting evidence for this hypothesis.

Hypothesis 1b was that the retention of oral information is lower with regular slides than without slides. In fact, the retention of oral information was significantly lower in the condition with regular slides than in the condition without slides (see Table 3 and Fig. 2), $F(1; 132) = 6.72$; $p = .01$; partial $\eta^2 = .05$. This difference constitutes a small to medium-size effect of the presentation mode and directly supports hypothesis 1b.

Finally, in hypothesis 1c the retention of information on slides was assumed to be higher than the retention of oral information in instructional situations with regular slides. Again, the descriptive pattern corresponded to this assumption (see Table 3 and Fig. 2). In an analysis of variance with repeated measures with two measures of the retention of information as the dependent variables, information source (information on slides vs. oral information) as a within-subjects factor, and course sections as a between-subjects factor, the corresponding main effect of the within-subjects factor *information source* was significant and had a large effect size, $F(1; 46) = 13.57$; $p < .01$; partial $\eta^2 = .23$.

In sum, while no direct evidence for hypothesis 1a could be obtained, hypotheses 1b and 1c were supported. Therefore, there is evidence for the existence of a negative effect of regular slides at the expense of the retention of oral information, both within the same presentation (hypothesis 1c) and in comparison to the retention of the same information in a potential alternative presentation without slides

Table 3
Means (*M*) and standard deviations (*SD*) for the retention of information, cognitive load and the subjective importance of slides in the three conditions.

Dependent variable		Presentation mode		
		Without slides	With regular slides	With concise slides
Recall of information	*n*	89	48	72
Overall information	*M*	.00	−.09	.25
	(*SD*)	(.77)	(.80)	(.77)
Oral information	*M*	.00	−.38	.11
	(*SD*)	(.77)	(1.01)	(.76)
Information on slides	*M*	–	.21	.39
	(*SD*)	–	(.88)	(1.10)
Cognitive load	*n*	87	47	70
	M	4.24	3.40	3.87
	(*SD*)	(1.35)	(1.26)	(1.37)
Subjective importance of slides	*n*	86	46	71
	M	3.47	3.23	3.65
	(*SD*)	(.90)	(.86)	(.85)

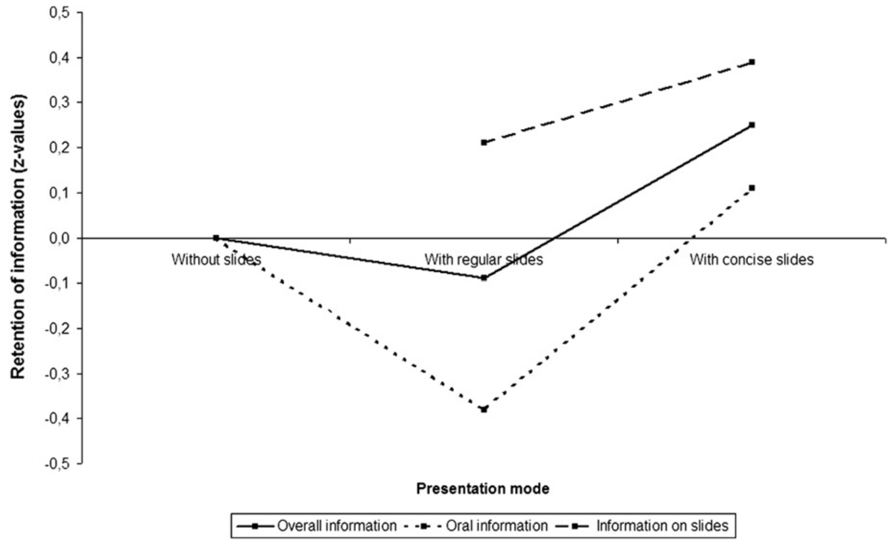

Fig. 2. Means for the three scales for the retention of information in the three conditions.

(hypothesis 1b). It is remarkable, however, that this "suppressive" effect of regular slides on the retention of information from speech could not be demonstrated to be the downside of a trade-off in favour of the retention of information on slides.

5.2. Explanation of the negative effect of regular slides on the retention of oral information

The second set of hypotheses dealt with the explanation of the negative effect of regular slides on the retention of oral information. The two competing explanations on the basis of cognitive demands that exceed learners' processing capacities and on the basis of dysfunctional allocation of attention are tested separately in the following two sections.

5.2.1. Cognitive demands that exceed learners' processing capacities

On average, the learners rated their cognitive load during the introductory presentation close to the midpoint ($M = 3.94$; $SD = 1.38$) of a scale ranging from "extremely easy" to "extremely difficult" in the conditions without slides and with regular slides. An explanation of the negative effect of regular slides on the retention of oral information as a consequence of cognitive demands that exceed learners' processing capacities implies higher cognitive load with regular slides than without slides (hypothesis 2). Contrary to this prediction, cognitive load was actually rated significantly lower in the condition with regular slides than in the condition without slides (see Table 3), $F(1;\ 129) = 5.60$; $p = .02$; partial $\eta^2 = .04$.

To test whether the lower ratings of cognitive load in the condition with regular slides reflect lower engagement in cognitive activities necessary or helpful for learning instead of overall cognitive load, the measure was validated by correlating it with overall retention of information. A significant small but negative correlation was obtained, $r(204) = -.14$, $p = .03$ (one-sided). This small negative correlation is in line with the assumption that the instrument did not capture mainly intrinsic or germane load. Therefore, hypothesis 2 receives no support from the data.

5.2.2. Dysfunctional allocation of attention

The average subjective importance of slides in the conditions without slides and with regular slides was somewhat above the midpoint of the scale ($M = 3.39$; $SD = .89$), but not extremely high. Although it was higher in the condition with regular slides than in the condition without slides (see Table 3), this difference was not significant, $F(1;\ 127) = .94$; $p = .34$; partial $\eta^2 = .01$.

The explanation of the negative effect of regular slides on the retention of oral information as a consequence of dysfunctional allocation of attention implies that particularly the learners with high subjective importance of slides remember less oral information with regular slides than without slides, whereas this effect should not be found in learners with a low subjective importance of slides (hypothesis 3). Put differently, subjective importance of slides should play a considerable negative role with respect to the retention of oral information in the condition with regular slides, whereas such an association should be considerably weaker in the condition without slides.

To test this assumption, an analysis of covariance with the retention of oral information as the dependent variable, presentation mode (no slides vs. regular slides), teaching assistant, and course section (nested within the combinations of presentation mode and teaching assistant) as between-subjects factors and the subjective importance of slides as a covariate was performed. In this analysis a term for the interaction between the between-subjects factor presentation mode and the covariate subjective importance of slides was included to test for the assumed differential role of the subjective importance of slides in the two conditions. A further analysis of covariance including all possible interactions between the covariate and all between-subjects factors to test the prerequisite of homogeneous coefficients for the covariate across conditions did not indicate any heterogeneous coefficients, all $Fs(1;\ 122) < 1$; $p > .32$; partial $\eta^2 < .01$.

The slopes for the subjective importance of slides were negative both in the condition without slides and in the condition with regular slides, but considerably more pronounced in the condition with regular slides ($b = -.45$) than in the condition without slides ($b = -.13$; see Fig. 3). However, the interaction effect between presentation mode and subjective importance of slides was not significant, $F(1;\ 125) = 3.24$;

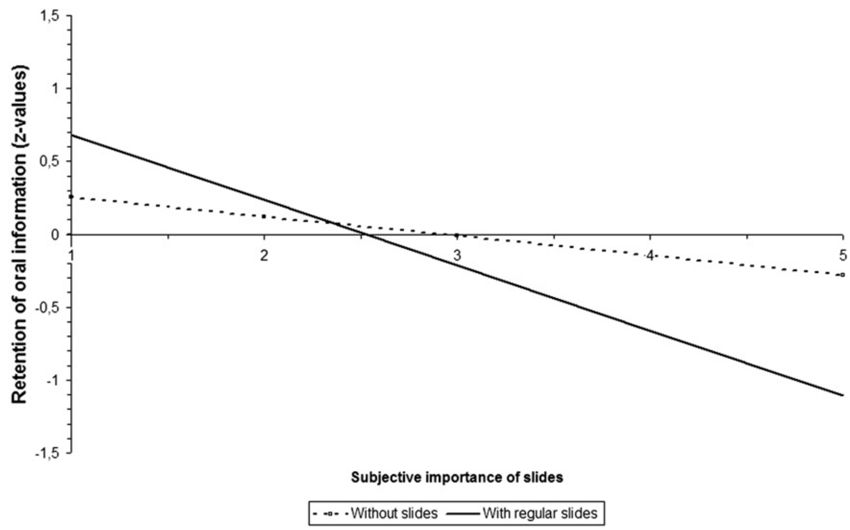

Fig. 3. Relations of the subjective importance of slides to the retention of oral information in the conditions without slides and with regular slides.

$p = .07$; partial $\eta^2 = .03$. Although the descriptive pattern is compatible with hypothesis 3, this finding does not yet constitute direct evidence for this hypothesis.

Therefore, the comparison between the conditions without slides and with regular slides with respect to the retention of oral information was repeated separately for learners with low (up to the median value of 3.33) and high (above the median value) subjective importance of slides. Although in both groups of learners the retention of oral information was lower in the condition with regular slides than in the condition without slides, this difference was significant and of a medium to large effect size only in the group of learners with high subjective importance of slides, $F(1; 52) = 6.46$; $p = .01$; partial $\eta^2 = .11$, but not in the group of learners with low subjective importance of slides, $F(1; 75) = 1.31$; $p = .26$; partial $\eta^2 = .02$. These findings support hypothesis 3.

5.3. Avoiding the negative effect of regular slides

The descriptive results pertinent to the avoidance of the negative effect of regular slides are displayed in Table 3 and Fig. 2. Hypothesis 4a contained the assumption that the overall retention of information is higher in the condition with concise slides than in the conditions with regular slides and without slides. This pattern was actually found in this study. In an analysis of variance with overall retention of information as the dependent variable and presentation mode (no slides vs. regular slides vs. concise slides), teaching assistant, and course section (nested within the combinations of presentation mode and teaching assistant) as between-subjects factors, the main effect of presentation mode was significant and constituted a small effect, $F(1; 201) = 3.19$; $p = .04$; partial $\eta^2 = .03$. To further elucidate this result, a contrast analysis with two orthogonal contrasts was performed. The first of these served as a specific test of the pattern of differences assumed in the hypothesis, whereas the second provided a test whether the two conditions assumed to be inferior to the condition with concise slides differed significantly from each other (see Table 4). The first contrast confirmed hypothesis 4a. The second contrast revealed no significant difference between the conditions without slides and with regular slides.

Hypotheses 4b and 4c pertain to the contributions of the two different information sources to this result. According to hypothesis 4b, the retention of information on slides should be higher with concise slides or regular slides than the retention of the same information presented without slides. To test this hypothesis, the retention of information on slides in the conditions with concise slides and regular slides had to be compared to the overall retention of information in the condition without slides (in which all information was presented orally). The pattern of results corresponded to this hypothesis, but the main effect of presentation mode failed to reach significance, $F(1; 201) = 2.25$; $p = .11$; partial $\eta^2 = .02$. However, an a priori contrast comparing the two conditions with slides to the condition without slides was significant and thereby supported hypothesis 4b. A second contrast that was orthogonal to the first one and compared concise slides to regular slides revealed no significant difference (see Table 4).

In hypothesis 4c, both concise slides and no slides were assumed to lead to higher retention of oral information than regular slides. The descriptive statistics were in accordance with this assumption. The main effect of presentation mode on the retention of oral information

Table 4
Contrast analyses for the retention of information.

Dependent variable	Presentation mode			Test statistics
	Without slides	With regular slides	With concise slides	
Overall information	−1	−1	2	$F(1; 206) = 6.55$; $p = .01$
	1	−1	0	$F(1; 206) = 0.37$; $p = .54$
Information on slides	−2	1	1	$F(1; 206) = 5.23$; $p = .02$
	0	−1	1	$F(1; 206) = 1.16$; $p = .28$
Oral information	1	−2	1	$F(1; 206) = 10.07$; $p < .01$
	−1	0	1	$F(1; 206) = 0.75$; $p = .39$

was significant and of small to medium size, $F(1; 201) = 5.72$; $p < .01$; partial $\eta^2 = .05$. A first contrast testing this particular pattern was significant, whereas a second contrast comparing concise slides to no slides was not. Thereby, hypothesis 4c was confirmed as well.

The remaining hypotheses referred to two explanations why concise slides can avoid the negative effect of regular slides and corresponded to the two explanatory accounts described above.

5.3.1. Reduced cognitive demands that do not exceed learners' processing capacities

The explanation that concise slides avoid the negative effect of regular slides on the retention of oral information by reducing cognitive load implies that cognitive load is higher with regular slides than with concise slides (hypothesis 5). In contrast to this hypothesis, cognitive load was lower with regular slides than with concise slides (see Table 3), but this difference was not significant, $F(1; 196) = 2.66$; $p = .07$; partial $\eta^2 = .03$. Although the three conditions differed descriptively with respect to cognitive load, the pattern of results is inconsistent with hypothesis 5.

5.3.2. More functional allocation of attention

Hypothesis 6 deals with the explanation based on a more functional allocation of attention in the condition with concise slides compared to the condition with regular slides in learners with high subjective importance of slides. Subjective importance of slides was higher in the condition with concise slides than in the other two conditions (see Table 3), although this difference failed to reach significance, $F(1; 195) = 2.91$; $p = .06$; partial $\eta^2 = .03$. Similar to hypothesis 3, hypothesis 6 contained the assumption that it is particularly learners with high subjective importance of slides who remember less oral information with regular slides than with concise slides, whereas this effect should not be found in learners with a low subjective importance of slides.

An analysis of covariance with the retention of oral information as the dependent variable, presentation mode (regular slides vs. concise slides), teaching assistant, and course section (nested within the combinations of presentation mode and teaching assistant) as between-subjects factors and the subjective importance of slides as a covariate including an interaction term between the between-subjects factor presentation mode and the covariate subjective importance of slides was used to test this hypothesis. The prerequisite of homogeneous coefficients for the covariate across conditions did not appear to be violated, all $Fs(1; 107) < 1$; $p > .39$; partial $\eta^2 < .01$.

While the slope for the subjective importance of slides was negative in the condition with regular slides (see above), it was close to zero ($b = .05$) in the condition with concise slides. The interaction effect between presentation mode and subjective importance of slides was significant, $F(1; 110) = 7.01$; $p = .01$; partial $\eta^2 = .06$. This indicated that the association between the subjective importance of slides and the retention of oral information differs between the condition with regular slides and the condition with concise slides. To illustrate this difference, in analogy to the analyses with respect to hypothesis 3, separate comparisons between the conditions with regular slides and with concise slides were conducted for the group of persons with low subjective importance of slides and the group of persons with high subjective importance of slides. Although the retention of oral information was lower in the condition with regular slides than in the condition with concise slides in both groups of learners, again the retention of oral information did not differ significantly between these two conditions in the group of persons with low subjective importance of slides, $F(1; 56) = 1.13$; $p = .29$; partial $\eta^2 = .02$. However, in the group with high subjective importance of slides, this difference was significant and indicated and extremely large effect, $F(1; 54) = 20.65$; $p < .01$; partial $\eta^2 = .28$. Accordingly, hypothesis 6 is supported.

6. Discussion

6.1. Theoretical implications

From the findings of this study several theoretical conclusions can be drawn. First, the study provides evidence for the existence of what might be called a "speech suppression effect" of regular slides: Retention of oral information was found to be lower with regular slides than without slides. This result replicates the finding of an earlier study from the literature about the effectiveness of presentation software (Savoy et al., 2009, p. 863 f.) and parallels an effect found in one study from cognitive load research (Kalyuga et al., 2004, p. 577). Beyond this, the present study showed that in presentations with regular slides it is information presented both orally and on slides that is better remembered than information presented only orally. However, the study could not unambiguously demonstrate that the retention of information is higher if it is presented on slides than if it is presented orally without slides. Currently, the detrimental effect of regular slides on the retention of oral information cannot be regarded as the downside of a trade-off in favour of information presented on slides because so far there is no clear evidence for such a positive effect. Accordingly, the speech suppression effect might even occur exclusively at the expense of the retention of oral information, both within the same presentation and in comparison to the retention of the same information in a potential alternative presentation without slides. In this respect, "PowerPoint is not merely a benign means of facilitating what educators have always done" (Craig & Amernic, 2006, p. 157 f.).

Of the two competing explanations of the speech suppression effect introduced above, the one based on cognitive demands that exceed the learners' processing capacity is not supported by the data. The regular slides used in this study were designed in accordance with commonplace recommendations concerning the maximum amount of information per slide. Consequently, the cognitive load the learners experienced was moderate and no higher with regular slides than without slides. A small negative correlation of this variable with the overall retention of information invalidates the potential objection that this measure may be mainly an indicator of intrinsic or germane load (or essential or generative processing). On the contrary, the negative effect of oral and written information compared to oral information found in one cognitive load study likewise was also not accompanied by a significant parallel difference in cognitive load (Kalyuga et al., 2004, p. 577). Hence, the findings do not support the position that the speech suppression effect is a special case of the redundancy effect studied in research about multimedia learning and cognitive load theory.

Instead, the fact that the speech suppression effect was found to be significant only in the group of persons with high subjective importance of slides indicates that it might occur as a consequence of dysfunctional allocation of attention. It seems likely that as soon as slides are presented, this belief results in a stronger focus on the information presented on slides rather than on the information presented orally. Further evidence for this explanation is contributed by the finding that the negative effect on the retention of oral information is prevented if concise slides are used. These provide fewer opportunities to focus one's attention almost exclusively on the slides. Besides, the pattern of results concerning the role of cognitive load and the subjective importance of slides when concise slides are used further corroborates this explanation.

Given the finding that the speech suppression effect was found only in learners with a high subjective importance of slides, this effect apparently constitutes an aptitude-treatment-interaction. The findings provide evidence that concise slides can compensate for the dysfunctional view of some learners that in particular information on slides is important, without being disadvantageous for learners without this dysfunctional view. Accordingly, this type of slides seems to be an optimal strategy for dealing with this aptitude–treatment interaction because typically such interactions require differential treatments for learners at different levels of aptitude (cf. Salomon, 1972, especially p. 339 f.). Interestingly they share an important feature with the kind of written information that resulted in a reverse redundancy effect in two studies from the multimedia learning literature (Mayer & Johnson, 2008, exp. 1, p. 383; exp. 2, p. 384; Moreno & Mayer, 2002, exp. 3, p. 161 f.): They contain only little written information (cf. Mayer & Johnson, 2008, p. 382 f.; Kalyuga et al., 2004, p. 579).

On a more general level, this study indicates that at least in the "multimedia scenarios" that are constituted by face-to-face instruction accompanied by visual media, learning may be influenced by mechanisms of attention allocation that operate within the limits of working memory and below the threshold of cognitive overload. Therefore, theoretical accounts dealing with these phenomena need to be developed further (cf. de Jong, 2010, p. 126).

6.2. Limitations

Apparently, the present study is limited in several respects. First, only effects on the retention of declarative information that is not particularly difficult to understand have been studied. The instruments employed to measure this kind of knowledge suffered from unsatisfactory reliability in the condition with concise slides. As mentioned above, low reliability results in more conservative hypothesis tests. The fact that nevertheless important effects of the condition with concise slides could be demonstrated was fortunate for the purposes of this study.

Another shortcoming is the measurement of cognitive load by means of a single item. Although this has been standard practice in cognitive load research for years (de Jong, 2010, p. 114 f.), longer questionnaires or other, more valid measures would be more appropriate. A particular problem in the present study is that the learners had to provide an overall estimate of cognitive load during a presentation lasting about half an hour. Nevertheless, the negative correlation of the single-item measure with the retention of information is in line with the assumptions of cognitive load theory and thereby provides some support for the validity of the measure as an indicator of extrinsic load. Future research should employ more advanced methods for the measurement of cognitive load.

Next, this study was conducted in a real-world learning scenario involving several instructors. In addition to advantages associated with this aspect of the study (e. g. with respect to generality), such a design can also be associated with lower precision and may even have extenuated some of the effects in the present study.

Furthermore, the assumption that persons with high subjective importance of slides direct their attention more towards information presented on slides rather than information presented orally, was not tested directly. Future laboratory studies including the collection of data concerning the allocation of attention could provide more direct evidence for the explanation advanced in this study.

6.3. Issues for future research

In addition to attempts to overcome the limitations of the present study, there are a number of issues that require further investigation. First, the speech suppression effect observed in this study needs to be replicated (and even be fully demonstrated as far as hypothesis 1a about the assumed superiority of slides with respect to information presented on slides is concerned). As already indicated, the explanation put forward in this study should be directly tested, for example in laboratory studies that might use video recordings of presentations that can be interrupted to obtain measures of attention.

A further issue concerns other ways to combat the impression that only information that is written on slides is important (cf. the recommendations not to let visual aids upstage the presenter from the time in which overhead projectors gained popularity; Yates & Orlikowski, 2007, p. 74). There may be approaches other than using slides with little content or including phases without projected slides. One other source of remedy against this impression might be the communication skills of the presenter (cf. Craig & Amernic, 2006, p. 151), for example "presence" (or "teacher immediacy", Carrell & Menzel, 2001, p. 232).

The beneficial effects of concise slides raise the question of the boundaries of "conciseness": It needs to be explored how much information should be put on slides in order to obtain the effect observed in this study. This is closely related to a final point: It has been argued that the selection of presentation modes should be dependent on the content to be delivered (Savoy et al., 2009, p. 866). This principle need not only apply at the larger scale of selecting the overall kind of media support. It may also apply at the level of individual units of content within a presentation. Therefore, future research most urgently needs to answer the question: What kinds of information should be put on slides? Candidate types of content include structural outlines, lists (with and without explanations), detailed explanations, definitions, examples, rules, comprehensive cases of application, graphical visualizations of abstract relations, realistic pictures of objects, summaries, and the like.

Given the body of prior research, it seems appropriate to emphasize that future studies should strive to comply with higher methodological standards. In addition to a closer connection to theoretical accounts from basic research, less quasi-experimental studies using convenience samples should be conducted. In particular, the treatments employed need to be completely unconfounded with instructors, cohorts of students, or tests for learning outcomes. One promising approach is constituted by balanced designs involving within-subjects manipulations of treatments (cf. Szabo & Hastings, 2000, p. 186). Furthermore, it has been argued that it is important to differentiate learning outcomes according to the source of the corresponding information because a focus on overall scores is likely to blur finer differences (Savoy et al., 2009, p. 866).

6.4. Practical implications

The practical implications of this study seem to be rather clear. They can be divided into two parts related to different directions of action.

The first approach would be to use concise slides instead of the ones that constitute the current standard, that is, only information that is absolutely necessary should be put on slides. However, there are some boundary conditions for this recommendation. The first refers to the audience: When little is known about the audience or the audience might be mixed with respect to their subjective importance of slides, the recommendation applies. If the audience does not hold this problematic view, regular slides may be innocuous.

Another boundary condition has to do with the weighting of information presented only orally and information presented on slides. There may be cases in which one can be sure that all information to be presented can be put on slides. Under such circumstances, there should be no problem because there will be no information that is presented only orally. However, it should also be noted that like other studies, the present study did not provide clear evidence for any superiority of regular slides with respect to the retention of information contained on them. Furthermore, in many cases putting everything on slides will result in very extensive slides that may have negative effects not observed in this study. Most importantly, however, frequently it will not be obvious in advance at what point of a presentation additional oral explanations might be necessary. Based on the findings from this study, putting most or all information on slides is likely to secure inferior attention for these explanations in a substantial group of learners.

At least two factors may interfere with the attempt to keep slides concise. The first is the common practice of using the slides presented to the audience as one's own presentation notes (which is even recommended in influential books, e. g. Kosslyn, 2007, p. 22 f.). The present study would rather favour a different recommendation: To clearly separate these two things and put more effort into the preparation of the actual delivery (as condensed in presentation notes) rather than exclusively into the design of the slides (Craig & Amernic, 2006, p. 156). The other factor is the additional function of PowerPoint documents as a canon for the material to be covered in exams. The expectations associated with this derived "genre" are likely to call for more detailed information on slides because in this case, the presenter typically is not available for disambiguation at the time at which the slides are studied (cf. Yates & Orlikowski, 2007, pp. 86–89). All these considerations favour the conclusion to limit the function of slides to one purpose: to support the oral presentation.

The second line of action is directed at advertising the view that a presentation is constituted by what the presenter says rather than by what is projected to the wall and commented on by the presenter (cf. Burke, James, & Ahmadi, 2009, p. 250). This is the more comprehensive cultural challenge. Hopefully the present study can contribute to it.

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