

# How Do Learners Process Information in Lectures? The Role of Projected Slides and Type of Note-taking

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**Abstract:** Today's lectures are typically supported by means of computer-based slide projections, and it is common for learners to take notes on printed handouts containing the lecturer's slides. In a 2x2-factorial design involving 81 students, the effects of slide projection (absent vs. present) and type of note-taking (on empty sheets vs. on handouts) were investigated with respect to the learners' processing of information and their knowledge about information presented on slides and about information presented orally immediately after a lecture and two weeks later after an additional review phase. Preliminary analyses indicate a beneficial effect of note-taking on handouts on knowledge about information presented on slides after the additional review phase, which appears to be mediated to a substantial extent by the processing of information presented on slides while watching the lecture. Hence the effect cannot be explained exclusively by the completeness of this information in the learners' notes.

Today's lectures typically involve computer-based slide projections. In conjunction with this technological aid, students often receive slides in advance to print and use them as a basis for note-taking. Despite substantial literatures about the effects of using computer-based slide projections (see Craig & Amernic, 2006; Levasseur & Sawyer, 2006; Shapiro, Kerssen-Griep, Gayle, & Allen, 2006 for reviews) and the effects of student note-taking in lectures (see Kiewra, 1989; Kobayashi, 2005; 2006 for reviews), little research has focused on the way in which these two aspects interact when using printed slides for note-taking. In particular, the role of the learners' processing of the information presented on slides or only orally in the lecture as well as the role of students' notes for review when preparing for an examination have not been investigated systematically so far. This interplay of learner-generated artefacts and their cognitive processing in a technology-supported learning scenario, both when creating these artefacts and when using them for further study, makes this topic an interesting challenge for Learning Sciences research.

## Prior research

### Computer-Based Slide Projections

Since the mid-nineties, many researchers have conducted studies about the effectiveness of computer-based slide projections in their own or their colleagues' lectures. According to several reviews, however, this body of research has failed to produce conclusive evidence for beneficial effects of using computer-based slide projections in lectures on student learning (Craig & Amernic, 2006, p. 150; Levasseur & Sawyer, 2006, p. 109-111; Shapiro et al., p. 69; Wecker, 2013). To the contrary, single studies have provided some indication that using computer-based slide projections in lectures may actually be detrimental with respect to certain aspects of knowledge acquisition, i. e. the acquisition of knowledge about information that is presented only orally (Savoy, Proctor & Salvendy, 2009, p. 863; Wecker, 2012, p. 267). Although replication studies are certainly needed to examine the robustness of these negative effects, it may at least be concluded from this research that future work should differentiate knowledge according to the sources of the information that students are supposed to learn about (Wecker, 2012, p. 271).

There are several potential explanations for the negative effect of computer-based slide projections on knowledge about information presented only orally: From a cognitive load perspective, this finding might be explained as a so-called "redundancy effect" (Sweller, 2005) because of cognitive overload caused by simultaneous written and oral presentation of information. On top of several theoretical reasons that question this explanation, the pattern of findings concerning cognitive load did not support it either (Wecker, 2012, p. 268). Another potential explanation for such a negative effect of computer-based slide projections on knowledge about information presented orally is that learners might process information presented only orally less deeply in the presence of computer-based slide projections and thereby less likely comprehend individual sentences (cf. Kintsch, 1988, pp. 166-168; 1998, pp. 96-101). Put differently, learners may be less likely to actually take notice of what is presented to them in oral speech when confronted with computer-based slide projections. Finally, learners may process information presented orally equally well with and without computer-based slide projections, but simply regard the information presented only orally as "secondary" and maybe less important (Adams, 2006). This could be reflected in different amounts of notes taken by the learners about information presented on slides and information presented only orally.

To evaluate these potential explanations, it would be helpful to measure the processing of information presented only orally, the degree of distraction by the processing of information presented on slides, and the amount of note-taking about information presented on slides and presented only orally.

## Note-Taking

Potential obstacles to the processing of information presented only orally could be compensated by relieving learners from the requirement to take notes about the information presented on slides. This is what happens when learners receive the lecturers' notes in advance in order to print them and use them as a basis for their note-taking during lectures, as it is common in many universities today.

When considering potential effects of different types of note-taking, the two main functions of note-taking differentiated in the literature need to be taken into account: First, it has been assumed that during note-taking, the processing of the information presented may be beneficially affected due to the requirement to transform it into something that can be written down quickly and still be understood later ("encoding function"). However, research indicates that these mechanisms alone may not be sufficient to improve learning (Kiewra, 1989, pp. 149 f.; Kobayashi, 2005, p. 251).

Second, note-taking enables learners to review and study the information presented to them on a later occasion („storage function“). This characteristic has in fact been found to increase learning outcomes (Kiewra, 1985, p. 33; 1989, p. 148). As a consequence, when studying the effects of different types of note-taking, it is imperative to include measures of learning outcomes after an opportunity for the learners to review their notes.

Several findings are of importance when considering the potential role of note-taking on handouts containing the lecturer's slides: First, the completeness of the learners' notes correlates with learning outcomes (Kiewra, 1987, p. 242; 1989, p. 150). This suggests that note-taking on handouts may foster learning to the extent that it leads to more complete notes.

Second, if learners take notes on their own, i. e. if they do not get handouts but use empty sheets of paper instead, their notes typically cover only a relatively small proportion of the information presented (Kiewra, 1985, p. 33). If, however, information is presented to them in written form (e. g. on the blackboard), it is more likely to be included in the learners' notes than if it is presented to them only orally (Locke, 1977, p. 94). The same has been found for computer-based slide projections (Austin, Lee & Carr, 2004, pp. 317 f.).

Third, if learners receive some kind of support for note-taking, such as incomplete handouts (Cardetti, Khamsemanan & Orgnero, 2010, pp. 82-84) or handouts containing structural outlines (Kiewra, Benton, Kim & Risch, 1995, pp. 175 f.), they acquire more knowledge than if they have to take notes on their own (Cardetti, Khamsemanan & Orgnero, 2010, p. 87; Kiewra, 1985, p. 35; Kiewra, 1989, p. 160; Kiewra, Benton, Kim & Risch, 1995, p. 177). A small number of studies have investigated the effects of note-taking on handouts that contain the lecturer's computer-based slides. Although learners tend to write less in this case than if they have to take notes on their own (Marsh & Sink, 2010, pp. 697; 701), typically the coverage of the information presented is higher (Austin, Lee & Carr, 2004, pp. 317 f.; Stefanou, Hoffman & Vielee, 2008, p. 11). The findings concerning effects on knowledge acquisition remain inconclusive, however (Bowman, 2009, p. 106; Marsh & Sink, 2010, p. 702; Raver & Maydosz, 2010, p. 194).

In light of these considerations it seems appropriate to investigate whether note-taking on empty sheets of paper may be associated with less processing of information presented only orally compared to note-taking on handouts, especially in the presence of a computer-based slide projection that learners attempt to copy down. In contrast, note-taking on handouts might relieve learners of this task and thereby increase the processing of information presented only orally.

Furthermore, note-taking on handouts is likely to lead to higher knowledge acquisition provided that learners have the opportunity to review the material on the basis of the notes they took on the handouts. This should apply particularly to the information presented on slides that is printed on the handouts as well. Such an effect could be due either to the completeness of information presented on slides in learners' notes taken on handouts as compared to less complete notes taken on empty sheets of paper, or to increased processing of information presented on slides while listening to a lecture and taking notes.

## Research Questions

The study presented in this paper aims to shed light on how slide projections and the type of note-taking impact learning in lectures via the processing of the information presented on slides and only orally, and via the notes learners take and use for later review. In the following, analyses pertaining to the following three specific research questions will be presented:

(1) What are the main and interaction effects of slide projection and type of note-taking on knowledge about information presented on slides and about information presented only orally immediately after a lecture and after learners had the opportunity to review and study using their own notes?

(2) What are the main and interaction effects of slide projection and type of note-taking on learners' processing of information presented on slides and of information presented only orally during a lecture?

(3) How is the processing of information presented on slides and of information presented only orally during a lecture related to their knowledge about information presented on slides and about information presented only orally immediately after a lecture and after learners had the opportunity to review and study using their own notes?

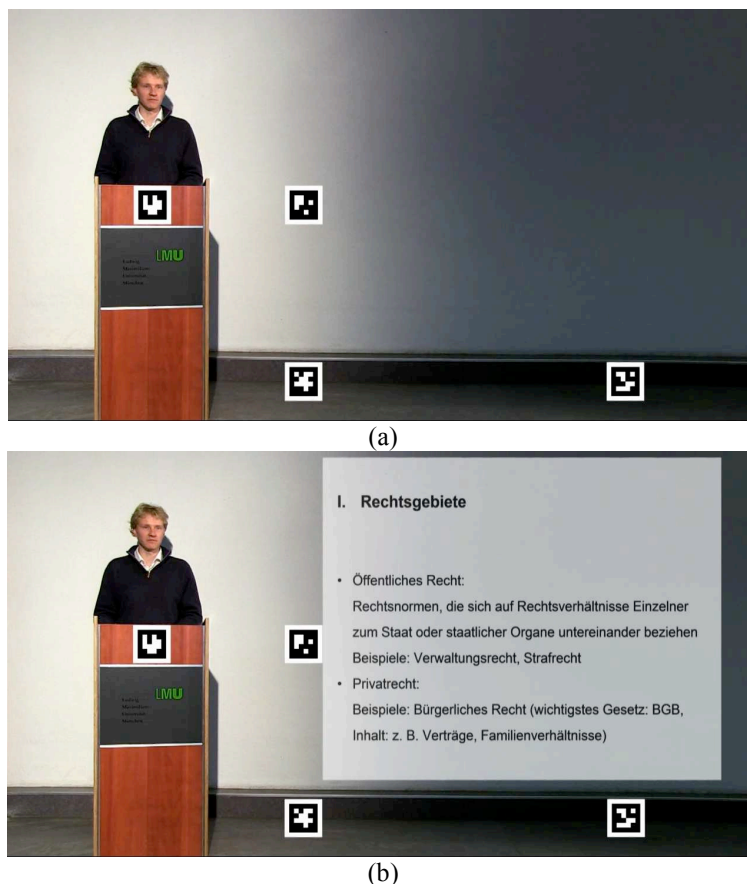
Data analysis for this project has not been finished yet. Therefore, analyses based on about 2/3 of the final sample are included in this paper, while the complete findings will be available for presentation at the conference.

## Method

### Instructional Unit and Setting

The present study was designed to make learners' processing during lectures accessible to measurement and analysis and to achieve as much experimental control as possible, while at the same time retaining as much of the authentic learning scenario as possible. The approach to measuring learners' cognitive processing of information presented only orally requires interrupting the lecture for the administration of test items referring to information presented within a narrow window of time before the interruption. Experimental control requires minimizing variation in implementation and presentation times among conditions. To achieve both of these goals, the video recording of a lecture was presented to the learners. Retaining as much of the authentic learning scenario as possible implied that learners should not watch the video on a computer screen, but in an almost life-size projection to the wall with high quality.

The topic of the lecture was the German legal system. This topic is covered in many different educational institutions, such as in social studies in ordinary schools or professional schools, in degree programs in Law at the university level, or in adult education centres. Nevertheless, the topic is sufficiently difficult, and the target group of participants has only little knowledge about it. It involves different kinds of knowledge that are typically presented using computer-based slide presentations, such as technical terms, definitions, classifications, rules, conditions for application etc. The lecture was given by a young man standing behind a lectern next to a white area that could be filled by projected slides (see Figure 1a), and had a duration of 30 minutes.



**Figure 1.** Stills from two versions – (a) without versus (b) with projected slides – of the same video recording of a lecture about the German legal system.

To investigate the role of learners' notes for learning in lectures, the participants could study their notes in a second experimental session two weeks after watching the lecture before taking a final test. To this purpose the notes they had taken while watching the lecture were returned to them during this second session for a review phase of 45 minutes. During this phase they could make annotations and take further notes using a pen in a colour different from the one used in first session.

## Design

The study had a two-factorial experimental between-subjects design with the factors *slide projection* (absent vs. present) and *type of note-taking* (on empty sheets vs. on handouts). Individual persons were assigned to the four conditions at random.

## Procedure

The first session of data collection was conducted with each learner individually. After a 5-minute introduction, they had up to 15 minutes to complete the first pretest for prior knowledge and further control variables. Then, the gaze-tracking equipment was calibrated, which could last for up to 15 minutes. Next, the learners watched the video recording of the lecture. Depending on whether their processing of the information presented was measured (see below), this could last either 30 minutes or about 45 minutes. Finally, they completed a 40-minute immediate posttest for knowledge and some additional variables.

About two weeks (i. e. 10 to 18 days) later, the learners participated in the second session of data collection in groups of six or seven persons. After completing a second pretest for further control variables within 30 minutes, they reviewed their own notes for 45 minutes. Finally, they completed the 45-minute delayed posttest for knowledge and some additional variables.

## Manipulation of Independent Variables

### Slide Projection

In the conditions *with slide projection*, text slides were cut into the video recording of the lecture at the position of the white wall area next to the speaker (see Figure 1b). The slides contained technical terms, definitions, rules and principles as well as examples in short phrases rather than full sentences. Overall, 31 slides including a title slide and an outline slide were shown. Each slide comprised at most seven lines (excluding headlines) or six points in bulleted or numbered lists. The background of the slides was white, and the slides did not contain any graphical corporate identity elements.

In the conditions *without slide projection*, the uncut video recording of the lecture was shown to the learners (see Figure 1a).

### Type of Note-Taking

In the conditions with *note-taking on empty sheets*, the learners received eight sheets of paper with lines on one side in portrait format. Upon request they could receive additional sheets of the same type.

In the conditions with *note-taking on handouts*, the learners received eight sheets of paper printed with content on the left and lines on the right on one side in portrait format. The content on the left hand side of each sheet corresponded to four slides used in the conditions with projected slides. However, no slide borders were printed on the handouts, and headlines were not repeated (as in sequences of slides belonging to the same section) in order to avoid too close resemblance to slides, especially for the participants in the condition without slide projection and with note-taking on handouts. In addition, upon request the learners could receive sheets of ruled paper of the same type as in the condition with note-taking on empty sheets.

## Measurement of Dependent Variables

### Knowledge

Knowledge was measured in both the immediate and the delayed posttest by means of an identical computer-based test that contained 32 multiple-choice items with four options one of which was correct. These items covered only content presented during the first two thirds of the lecture, for reasons to be explained below. Half of the items covered information that was presented on slides in the conditions with slide projection, half of them covered information that was presented only orally in all conditions. Separate scales were constructed for *knowledge about information presented on slides* and *knowledge about information presented only orally* by adding the scores for all items belonging to the respective scale. Then, the scales were z-standardized for both the immediate and the delayed posttest using the means and standard deviations from the condition without slide projection and with note-taking on empty sheets in the immediate posttest. Scales for *overall knowledge* in the immediate and delayed posttest were constructed by calculating the mean of the scales for knowledge about information presented on slides and knowledge about information presented only orally in the respective test.

A subset of six items from the posttests was used to measure *prior knowledge* in the first pretest and scored accordingly (but without the z-standardization).

### Processing of Information

Processing of information was measured in two ways: Processing of information presented on slides and of information presented only orally was captured by means of items that were interspersed during the final third of the video-recorded lecture (to avoid interference with the knowledge measured in the posttest). In addition, processing of information presented on slides was also captured by means of gaze-tracking.

Processing of both kinds of information was measured by 16 multiple-choice items with four options one of which was correct. These items were presented to the learners during an interruption of the video within 30 seconds after the information covered in the item had been presented in the lecture. Half of them covered information presented on slides, and half of them covered information presented only orally. These constraints were applied both to prevent forgetting and interference of reliance on the phonological loop, and to avoid sensitizing the participants to one of the two sources of information (slides or oral speech). Furthermore, to check for any reactivity associated with this measurement, measures of processing by means of interspersed items were taken from only half of the participants in each condition.

Two scales were constructed for *processing of information presented on slides* and *processing of information presented only orally* by adding the scores for all items belonging to the respective scale. Then, the scales were z-standardized using the means and standard deviations from the participants to whom the interspersed items were administered in the condition without slide projection and with note-taking on empty sheets.

In addition to this item-based measurement of learners' processing of information, their gazes were tracked using an Ergoneers 25 Hz head-mounted eye-tracker. The gaze data were anchored to the visual scenario by means of five marker symbols placed at different positions the learners could look at within the setting, such as the lectern or the projection area in the video, or the learners' table (see Figure 1a and b). The markers were captured by the field camera and recognized automatically by the software.

Areas of interest were defined to capture learners' visual attention to all individual information units on the slides. These areas of interest were anchored to the markers in the field camera video. Furthermore, learners' own note-taking was operationalized as the automatic recognition of the marker placed on the learners' table in the field camera video because this marker became only visible when the learners lowered their eyes to their notes. Besides, for each information unit in the lecture the time windows in which they were presented orally to each participant were determined based on timestamps in the log files.

These data are used to construct the following measures: (a) the proportion of each learner's dwell time in the corresponding area of interest during which the same information unit is presented orally (indicating the *proportion of slide reading with consistent oral input* for each information unit), (b) the proportion of each learner's dwell time in the corresponding area of interest during which a different information unit is presented orally (indicating the *proportion of slide reading with inconsistent oral input*), (c) the proportion of the oral presentation time during which the learner read the text in the corresponding area of interest (indicating the *proportion of oral input consistent with slide reading*), and (d) the proportion of the oral presentation time during which the learner read the text in a different area of interest or was occupied with his or her notes (indicating the *proportion of oral input inconsistent with slide reading*). These analyses will be completed by the time of the conference.

### Amount of Note-Taking

The learners' notes are used as a further data source. The amount of note-taking is determined separately for information that is presented on slides and information presented only orally. The learners' notes are segmented to idea units of a size (typically sentences or phrases) corresponding to the 261 information units contained in the lecture. Each of the resulting segments is coded as either one of the 261 information units contained in the lecture or as other content. Furthermore, each segment is coded as written down while watching the lecture or as written down during the review phase, based on the colour of the pen used.

Three coders independently analyzed a portion of the data from all conditions. Their agreement indicates satisfactory objectivity (81 to 82 %; Cohens  $\kappa = .81$  to  $.82$ ). The whole material is currently being coded.

Two scales are constructed from these data: The *amount of note-taking concerning information that is presented on slides* and the *amount of note-taking concerning information that is presented only orally* are calculated as the proportion of the information units contained in the learner's notes as compared to all information units from the respective information source (slides or only oral speech).

## Participants

The dataset analyzed for the present study includes the first 81 participants, mainly students of Psychology or Education (but not of Law). They were recruited by means of lecture visits, postings on notice boards, and social media. They were compensated by receiving either money or credit counting towards participation requirements in their degree programs.

The sample comprises 73 % female and 27 % male students. On average they were  $M = 24.0$  ( $SD = 6.1$ ) years old.

## Statistical Analysis

Because of the preliminary character of the present analyses based on a sample smaller than the final sample size, the level of significance was set to 10 % for all statistical tests presented in this paper.

## Results

### Effects on Knowledge about Information Presented on Slides and Knowledge Presented Only Orally Immediately after the Lecture and Two Weeks Later

The effects of slide projection and type of note-taking on knowledge about information presented on slides and knowledge presented only orally immediately after the lecture and two weeks later were analyzed by means of analyses of covariance with prior knowledge as a covariate. In addition to the two independent variables, the factor whether measurement of the processing of information by means of interspersed items had taken place was included as a further between-subjects factor. With one exception, no significant main effect of the measurement of the processing of information and no interaction effect with any of the other factors was found.

Concerning *knowledge about information presented on slides in the immediate posttest*, learners in the conditions without slide projection ( $M = 0.10$ ;  $SD = 0.82$ ) demonstrated only minimally higher amounts of knowledge about information presented on slides than learners in the condition with slide projection ( $M = 0.07$ ;  $SD = 0.69$ ). This difference was not significant,  $F(1; 72) = 0.52$ ;  $p = .48$ ; partial  $\eta^2 = .01$ . Similarly, learners in the conditions with note-taking on empty sheets ( $M = 0.12$ ;  $SD = 0.80$ ) exhibited little more of this knowledge than learners in the conditions with note-taking on handouts ( $M = 0.06$ ;  $SD = 0.70$ ). This difference was not significant,  $F(1; 72) = .34$ ;  $p = .56$ ; partial  $\eta^2 = .01$ , and neither was the interaction of the two independent variables,  $F(1; 72) = 1.48$ ;  $p = .23$ ; partial  $\eta^2 = .02$ .

Although with respect to *knowledge about information presented only orally in the immediate posttest* the descriptive findings showed slightly higher knowledge about information presented only orally in the conditions without slide projection ( $M = 0.19$ ;  $SD = 0.93$ ) as compared to the conditions with slide projection ( $M = 0.01$ ;  $SD = 1.07$ ) – which is in line with the speech suppression effect observed in the literature –, this difference was not significant,  $F(1; 72) = 1.91$ ;  $p = .17$ ; partial  $\eta^2 = .03$ . Likewise, the difference between the conditions with note-taking on empty sheets ( $M = -0.10$ ;  $SD = 1.05$ ) and the conditions with note-taking on handouts ( $M = 0.28$ ;  $SD = 0.94$ ) was not significant,  $F(1; 72) = 1.93$ ;  $p = .17$ ; partial  $\eta^2 = .03$ . Furthermore, there was no indication of an interaction effect,  $F(1; 72) = 0.05$ ;  $p = .83$ ; partial  $\eta^2 < .01$ .

*Knowledge about information presented on slides in the delayed posttest* was minimally lower in the conditions without slide projection ( $M = 0.65$ ;  $SD = 0.83$ ) than in the conditions with slide projection ( $M = 0.69$ ;  $SD = 0.87$ ), but this difference was not significant,  $F(1; 72) = 0.02$ ;  $p = .88$ ; partial  $\eta^2 < .01$ . In contrast, the difference between the conditions with note-taking on empty sheets ( $M = 0.36$ ;  $SD = 0.82$ ) and note-taking on handouts ( $M = 0.95$ ;  $SD = 0.78$ ) in favour of the latter was significant and corresponded to a large effect,  $F(1; 72) = 10.60$ ;  $p < .01$ ; partial  $\eta^2 = .13$ . The interaction effect was not significant,  $F(1; 72) = 2.05$ ;  $p = .16$ ; partial  $\eta^2 = .03$ .

With respect to *knowledge about information presented only orally in the delayed posttest* learners in the conditions without slide projection ( $M = 0.45$ ;  $SD = 0.97$ ) demonstrated slightly higher knowledge about information presented only orally than learners in the conditions with slide projection ( $M = 0.31$ ;  $SD = 0.98$ ). Although again descriptively in line with the speech suppression effect, this difference failed to reach significance,  $F(1; 72) = 1.37$ ;  $p = .25$ ; partial  $\eta^2 = .02$ . The difference between the conditions with note-taking on empty sheets ( $M = 0.24$ ;  $SD = 1.03$ ) and note-taking on handouts ( $M = 0.50$ ;  $SD = 0.90$ ) in favour of the latter was not significant as well,  $F(1; 72) = 0.82$ ;  $p = .37$ ; partial  $\eta^2 = .01$ . Again, there was no indication of an interaction effect,  $F(1; 72) = 0.41$ ;  $p = .52$ ; partial  $\eta^2 = .01$ .

### Effects on Processing of Information Presented on Slides and Information Presented Only Orally

The effects of slide projection and type of note-taking on the processing of information presented on slides and knowledge presented only orally were analyzed by means of analyses of covariance with prior knowledge as a covariate on the basis of the learners that received the interspersed items. The *processing of information*

*presented on slides* was slightly higher in the conditions without slide projection ( $M = 0.31$ ;  $SD = 1.49$ ) than in the conditions with slide projection ( $M = 0.11$ ;  $SD = 1.65$ ), but this difference was not significant,  $F(1; 33) = 0.41$ ;  $p = .53$ ; partial  $\eta^2 = .01$ . However, learners in the condition with note-taking on empty sheets ( $M = -0.34$ ;  $SD = 1.60$ ) – according to the less stringent level of significance applied in this preliminary analysis – exhibited significantly lower processing of information presented on slides than learners in the condition with note-taking on handouts ( $M = 0.63$ ;  $SD = 1.44$ ),  $F(1; 33) = 3.12$ ;  $p = .09$ ; partial  $\eta^2 = .09$ . No significant interaction effect was found,  $F(1; 33) = 0.52$ ;  $p = .48$ ; partial  $\eta^2 = .02$ .

With respect to the *processing of information presented only orally* the conditions without slide projection ( $M = 0.05$ ;  $SD = 1.24$ ) and with slide projection ( $M = -0.08$ ;  $SD = 1.53$ ) did not differ significantly,  $F(1; 33) = 0.32$ ;  $p = .57$ ; partial  $\eta^2 = .01$ . Also the difference between the conditions with note-taking on empty sheets ( $M = -0.36$ ;  $SD = 1.19$ ) and the conditions with note-taking on handouts ( $M = 0.25$ ;  $SD = 1.53$ ) did not differ significantly in this respect,  $F(1; 33) = 1.23$ ;  $p = .28$ ; partial  $\eta^2 = .04$ . Furthermore, there was no significant interaction effect,  $F(1; 33) = 0.89$ ;  $p = .35$ ; partial  $\eta^2 = .03$ .

## The Role of Processing of Information for Knowledge

The processing of information presented on slides significantly correlated with knowledge about information presented on slides both in the immediate posttest,  $r = .35$ ;  $p = .02$ , and in the delayed posttest,  $r = .59$ ;  $p < .01$ . Similarly, the processing of information presented only orally significantly correlated with knowledge about information presented only orally both in the immediate posttest,  $r = .52$ ;  $p < .01$ , and in the delayed posttest,  $r = .55$ ;  $p < .01$ .

As the type of note-taking had a significant effect on knowledge about information presented on slides in the delayed posttest, a mediation analysis for this effect was conducted with processing of information presented on slides as the potential mediator. The effect size of partial  $\eta^2 = .21$  without controlling for processing of information presented on slides that was found for the learners from whom measures of processing were collected was reduced to partial  $\eta^2 = .14$  by including processing of information presented on slides as a covariate. This means that 32.9 % of the effect of note-taking on handouts as compared to note-taking on empty sheets on knowledge about information presented on slides exhibited in the delayed posttest seem to be mediated by the processing of information presented on slides while watching the lecture.

## Discussion

The descriptive differences between the conditions without and with slide projection with respect to knowledge about information presented only orally in both posttests are compatible with the speech-suppression effect reported in the literature (Wecker, 2012, p. 267). However, in the preliminary analyses presented here they failed to reach significance. It remains to be seen whether in the final sample this effect will be replicated.

Note-taking on handouts had a strong beneficial effect compared to note-taking on empty sheets on knowledge about information presented on slides (and printed on the handouts) after the learners had the opportunity to study using their notes, and tended to benefit the processing of information presented on slides during the lecture. The former effect appears to be mediated to a large extent by the processing of information presented on slides while watching the lecture. This suggests that – in contrast to the storage hypothesis – this effect is not exclusively due to the availability of the information that was presented on slides on the handouts during review. Rather – in line with the encoding hypothesis – learning seems to be influenced by the processing of this information during note-taking as well (Kiewra, 1989, pp. 149 f).

That the two scales for processing of information presented on slides and of information presented only orally significantly correlated with the respective knowledge scales in the immediate and in the delayed posttest, provides some initial validation for these measures.

Obvious limitations of the analyses presented here include the liberal level of significance chosen due to the current state of the project. This issue is connected to the insufficient sample size included in the present analyses as well as the issue of not yet including measures of processing of information based on gaze tracking and analyses of the amount of note-taking. Beyond these limitations that have to do with the current state of the project, despite serious efforts to keep the learning situation as similar to a real-life lecture setting, several characteristics of the learning scenario may be regarded as somewhat artificial. In particular, this applies to the video-taped lecture viewed in individual learning sessions and interrupted for some participants by interspersed items, to the review phase of limited duration immediately before the final test, during which the learners could only use their notes rather than textbooks and other resources, and the final test as a proxy for a real examination. Future studies should relax some of the laboratory-type restrictions of the present study.

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