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SHORT PAPER

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Flickering presentations do affect the judgment of learning but not the learning outcome

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Abstract

We examined whether visual disfluency, as elicited by presenting text on flickering slides, affects learning positively and the global judgment of learning (JOL) negatively. Participants ($N = 202$ in Experiment 1, between-subjects design; $N = 53$ in Experiment 2, within-subjects design) saw in an online session multiple slides including textual information that they had to learn. The slides were presented either fluently or disfluently, that is, interrupted by rapid presentations of black slides, evoking a flickering effect. Thus, instead of manipulating the textual material (e.g., by using different fonts), as most studies on the disfluency effect so far did, we manipulated the characteristics of the presentation (i.e., flickering vs. nonflickering). In both experiments, JOL was lower in the flickering than in the nonflickering condition. However, flickering slides did not lead to a better memory performance. The results provide further evidence for the assumption that a beneficial disfluency effect is questionable.

KEYWORDS
distance, judgment of learning, learning, learning disfluency effect

1 | THE PERCEPTUAL DISFLUENCY EFFECT

Commonly, it is assumed that learning is most successful when information processing is easy and undisturbed. The disfluency effect (Alter et al., 2007; Oppenheimer, 2008), however, implies that impaired information processing can improve cognitive performance. Perceptual (visual) disfluency denotes the manipulation of the visual appearance of texts in order to make them harder to read by, for example, using hard-to-read fonts (Diemand-Yauman et al., 2011; French et al., 2013; Weissgerber & Reinhard, 2017), cursive handwriting (Geller et al., 2018), rotated/inverted words (Sungkhasettee et al., 2011), words with scrambled letters (Weissgerber & Reinhard, 2017). To explain the disfluency effect, it has been proposed that disfluent perceptional processes may serve as metacognitive cue for learners, enhancing their self-regulation during reading by investing more effort in processing the text, which boosts memory performance (Diemand-Yauman et al., 2011).

Theoretically, however, disfluency might also have a contrary effect. The decoding of a deformed text might require *more* processing resources, which are no longer available for deeper processing of the text, thus, impairing its processing and diminishing the learning output. In sum, both effects (i.e., the benefits caused by deeper processing and the disadvantages caused by a poorer processing of the material) could level each other out.

In fact, many studies failed to replicate the disfluency effect (e.g., Eitel et al., 2014; Geller et al., 2020; Witherby & Carpenter, 2022, Experiment 2; Yue et al., 2013), even an attempt to replicate the original study of Diemand-Yauman et al. (2011) by Rummer et al. (2016), using the same material. It is therefore still on debate whether the disfluency effect with text-based learning exists at all. The doubt has become larger given a meta-analysis, revealing a null effect of text-based disfluency (Xie et al., 2018), which has, however, been criticized for methodological problems (Weissgerber et al., 2021).

2 | FLICKERING SLIDES AS PERCEPTUAL DISFLUENCY

Digitalization processes in educational contexts have significantly accelerated during the last years because of technological progress (e.g., Schmidt & Tang, 2020) and the COVID-19 pandemic, demanding online lessons for students due to contact restrictions in schools and universities (e.g., Cone et al., 2021; Rof et al., 2022). However, internet connections during online meetings are sometimes unstable, evoking interruptions of sound and/or vision, begging the question of whether such interruptions in online presentations affect the learning outcome. On the one hand, interrupted online presentations—as operationalized in the present study by means of flickering slides—might impair the learning outcome because flickering (like eye-blinking) interrupts the continuity of the perceptual input (Volkmann et al., 1980) and thereby makes the encoding of visual information more difficult.[1] On the other hand, flickering slides could also serve as perceptual disfluency, boosting the learning outcome. In contrast to prior disfluency manipulations, flickering slides have a special feature: Disfluency evoked by flickering is not inherent in the textual material itself, but only in the presentation. Flickering of easy to read texts temporarily interrupt perceptual processing rather than continuously hampering the input of information. Therefore, a positive effect of flickering presentations on memory could be expected.

3 | THE PRESENT STUDY

We presented a learning text disfluently (i.e., on flickering slides), as it might occur in online learning contexts. This manipulation differs from other attempts to exactly or conceptually replicate the disfluency effect on learning as these studies manipulated the learning material directly by changing the appearance of the texts (or the pictures). In our study, in contrast, the learning material as such (i.e., the text on the slides) remained unchanged, and disfluency was elicited by disruptions of the presentation of the slides only. Thus, the flickering might provide a meta-cognitive cue to promote deeper processing and, at the same time, does not require additional resources to decode the text itself. A flickering presentation (of easy-to-read fonts) is expected to demand less cognitive resources than presenting (nonflickering) hard-to-read fonts. At the same time, interrupting the presentation of easy-to-read learning material for short periods of time is a disfluent presentation condition since it interrupts learners' reading process. Thus, flickering should trick learners into deeper processing to the same degree as hard-to-read fonts are assumed to do.

Furthermore, flickering as visual dynamic can also automatically attract visual attention. In contrast to abrupt onsets of single distractors, continuous flickering can capture visual attention also for longer durations (e.g., Stolte & Ansorge, 2021). In real life, flickering is used as signal to pay attention (e.g., flashing lights of ambulances or public advertisement). Accordingly, flickering slides might urge readers to stronger focus on the relevant stimuli (i.e., the text on the slides) instead of focusing seductive details of the surrounding. The enhanced attention in the flickering condition might additionally contribute to a positive effect on learning.

We evoked the flickering in the present study by inserting rapidly presented black slides within the regular presentation of mute text slides, as they are often used as a basis for online lectures. Learners' performance in a multiple-choice test on the text served as dependent variable. Furthermore, learners' global judgment of learning (JOL) was assessed by asking them immediately after the learning phase to indicate the expected percentage of correctly answered questions in a subsequent multiple-choice test. JOL as one aspect of meta-cognition (Dunlosky & Bjork, 2008) is usually negatively related to the perceived effort in the encoding and learning phase (Koriat et al., 2006). If the flickering of slides is perceived as an obstacle, requiring more effort of the learners in the encoding phase, it should result in lower JOL compared to nonflickering slides. A number of recent papers on the disfluency effect did not only measure learning outcomes but also JOLs, usually revealing lower JOLs for disfluent than for fluent learning material (e.g., Geller et al., 2020; Magreehan et al., 2016; Witherby & Carpenter, 2022 for such a pattern concerning JOL of disfluent learning material).

We expected flickering slides to positively affect the learning outcome because it may stimulate attention focusing towards the text content and more effortful processing, by, at the same time, wasting no additional cognitive resources into the encoding of disfluent material as such. The flickering, however, should lead to lower JOL because it might be perceived as nonfluent learning condition compared the nonflickering presentation, and, hence, to less effortful learning. Two experiments were conducted, manipulating the flickering between- (Experiment 1) or within-subjects (Experiment 2), because it has been suggested that JOL and recall are affected by disfluency only when learners pass through the fluent condition, too (Yue et al., 2013).

4 | EXPERIMENT 1

4.1 | Method

4.1.1 | Sample

This online experiment was conducted by means of SoSciSurvey (www.soscisurvey.de). Participants were invited via an internet link distributed via social media platforms, university email distribution lists, and SurveyCircle (www.surveycircle.com). In total, 238 adults participated, of which 36 were excluded because of being younger than 18 years old, having insufficient knowledge of German to understand the factual texts, or not having completed all tasks.

The final sample included 202 participants (156 female, 41 male, 5 diverse; mean age: 27 years, range: 18–72 years), thereof 152 students (75%), 36 employees (18%), and 14 (7%) with other statuses.

Ninety-six of them were randomly assigned to the experimental group and 106 to the control group.

To determine whether there was an effect of presentation condition on JOL and on test performance, two *t*-tests were planned, each with $\alpha = 0.05$, a power of .95, and a medium effect size (Cohens' $d = .5$), resulting in a required sample size of $N = 210$ according to G*Power (Faul et al., 2007).

4.1.2 | Design

In Experiment 1, a between-subjects design was used with the independent variable presentation condition (i.e., nonflickering vs. flickering slides). Global JOL and actual test performance served as dependent variables.

4.1.3 | Material

All participants saw a mute online PowerPoint presentation referring to placebo and nocebo effects, including seven slides (see Appendix A). Five slides were presented for 20 s each, and two slides with less content (slides 4 and 7) for 15 s. Presentation durations were tested in advance to allow for sufficient reading time. In the control group, these slides were presented without disturbance. In the experimental group, the presentation of each slide was interrupted four times in regular distances of time by the rapid presentation of a black slide (for 100 ms each), eliciting the impression of flickering. The total duration of the content presentation was constant in both conditions. In addition, participants saw as first slide (5 s) the title (i.e., "What are Placebo and Nocebo Effects actually?") and a final slide (3 s), indicating the end of the presentation, both without flickering.

Global JOL were assessed by asking participants immediately after the learning phase to indicate the expected percentage of correctly answered questions in the subsequent multiple-choice test on a scale ranging between 0% and 100%.

The memory test consisted of eight multiple-choice test questions referring to the information on the slides (see Appendix B). Participants were told that one or more alternatives could be correct and that they would get one point for each correctly selected alternative and a minus point for an incorrectly selected alternative. This procedure was introduced in order to prevent participants from selecting all alternatives. The number of correct alternatives per question ranged between one and two. Participants could achieve a score of 10 points in total in the test, and their actual performance was transformed into percent to make it comparable with the JOL.

4.1.4 | Procedure

The instruction started by informing the participants that they would learn something about placebo and nocebo effects, taking about 10–15 min, and that it was important to complete all tasks, using a desktop computer or laptop only. Furthermore, all participants were told that due to the high utilization of the website, minor technical disruptions could occur, including flickering screens, but that this would not cause any problem for the course of the study.

Then, participants provided their informed consent statement and socio-demographic information. Thereafter, they were assigned randomly to either the experimental group (i.e., flickering presentation) or to the control group (i.e., nonflickering presentation). It was told that in the following, they would be presented with information about placebo and nocebo effects and required to read them carefully and memorize them as best as possible, because they would later be asked to answer questions concerning the content. Participants were informed that they could start the presentation individually by clicking the "play" button and that the slides would then be presented automatically. They were not allowed to make any notes or to pause the presentation. After the presentation, participants were asked to proceed to the next part of the study by clicking the "continue" button.

After the learning phase, participants first provided a global JOL by estimating the percentage of correct answers (between 0% and 100%) they would achieve in a subsequent memory test referring to the presented information. Thereafter, eight multiple-choice test questions were presented in random order. Participants were instructed to complete each question in a self-paced manner and, if they did not know the answer, to select the alternative "I don't know." After responding each question, participants could not turn back and alter their choice.

At the end, participants were thanked for their participation, informed about the purpose of the study, and had the opportunity to enter a lottery to win one of five gift coupons, each with a value of 20 EUR.

4.2 | Results

Two *t*-tests for independent samples were computed to check whether the presentation condition affected global JOL and memory performance. JOL was higher in the nonflickering condition compared to the flickering condition, $t(200) = 3.66$, $p < .001$, Cohen's $d = 0.49$, while there was no effect of flickering on the actual memory performance, $t(200) = 0.89$, $p = .37$, Cohen's $d = 0.13$ (see Table 1).

Two Bayesian *t*-tests confirmed the results. For JOL, the analysis revealed—according to Jeffreys (1961)—extreme evidence for the alternative hypothesis ($BF_{10} = 139.35$, % error: $< .001$), suggesting that the data were about 139 times more likely to emerge under the alternative hypothesis (i.e., smaller JOL in the flickering than in the nonflickering condition) than under the null hypothesis. For the test performance, the analysis revealed anecdotal evidence for the null hypothesis ($BF_{01} = 2.79$, % error: $< .001$), suggesting that the data were about three times more likely to emerge under the null hypothesis than under the alternative hypothesis (i.e., better test performance in the flickering than in the nonflickering condition).

	Experiment 1		Experiment 2	
Presentation condition	JOL	Test	JOL	Test
Flickering	70% (20%)	63% (25%)	64% (19%)	83% (18%)
Nonflickering	79% (17%)	59% (27%)	70% (16%)	88% (11%)

Note: Standard deviations in parentheses.

TABLE 1 Mean global judgment of learning (JOL) and actual test performance per presentation condition in Experiments 1 and 2.

5 | EXPERIMENT 2

Experiment 2 was conducted to examine whether the results' pattern can be replicated in a within-subjects design because studies suggested that the disfluency effect emerges particularly when disfluency was manipulated within-subjects and not between-subjects (e.g., Yue et al., 2013). Except for the design, the method was largely comparable to that of Experiment 1, with some minor changes concerning the sample, material and procedure.

5.1 | Method

5.1.1 | Design

In contrast to Experiment 1, the presentation condition (i.e., flickering vs. nonflickering slides) was manipulated within subjects. Global JOL and test performance (both in %) served again as dependent variables.

5.1.2 | Sample

The required sample size was calculated a priori by means of G*Power (Faul et al., 2007) for a dependent samples *t*-test with $\alpha = .05$, a power of .90, and a medium effect size of $d = 0.5$, resulting in $N = 44$ participants. In total, 59 adults started the experiment, of which six were excluded because of being younger than 18 years old, having insufficient knowledge of German to understand the factual texts, not having completed all tasks or having taken part in Experiment 1.

The final sample included 53 participants (43 female, 8 male, 2 diverse) with a mean age of 25 years (range: 18–54 years), thereof 44 students (83%), eight employees (15%), and one participant (2%) with another status.

5.1.3 | Material

A second set of slides was generated addressing the effect of pets on humans' well-being (see Appendix C), which was presented in one condition, while the slides of Experiment 1, addressing placebo and nocebo effects, were presented in the other condition, respectively. Information amount (number of words and information units) and difficulty were largely comparable for the two learning contents. The multiple-choice tests on each content included 11 questions, each with only one correct alternative (see Appendices B and D). Thus, participants could get 11 points at maximum. The achieved number of points was again transformed into percent.

5.1.4 | Procedure

Experiment 2 was also conducted online, but this time, participants had to join the session via Zoom so that the experimenter could control their compliance with the instruction. The procedure was similar to that in Experiment 1, with the exception that participants were exposed to two presentations (i.e., a flickering and a nonflickering one) one after the other. The order of the contents and of the presentation conditions was counterbalanced between participants. After each presentation, participants first provided a global JOL and then completed the corresponding test. To rule out confounding effects of the learning content, half of the participants received the placebo slides in a flickering presentation, while the other half received the pets' effect slides in a flickering presentation. As manipulation check, participants had to evaluate the visual quality of the presentations after the second test on a 6-point Likert scale ranging from 1 (very bad) to 6 (very good).

5.2 | Results

The manipulation was successful, resulting in higher visual quality ratings in the nonflickering condition ($M = 5.70$, $SD = .67$) than in the flickering condition ($M = 3.53$, $SD = 1.15$), $t(52) = 11.54$, $p < .001$, $d = 1.59$.

To test the hypotheses, two *t*-tests for dependent samples were computed to check whether the presentation condition affected JOL and memory performance (for descriptive statistics, see Table 1). Like in Experiment 1, JOL was higher in the nonflickering condition than in the flickering condition, $t(52) = 2.67$, $p = .010$, Cohen's $d = 0.37$, while for the actual memory performance, there was no significant effect of flickering, $t(52) = 1.97$, $p = .054$, Cohen's $d = 0.27$.

Two Bayesian *t*-tests confirmed these results. For JOL, the analysis revealed—according to Jeffreys (1961)—moderate evidence for the alternative hypothesis ($BF_{10} = 7.17$, % error: < .001), suggesting that the data were about seven times more likely to emerge under the alternative hypothesis (i.e., smaller JOL in the flickering than in the nonflickering condition) than under the null hypothesis. For the test performance, in contrast, the analysis revealed strong evidence for the null hypothesis ($BF_{01} = 18.99$, % error: = 0.11), suggesting that the data were about 19 times more likely to emerge under the null hypothesis than under the alternative hypothesis (i.e., better test performance in the flickering than in the nonflickering condition).

6 | GENERAL DISCUSSION

In two experiments, it was examined whether the flickering of slides in an online presentation—as it can occur because of unstable internet connections—affects learners' global JOL and their actual learning outcome in a text-based learning task. While flickering as kind of a disfluent learning condition was manipulated between subjects in Experiment 1, it was varied within subjects in Experiment 2. The latter design was used in the replication because previous research suggested that the disfluency effect might be more probable to emerge when participants experience both the fluent and the disfluent condition (Yue et al., 2013). In both experiments, flickering slides resulted in lower JOL than nonflickering slides, but flickering had no effect on learners' actual performance in a memory test. These results were confirmed by Bayesian analyses. The findings imply that learners in the flickering condition perceived more difficulties for their learning process, but that these difficulties did neither positively nor negatively affect their actual learning outcome. This finding conflicts with the assumption that visual disfluency promotes learning processes (Diemand-Yauman et al., 2011; French et al., 2013). In the following, the results will be discussed in the light of existing theoretical accounts and other findings, starting with the results concerning JOL.

The negative effect of flickering slides on JOL is in line with other findings showing that participants evaluated their learning success to be lower as consequence of presenting learning material disfluently instead of fluently (e.g., Weissgerber & Reinhard, 2017). However, Yue et al. (2013) reported no effect on JOL when disfluency (in this case: blurred words) was manipulated between subjects. The effect emerged only when it was manipulated within subjects (Yue et al., 2013, Experiment 1a; see also Magreehan et al., 2016). The findings of Experiment 1 underline that a disfluency manipulation by means of flickering slides is strong enough to evoke also between-subjects effects on JOL, especially when sample size is large enough. The effect of disfluency on JOL may have been absent in prior studies using between-subjects designs because of insufficient power (e.g., 13 participants per experimental group in the between participants experiment by Yue et al., 2013, Experiment 1b). However, another sufficiently powered study also found no effect of a decreased visual quality (i.e., blurred text and pictures) of slides on JOL (Witherby & Carpenter, 2022, Experiment 2), but this study differed in several aspects from the present one. First, the fluency of the material as such was reduced, not the fluency of the presentation, as in the present study. Furthermore, the visual presentation in the study of Witherby and Carpenter (2022) was accompanied by a (fluent or disfluent) auditory lecture, and participants were additionally asked on which aspects they had based their JOL. Instead of relying on the visual fluency of the material, most participants oriented their JOL on the material content and on their own abilities, or on unrelated aspects. In the present study, only visual fluency was manipulated and only the flickering presentation, not the text itself was disfluent. These characteristics might have been more salient, having a larger impact on JOL than in other studies.

The finding of an effect of flickering slides on JOL but not on the actual learning outcome in both experiments is in line with previous research, in which the learning material was, in contrast to our manipulation, directly manipulated via font or word order within sentences. For example, Rhodes and Castel (2008) showed that the subjectively perceived fluency of processing the learning material does not necessarily affect actual memory performance but leads to meta-cognitive illusions. Besken and Mulligan (2013, Experiment 1) demonstrated a crossed double dissociation between actual and predicted memory performance by means of a disfluency manipulation, in which single words were backwardly masked or remained intact. Intact words received better JOLs, but backwardly masked words were better remembered. This kind of double dissociation was not revealed in the present study. On the contrary, in Experiment 2, there was even a nonsignificant tendency ($p = .054$) that memory performance was poorer in the flickering than in the nonflickering condition, which would be in line with participants' JOL.

The absent effect of flickering slides on the learning outcome in the present study corresponds not only to studies failing to directly replicate the original disfluency effect (Rummer et al., 2016), but also to other studies trying to conceptually replicate this effect (for a meta-analysis, see Xie et al., 2018). For example, Witherby and Carpenter (2022, Experiment 2) found no benefit of a visually disfluent online lecture, in which text and pictures were blurred, for learning. Furthermore, Eitel et al. (2014), found no benefits of a disfluency manipulation for multi-media material including text in a hard-to-read font and blurred, distorted pictures that looked like a bad copy (see also İlic & Akbulut, 2019, for a similar multimedia manipulation of disfluency, yielding no benefit).

Different accounts may explain the lack of an effect of flickering slides on memory in the present experiments. First, it can be taken as further evidence that no robust disfluency effect exists (e.g., Xie et al., 2018), not even in the context of a conceptual replication, like in the present study that did not manipulate the fluency of the appearance of the text as such but the fluency of its presentation. Second, our data have shown that learners had perceived the visual distortions in the experimental condition, as suggested by lower JOL and by their evaluation of the visual quality of the presentations in Experiment 2, serving as manipulation check. As a consequence, they might have compensated the potential impairing effect of this distraction by investing more effort in the encoding and processing of the disfluent material, which leveled out—in the end—the impairing effects, but which was not strong enough to yield overcompensating/positive effects. If such compensating processes are conscious, asking learners to reflect and report their strategies and assessing their cognitive load might be worthwhile in future research. However, in the study of Eitel et al. (2014), perceptual disfluency led only in one experiment of four to higher subjective evaluations concerning mental effort and to a better performance in a transfer test, which is a weak proof for the disfluency effect in multimedia learning. Thus, the assumption concerning compensating mental effort requires further research.

A third account to explain the absent effect of flickering slides on memory refers to the interval between study phase and test phase, which might have been too short in the present study. As a (more or less) desirable difficulty (Bjork, 1994), the disfluency effect might more likely appear for delayed than for immediate tests (Weissgerber & Reinhard, 2017). However, even students in the original study of Diemand-Yauman et al. (2011, Experiment 1), which revealed a disfluency effect, were tested already 15 min after the learning phase. Thus, this explanation is not very probable.

In view of many failing attempts to replicate the disfluency effect, moderator effects have been proposed, such as the level of disfluency, with a larger effect for mild disfluent than for severely disfluent fonts (Geller et al., 2018). This approach is in line with the consideration that a lower task difficulty, as reflected by a higher overall performance, might promote the disfluency effect (Rummer et al., 2016), while this effect is rather improbable for more difficult tasks. Furthermore, the distinctiveness of the presentation in terms of learners being less familiar with disfluent displays, might promote the effect (Rummer et al., 2016). Another potential factor is whether learners expect a test after the learning phase or not. While Eitel and Kühl (2016) found no interaction between the disfluency manipulation and test expectancy, Geller and Peterson (2021) reported a disfluency effect, evoked by a hard-to-read font, only when learners did not expect a subsequent test (see also French et al., 2013). Participants of the present study were aware that they took part in a learning study, even if the test was not explicitly announced in advance, but no disfluency effect was revealed.

However, chasing moderator effects and searching for boundary conditions suggests that a robust disfluency effect in educational contexts is rather unlikely to exist (cf. Eitel et al., 2014). The present study expands this assumption to fluency manipulations, implemented between and within subjects, that do not directly address the readability of text but instead manipulate the fluency of its presentation. However, one can nevertheless conclude, based on our data, that technical problems during online learning in terms of flickering slides do not necessarily impair the learning outcome of the audience. Nevertheless, it could lead to more negative evaluations of the presentation because the audience has the impression of having learned less.

CONFLICT OF INTEREST STATEMENT

There is no conflict of interest.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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ENDNOTES

[1] This effect is, for example, demonstrated by phenomena such as change blindness. Changes in pictures or words are easily detected when the changed picture or word is presented immediately after its original version, but hard to detect when the two presentations are interrupted by a blank screen, a blink, or another interruption for several milliseconds (e.g., Rensink et al., 1997; Simons & Levin, 1997; Simons, 2010).

[2] Unfortunately, it was missed to reduce the number of correct alternatives of this question to only one in Experiment 2. Therefore, the first correct alternative concerning side effects was no further considered in the analyses.

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APPENDIX A: LEARNING TEXT (EXPERIMENT 1): WHAT ARE PLACEBO AND NOCEBO EFFECTS?

Word count (in the original version in German in total): 303

Slide 1: Placebo effect

- Positive bodily or psychological changes
  - as result of taking pseudo medicine that contains no active ingredient
  - or as result of pseudo treatments, like a simulated operation or an infusion of a simple sodium chloride solution

Slide 2: Placebo effect

- How can placebo effects be explained?
  - generation of expectancy effects that base on complex psycho- and neurobiological processes in the brain
  - the brain releases endogenous substances (opioids) that act, for instance, pain-relieving

Slide 3: Placebo effect

- When does the placebo effect occur?
  - Placebo effect presumably plays a role in each treatment success (also in addition to medical treatment)
  - Without placebo effect, the dosage of active ingredients ought to be twice as high on average
  - Stronger effect when people have already prior experiences with effective medicine
  - Placebo effect limited among chronic ill persons

Slide 4: Nocebo effect

- The nocebo effect is the opposite of the placebo effect.
  - that is, a positive effect of an effective medicine does not occur
  - or side effects of a medicine occur that cannot be explained biochemically

Slide 5: Nocebo effect

- How can the nocebo effect be explained?
  - Individuals generate expectancy effects, too, but a negative one
  - For instance the expectancy of side effects of the medicine based of a patient information leaflet
  - As a result, pain centers in the brain are activated (biochemical processes) that elicit pseudo pain perception

Slide 6: Corona vaccination and nocebo effect

- There are individuals who fear potential side effects of the corona vaccination
  - based on (social) media and other private and public influences
  - however, these expectations are exaggerated
  - a study in which half of the participants received a real corona vaccination and the other half received a pseudo medication
    - two third of the participants who had received a real vaccination reported headaches as result of the vaccination
    - but also one third of the participants who had received a pseudo medication did so (i.e., nocebo effect)

Slide 7: Preventing nocebo effects

- role of physicians: Fostering positive expectations and optimism; not dramatizing side effects
- for instance by emphasizing positive information: "90% of the patients tolerated the medicine well" (instead of "10% of the patients experienced side effects")

APPENDIX B: QUESTIONS MULTIPLE-CHOICE TEST PLACEBO AND NOCEBO EFFECTS (EXPERIMENT 1/EXPERIMENT 2)

Note: Correct alternatives are indicated by (c). In Experiment 1, the test on placebo and nocebo effects consisted of eight multiple-choice questions: six with one correct alternative and two with two correct alternatives (i.e., 10 points in total). In Experiment 2, the test on placebo and nocebo effects consisted of 11 multiple-choice questions, each with one correct alternative. In doing so, the questions 1, 2, and 6 were added in Experiment 2, and one alternative in question 3 was changed to have only one correct alternative.

1. What is meant by the placebo effect? (in Experiment 2 only)
   - A medicine is even then effective when patients do not believe in its effect
   - A medicine is even then effective when it has no active ingredients (c)
   - A medicine is only then effective when patients believe in its effect
   - Patients can omit a medicine as long as they believe strong enough in self-healing
   - I do not know.
2. What is known regarding the emergence of the placebo effect? (in Experiment 2 only)
   - The placebo effect emerges only in people who believe in homeopathy
   - The placebo effect presumably plays a role in all medical treatments (c)
   - The placebo effect emerges on particular in stationary medical treatments
   - The placebo effect is stronger for psychological illnesses than for physical illnesses
   - I do not know.
3. How can the placebo effect be explained? (in Experiment 2, second alternative changed into "expectation of the physician promotes self-healing of the patient" – incorrect)
   - Pain centers in the brain are activated
   - Endogenous substances (e.g., opioids) are released (c)
   - Subjective experiences elicit biochemical processes (c)
   - Medicaments strengthen endogenous processes
   - I do not know.
4. For whom are the placebo effects especially strong?
   - for people suffering from a chronic illness
   - for older people
   - for people who already made positive experiences with medicines (c)
   - for people with a lower educational level
   - I do not know.
5. What is meant by the nocebo effect?[2]
   - that a positive effect of a medicine will be enhanced
   - that an expected side effect of a medicine occurs (c)
   - that a positive effect of a medicine does not occur (c)
   - that a pseudo medicine evokes a positive effect
   - I do not know.
6. How can the nocebo effect be explained? (in Experiment 2 only)
   - Subjective expectations of patients evoke biochemical processes (c)
   - Medicament possesses too little active ingredients
   - Patients need a higher dose of the medicament
   - Patients have developed a resistance against the medicament
   - I do not know.
7. Which role plays the nocebo effect for the corona vaccination?
   - People refuse vaccination because they fear side effects.
   - People do not believe in the effectiveness of the corona vaccination.
   - People expect side effects of the vaccination, which in fact emerge (c)
   - People believe that the effect of the vaccination drops rapidly.
   - I do not know.
8. How can nocebo effects be prevented?
   - by showing people statistics concerning the probability of side effects of medicines
   - by emphasizing that self-regulating forces of humans are strong
   - by not emphasizing potential side effects of medicines (c)

– by asking people to read the patient information leaflet of medicines thoroughly
– I do not know.

9. Imagine that someone took a sweetener tablet in place of a pain-relieving medicine. Now he feels better. What effect might this be?
   – placebo effect (c)
   – nocebo effect
   – none of the two
   – I do not know.
10. Imagine that someone gets a chemotherapy and knows that it elicits nausea. In fact, he feels a strong nausea during the therapy. What effect might this be?
   – placebo Effect
   – nocebo effect (c)
   – none of the two
   – I do not know.
11. Imagine someone has toothaches but fears the dentist. When he finally makes an appointment at the dentist, his toothaches lessen abruptly. What effect might this be?
   – placebo effect
   – nocebo effect
   – none of the two (c)
   – I do not know.

APPENDIX C: LEARNING TEXT (EXPERIMENT 2): DO PETS HAVE A POSITIVE EFFECT ON HEALTH?

Word count (in the original version in German in total): 300

Slide 1: The Pet Effect

- Assumption that pets positively affect the physical and psychological health of their owners
- Former studies showed that:
  – heart attack patients owning a pet had a higher survival chance than heart attack patients without a pet
  – petting cats and dogs, and observing fishes in an aquarium lowers blood pressure and stress level

Slide 2: The Pet Effect

- Explanations for the positive Pet Effect:
  – Pets serve as social support and thereby reduce stress in burdening situations
  – Pets stimulate owners to move more
  – Less stress and more motion prevent, for example, cardiovascular diseases

Slide 3: Studies that question the Pet Effect

- More recent studies did not find differences between pet owners and nonpet owners
  – The have a similar:
    ◦ Level of happiness
    ◦ Feeling of loneliness
    ◦ Mortality risk

Slide 4: Studies that question the Pet Effect

- More recent studies found even negative associations between owning pets and the health of their owners:
  – Lower survival rates and higher risk of relapse of heart attack patients with pets compared to those without pets
  – Pet owners are more depressive than nonpet owners
  – Dog owners have more health problems than nondog owners

Slide 5: Explaining the contradicting results concerning the Pet Effect

- Methodological problems:
  – Pet owners potentially differ from nonpet owners already before they get themselves a pet regarding:
    ◦ Health (e.g., blood pressure, depression)
    ◦ Live style (e.g., exercising, smoking, obesity)
    ◦ Socio-economic status
  – Participants of the studies often only self-rated their health (self-reports not objective)

Slide 6: Explaining the contradicting results concerning the Pet Effect

- Problems with the publication system: Studies that failed to find positive effects were often not published (publication bias)
  – because the results did not meet the expectations and wishes of the public
  – and because articles, therefore, sell less

Result: Overestimation of the positive effect of pets

Slide 7: Do pets help to enhance well-being of their owners during the COVID-19 pandemic?

- Survey among more than 2400 individuals (half of them were pet owners)
  – Pet owners reported lower well-being during the COVID-19 pandemic compared to nonpet owners
  – Negative association particularly strong for women, families with more than two children, and unemployed people

APPENDIX D: QUESTIONS MULTIPLE-CHOICE TEST (EXPERIMENT 2)

Note. Correct alternatives are indicated by (c).

1. What is meant by the Pet Effect?
   - that the fur of pets evokes an allergic reaction
   - that pet owners more and more converge with their pets over time
   - that pets contribute to the effect that their owners become more domestic
   - that pets have a positive effect on the health of their owners (c)
   - I do not know.
2. How did the Pet Effect manifest itself in former studies?
   - Pet owners suffered less frequently of cancer
   - Pet owners survived more frequently heart attacks (c)
   - Pet owners survived more frequently strokes
   - Pet owners suffered less frequently of dementia
   - I do not know.
3. How can the positive effect of pets be explained?
   - Pet owners are connecting each other and thereby generate a network of social support
   - Pet owners take more care of hygiene and thereby avoid infectious diseases
   - Pets serve as social support and thereby reduce stress (c)
   - Pets serve as distraction from everyday problems
   - I do not know.
4. What did more recent studies find concerning the Pet Effect?
   - They confirmed the positive effect of pets on health and well-being of their owners
   - They showed that the pet effect emerges only for special pets
   - They found also negative or no associations between pet ownership and health and well-being (c)
   - They showed that pet ownership has increased over time
   - I do not know.
5. What did more recent studies on the Pet Effect find concerning depression?
   - Pet owners are on average more depressive than nonpet owners (c)
   - Depression seems to be independent of pet ownership
   - Especially owners of reptiles and fishes tend to be more depressed than nonpet owners
   - Depressive people more often get themselves a pet
   - I do not know.
6. What is the problem of many studies that examined the effect of pets on the health of their owners?
   - they did not consider that pet owners might differ from nonpet owners already before they get themselves a pet (c)
   - that only a small part of all pet owners was considered
   - that no representative sample of pets was considered
   - that health was not clearly defined in advance
   - I do not know.
7. What is a further problem of many studies that examined the effect of pets on the health of their owners?
   - that the health of the participants was only evaluated by a physician
   - that participants evaluated their health themselves (c)
   - that the health of the participants was assessed only once
   - that health-related data are subject to data privacy and can therefore not be used
   - I do not know.
8. What is meant by "publication bias"?
   - only those studies are published that provide new insights
   - only those studies are published that confirm expected effects (c)
   - only those studies are published that were conducted by well-known scientists
   - only those studies are published that confirm known effects
   - I do not know.
9. What is a result of the publication bias concerning the Pet Effect?
   - The positive effect of pets on the health of their owners was overestimated (c)
   - The positive effect of pets on the health of their owners was underestimated
   - The number of publications on the pet effect per year significantly dropped
   - none, because pet owners usually write no scientific reports
   - I do not know.
10. What was found concerning the effect of pet ownership during the COVID-19 pandemic?
    - Pet owners reported a higher well-being than nonpet owners
    - Pet owners reported a lower well-being than nonpet owners (c)
    - Pet owners had a lower risk of getting infected with Corona than nonpet owners
    - Pet owners had a lower risk of suffering from long-term effects of a Corona infection than nonpet owners
    - I do not know.
11. Imagine that you are a women with three kids. Should you—based on your knowledge from the learning material—get yourself a dog to enhance your well-being during the COVID-19 pandemic?
    - yes
    - no (c)
    - the pet effect is independent of sex
    - the pet effect is independent of the number of children
    - I do not know.