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SHORT PAPER

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Modality-general benefit of eye-closure on the retrieval of intentionally learned information

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Abstract

The beneficial effect of eye-closure during retrieval was demonstrated in many studies addressing eyewitness memory or memory of episodic events. Fewer studies examined the effect concerning the intentional learning of verbal information. Furthermore, the question of whether the eye-closure effect is modality-specific, boosting visual memory only, or modality-general, boosting also other forms of memory (e.g., auditory memory), is still open. These issues were addressed in the present study. Participants ($N = 129$) were asked to study aurally and visually presented lists of unrelated nouns (within-subjects). During free recall, participants either kept their eyes open or closed their eyes (between-subjects). Eye-closure resulted in better free recall than keeping the eyes open. Importantly, this effect emerged for both visually and aurally presented word lists, suggesting that the effect of closing the eyes is rather modality-general. The results are discussed with respect to limitations of previous studies and practical implications.

KEYWORDS
eye-closure effect, intentional learning, long-term memory, modality-specificity, verbal memory, visual distraction

1 | INTRODUCTION

When people try to remember something, they often look away or even close their eyes. Research demonstrated that people avert gaze and close their eyes more often when they try to recall autobiographical facts and general knowledge that are difficult to retrieve, and that this behavior promotes more correct answers (Glenberg et al., 1998; see also Radel & Fournier, 2017, for a replication). However, most studies so far revealing a positive effect of closing the eyes on retrieval addressed eye-witness memory (i.e., incidental learning of multimodal facts of episodes), assessed both in natural contexts and in the laboratory (e.g., Perfect et al., 2008, 2012; Vredeveldt et al., 2011; Vredeveldt & Penrod, 2013; Wagstaff et al., 2004).

The eye-closure effect has been investigated less frequently with regard to the recall of intentionally learned verbal information. In one study (Einstein et al., 2002), participants were presented aurally with word pairs. Cued recall after a short distractor task was better in the eye-closure condition and in a condition in which participants looked at a small cross on a blank computer screen, compared to a condition in which they looked at changing pictures on the screen. Thus, preventing visual distraction—as it usually occurs when scanning the environment with open eyes—improved retrieval. The effect of visual distraction on memory was already reported by Glenberg et al. (1998, Exp. 5), showing a better recall performance of words when participants looked on a simple (static picture) than on a complex (dynamic, silent movie) visual display. However, no eye-closure condition was realized in this study and only recall of the middle five items of each word lists (but not of the first and last five words) was analyzed. Rae and Perfect (2014) tried to replicate and extend this experiment in a series of five experiments, revealing inconsistent results. The effect of simple versus complex visual distraction was confirmed for the mid-list words but not for the first and last words of each list in Experiment 1, but not in Experiment 2 and 3, in which the presentation rate of the words and interference by presenting words of the same category was additionally manipulated. Unfortunately, again no closed-eyes condition was realized (or it was subject to a coding error in Experiment 1, respectively).

The effect of eye closure on the recall of objects (and their number) was investigated in another study (Wais et al., 2010, Exp. 1). Participants were presented with pictures of objects that differed in their number (i.e., 1–4 objects per category). The first task was to judge whether each object would fit into a shoebox and whether they could carry the objects in their hands and arms. After 1 h, an unannounced cued-recall test followed by presenting participants with an auditory description of objects and asking them to decide whether the objects were shown before (“old”) or not (“new”), and to indicate the number of the old objects (i.e., recollection of details). During the test, participants closed their eyes, looked at a gray display, or at pictures of scenes, serving as visual distractors. The visual distraction, compared to the other two conditions, impaired the correct recollection of the number of previously presented objects, and looking at a gray display or at pictures of scenes impaired the identification of lures (i.e., false alarms). The identification of objects for which participants indicated an incorrect number was not affected by the visual distraction conditions. However, incidental rather than intentional learning was addressed in this study.

Similar findings were revealed by Parker and Dagnall (2020) who presented participants with pictures of objects to be studied and thereafter conducted a recognition test. Closing the eyes shortly before and after the visual presentation of the targets in this test increased correct recognition and reduced false alarms compared to keeping the eyes constantly open. In a more recent study, Parker et al. (2022) investigated the eye-closure effect and its interaction with working memory and processing capacity. Participants were first assigned to extreme (i.e., upper and lower quartile) digit span groups (Exp. 1) or extreme reading span groups (Exp. 2) and saw then two lists of word, each involving 25 words. After the presentation of each word list and a short distractor task, a verbal free recall test followed that was completed either with open or with closed eyes (manipulated within-subjects). In both experiments, a positive eye-closure effect on recall performance was revealed independently of participants' digit and reading span. However, the eye-closure effect emerged only for words participants had denoted as “remembered” (referring to the recollection of a word including contextual details from the study episode), but not for words indicated as “known” (lacking such contextual details) or for words indicated as “guessed”.

To sum up, the eye-closure effect seems to emerge not only for incidentally encoded information but also for intentionally studied items, even though the effect might not be as robust, depending on certain boundary conditions (Parker et al., 2022; see also Kyriakidou et al., 2014, for mixed results with children, and Craik, 2014, for a discussion).

Two accounts have been proposed to explain the beneficial effect of eye-closure on memory. In the domain-general account (e.g., Perfect et al., 2008; Wais & Gazzaley, 2014), it is assumed that closing the eyes prevents people from monitoring the environment, thereby reducing cognitive load. The released cognitive resources (e.g., concentration or the central executive) can be used for more elaborated retrieval. It has even been demonstrated that eye-closure can reduce the negative effect of auditory distraction on the recall of both visual and auditory details (Perfect et al., 2011), underlining the domain-general effect. The modality-specific account, in contrast, proposes that closing the eyes improves visual memory in particular (but not auditory memory) because cognitive resources for visual imagery and simulation are released that stimulate the retrieval of visual information only (e.g., Caruso & Gino, 2011; Wais et al., 2010).

In order to clarify whether the eye-closure effect is modality-specific or modality-general, Mastroberardino and Vredeveldt (2014) presented children short video clips showing a theft scene, and asked them thereafter for details. Children who closed their eyes during this inquiry or who looked at a blank screen provided more visual details than children who were exposed to visual distraction by keeping their eyes open. No such effect emerged for the recall of auditory details, suggesting a modality-specific effect. However, retrieval of visual information was also impaired when children were exposed to auditory distraction, which suggests a cross-modal interference. The results thus do not provide clear evidence for either a modality-specific or a modality-general effect of distraction. Vredeveldt et al. (2011), however, reported modality-specific effects of (visual or auditory) distraction on adults' recall of visual and auditory information in an eye-witness paradigm. Moreover, the benefits of eye-closure seem to be modality-general for less detailed episodic information, but modality-specific for more detailed episodic information (Vredeveldt et al., 2012). Interestingly, this study found no effect of auditory distraction (compared to a quiet context) on visual and auditory information retrieval. Thus, the modes of action underlying the eye-closure effect on memory are not clear yet and investigating them in natural settings might be problematic because visual and auditory information is usually not comparable in these settings, including different details (e.g., colors and shapes versus spoken words and sounds). In addition, there might be a confound because auditory information in real-life contexts often includes verbal information, whereas visual information often includes non-verbal information. Thus, drawing conclusions on whether closing the eyes benefits memory for visual information only on the basis of real-life events, is difficult. This is true in particular when one seeks to find our whether eye-closure can also benefit memory in intentional learning situations (e.g., at school). A better way to examine the modality-specificity would be to use verbal information only that is presented either visually or aurally. Keeping the information content constant can only be achieved in more controlled settings, such as during the learning of word lists or facts that are presented aurally or visually.

To our knowledge, there is only one study (Uchiyama & Mitsudo, 2020) in which participants were presented aurally or visually with lists of unrelated word. After a retention interval, they had to rehearse the words either with open or closed eyes. Then they completed a recognition test, including again aurally or visually presented words, but with keeping their eyes open. There was no effect of closing the eyes during rehearsal, neither after 5 min nor after 1 week. However, the eye-closure manipulation preceded the actual memory test and therefore might have yielded no effect. In addition, presentation modality and recognition modality were manipulated between-subjects. Potentially, the sample size ($N = 110$ in Exp. 1 and $N = 44$ in Exp. 2), and there with the power, was too small to detect an effect.

The present study investigated the eye-closure effect on recall of intentionally learned material, that is, word lists that were presented aurally or visually. If the effect of closing the eyes during recall—compared to keeping the eyes open—is modality-general, it should emerge for both presentation conditions; if it is modality-specific, it should emerge in the visual presentation condition only (or should be at least larger in this condition compared to the auditory presentation condition).

2 | METHOD

2.1 | Design

A 2 x 2 mixed design was realized, with eye-closure (open vs. closed) manipulated between subjects, and presentation modality of the information to be learned (i.e., visual versus aural) manipulated within subjects. Performance in a recall test (% of previously studied words that were recalled correctly[1]) served as dependent variable.

2.2 | Sample

The required sample size was calculated by means of G*Power (Faul et al., 2007) for two one-sided *t*-tests, assuming a power of $1\text{-}\beta = 0.80$, an alpha of 0.025, a mean effect size of $d = 0.5$, resulting in $N = 128$. To be included, participants had to be at least 18 years old, mastering German at a native level, having (corrected) normal visual and auditory abilities, and no diagnosed learning or memory disorders. The final sample ($N = 129$; 26 male, 103 female; mean age: $M = 25.0$ years, $SD = 9.6$ years) consisted mainly of psychology students of the local university (64%), 67% of the participants had a high-school diploma, and 24% a college or university degree. Participants were recruited via mailing lists of the university, social media, and other channels, and participated with informed consent. They could take part in a lottery to win 10 x 25 EUR; psychology students could also get course credit.

2.3 | Material

Two lists of words were generated (one presented visually, one aurally; counterbalanced), each including 18 simple, non-composite nouns referring to categories like food, animals, artifacts, toys, and so on (for complete lists, see Appendix). During the visual presentation, each noun of the list was presented via PowerPoint on the center of a single slide, printed in Arial, 100 pt in black. Each slide was presented for 3 s in an automatic mode. During the aural presentation, participants looked at a white, empty slide, and the prerecorded words of the list were played back with a time lag of 3 s. Before the aural presentation started, a white test slide was presented including the spoken sentence ("This is a test:"), requesting participants to adjust the volume of their technical device so that they could hear the following aural presentation.

2.4 | Procedure

The study was realized as synchronous online study using the video-conference system Zoom. It allowed the experimenter to personally instruct the participants, to control their compliance with the instructions in the learning and test phase (e.g., closing their eyes), and to record their test performance.

Participants were invited to join the study to a certain date via a Zoom link by using their computer, notebook or tablet for this study, no a smart phone. Before the study started, participants were asked to ensure that they were alone in a quiet room, that all other technical devices were muted, and that no other programs but Zoom in full-screen mode were opened. Thereafter, a slide including general information on the study (duration, procedure) was presented and read aloud by the experimenter. Then, participants received a link via the chat function of Zoom redirecting them to a form asking for their informed consent, and to an online questionnaire, asking for their demographic data. When participants met all inclusion criteria (see Section 2.2), they were asked to close the browser and to return to Zoom in full-screen mode to proceed with the main study.

When they had returned, the experimenter read the instructions, asking participants to study the word lists that will be presented attentively because they would have to recall these words later. Participants were also told that making notes or using other aids was not allowed, which was also monitored by the experimenter. Thereafter, the word lists were presented (one word list visually and the other one aurally, with order of the word lists and of presentation mode counterbalanced). The experimenter remained visible in a small window in one corner of the screen during the presentation of the word lists.

Each list was followed a short distractor task to prevent participants from memorizing the words (i.e., counting from 143 or 113, respectively, in steps of 3 backwards, lasting approximately 1 min). Thereafter, the test phase followed in which participants had to verbally recall the presented words without time limit. During recall, participants were instructed by the experimenter to either keep their eyes open ($n = 65$) and to look at the screen, where the experimenter was visible as full-screen keeping eye-contact, or to close their eyes and to keep them closed until no further word of the list came into their mind ($n = 64$). The experimenter observed the participants, ensuring that they complied with the instructions and reminded them to close their eyes in the few cases it was necessary, and recorded the responses. In the end, the experimenter debriefed

TABLE 1 Mean recall performance (in %) per condition.

	Presentation modality		
Eyes during recall	Visual	Aural	Total
Open	43.7 (15.2)	41.6 (17.5)	42.7 (13.8)
Closed	53.7 (17.8)	50.3 (16.7)	51.9 (15.0)
Total	48.6 (17.2)	45.9 (17.6)	

Note: *SD* in parentheses.

the participants concerning the hypotheses and thanked them for their participation.

3 | RESULTS

Because there were hardly any false recalls or between-list confusions (see also Parker et al., 2022, for similar findings), they were not considered further. A preliminary analysis confirmed the comparability of the two lists of words concerning memory performance, $F(1, 127) = 2.35$, $p = .13$, which was confirmed by a Bayesian analysis, using JASP 16.4 (JASP Team, 2022), yielding moderate evidence for a null effect ($BF_{10} = 0.2$, % error: 0.0). To test whether closing the eyes led to a better memory performance than keeping the eyes open, and whether the effect was larger when words had been presented visually than aurally, a 2 x 2 mixed ANOVA was computed with the between-subjects factor eye-closure and the within-subjects factor presentation modality (for descriptive statistics, see Table 1). As expected, closing the eyes resulted in a better recall performance than keeping the eyes open, $F(1, 127) = 13.47$, $p < .001$, $\eta_p^2 = 0.10$. The main effect of presentation modality was not significant, $F(1, 127) = 3.12$, $p = .08$, $\eta_p^2 = 0.02$, which was also true for the interaction of the two variables, $F(1, 127) = 0.19$, $p = .66$. These results were confirmed by a Bayesian ANOVA, revealing the strongest evidence for the model including eyes closure as only factor to explain the data ($BF_{10} = 74.1$, % error: 2.8). For presentation modality, there was anecdotal evidence in favor of a null effect ($BF_{10} = 0.6$, % error: 1.1), and for the interaction, there was moderate evidence in favor of a null effect ($BF_{10} = 0.2$, % error: 0.1).

4 | DISCUSSION

This experiment investigated whether the beneficial effect of closing one's eyes during recall also emerges for the recall of intentionally learned verbal information, and whether the effect is modality-specific, boosting visual memory only, or general, boosting also auditory memory. To test modality-specificity, the information to be learned was held constant across the visual and aural presentation, which is rather impossible when the eye-closure effect is examined with regard the retrieval of episodic, natural scenes. In addition, the material had a verbal format in both conditions (i.e., words, presented aurally or visually) to keep verbal information comparable.

Participants recalled studied words significantly better when they closed their eyes during recall than when they kept their eyes open. Importantly, the effect emerged for both visually and aurally presented words. The results imply that there is a beneficial eye-closure effect for recalling intentionally learned verbal information, which is modality-general, because the effect was revealed for auditive information, too. Thus, closing the eyes during retrieval might reduce cognitive load, saving modality-general cognitive resources that are otherwise used to process the environment (e.g., Perfect et al., 2008). These resources could, in turn, be deployed to more elaborative and therewith more successful retrieval. These findings have important implications going far beyond eye-witness memory because they might be transferred to more formal, intentional learning situations. The modality-general effect of eye-closure on the recall of intentionally learned content suggests that it might be helpful for learners to close their eyes when trying to retrieve information that they have acquired in school or university lessons or in their learning phases at home. As pointed out by the present study, the benefit might emerge for both auditory (e.g., explanations of the teacher) and visual material (e.g., information shown on a blackboard).

In order to assess these ideas, further research including more complex, coherent material, typically used in the context of intentional learning, is required. Given that the eye-closure effect emerged for the retrieval of incidentally learned complex episodic events (e.g., Vredeveldt et al., 2011), it is expected that it will emerge also for intentionally learned complex material. The finding that closing the eyes also promotes the solving of arithmetic tasks (Glenberg et al., 1998, Exp. 5) reinforces this assumption.

A limitation of the present study is that the word lists presented visually and aurally (see Appendix) largely included visualizable terms (e.g., tennis). Thus, even if there was only a main effect of eye-closure across both presentation modalities, but no interaction of eye-closure and presentation modality, it cannot fully be ruled out that participants also used visual imagery to retrieve the aurally presented words and that therefore eye-closure had also an effect for this kind of presentation. To test this, two lists of words could be used in future research, one including visualizable terms and another one including more abstract, not visualizable terms (e.g., freedom) that are presented visually or aurally. If there was a positive main effect of eye-closure for both lists in both presentation conditions, the assumption of a modality-general effect would be strengthened.

In addition, the experimenter, visible on the monitor in the open-eyes condition, could have served as social stressor, which might have additionally impaired participants' recall performance. Even if such situations are usual in formal educational contexts (e.g., oral exams), it seems promising to examine the eye-closure effect on intentionally learned material with another control condition, not including a social stimulus but a short movie (see Glenberg et al., 1998) or just the pure environment without the experimenter. It would also be interesting to see whether the effect emerges to the same degree when learning and recall take place in real interactions instead of in an online setting.

To sum up, closing the eyes promotes the retrieval of intentionally acquired verbal information, independently of whether it was presented visually or aurally. This effect could be a promising candidate to boost memory performance in real-world learning contexts.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data are available at OSF (https://osf.io/cj3qp/?view_only=0812b5474cf740bda59329d1e0f59079).

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ENDNOTES

[1] Intrusions were rare and therefore not considered.

REFERENCES

Caruso, E. M., & Gino, F. (2011). Blind ethics: Closing one's eyes polarizes moral judgments and discourages dishonest behavior. *Cognition*, *118*, 280–285. https://doi.org/10.1016/j.cognition.2010.11.008

Craik, F. I. (2014). Effects of distraction on memory and cognition: A commentary. *Frontiers in Psychology*, *5*, 841. https://doi.org/10.3389/fpsyg.2014.00841

Einstein, G. O., Earles, J. L., & Collins, H. M. (2002). Gaze aversion: Spared inhibition for visual distraction in older adults. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *57*, P65–P73. https://doi.org/10.1093/geronb/57.1.P65

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*, 175–191. https://doi.org/10.3758/BF03193146

Glenberg, A. M., Schroeder, J. L., & Robertson, D. A. (1998). Averting the gaze disengages the environment and facilitates remembering. *Memory & Cognition*, *26*, 651–658. https://doi.org/10.3758/BF03211385

JASP Team. (2022). JASP (Version 0.16.4) [Computer software].

Kyriakidou, M., Blades, M., & Carroll, D. (2014). Inconsistent findings for the eyes closed effect in children: The implications for interviewing child witnesses. *Frontiers in Psychology*, *5*, 448. https://doi.org/10.3389/fpsyg.2014.00448

Mastroberardino, S., & Vredeveldt, A. (2014). Eye-closure increases children's memory accuracy for visual material. *Frontiers in Psychology*, *5*, 241. https://doi.org/10.3389/fpsyg.2014.00241

Parker, A., & Dagnall, N. (2020). Eye-closure and the retrieval of item-specific information in, eye-closure & the retrieval of item-specific information in recognition memory recognition memory. *Consciousness and Cognition*, *77*, 102858. https://doi.org/10.1016/j.concog.2019.102858

Parker, A., Parkin, A., & Dagnall, N. (2022). Eye-closure effects and the influence of short-term storage and processing capacity on episodic memory. *Memory*, *30*, 1018–1030. https://doi.org/10.1080/09658211.2022.2072894

Perfect, T. J., Andrade, J., & Eagan, I. (2011). Eye closure reduces the cross-modal memory impairment caused by auditory distraction. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *37*, 1008–1013. https://doi.org/10.1037/a0022930

Perfect, T. J., Andrade, J., & Syrett, L. (2012). Environmental visual distraction during retrieval affects the quality, not the quantity, of eyewitness recall. *Applied Cognitive Psychology*, *26*, 296–300. https://doi.org/10.1002/acp.1823

Perfect, T. J., Wagstaff, G. F., Moore, D., Andrews, B., Cleveland, V., Newcombe, S., Brisbane, K.-A., & Brown, L. (2008). How can we help witnesses to remember more? It's an (eyes) open and shut case. *Law and Human Behavior*, *32*, 314–324. https://doi.org/10.1007/s10979-007-9109-5

Radel, R., & Fournier, M. (2017). The influence of external stimulation in missing knowledge retrieval. *Memory*, *25*, 1217–1224. https://doi.org/10.1080/09658211.2017.1282519

Rae, P. J., & Perfect, T. J. (2014). Visual distraction during word-list retrieval does not consistently disrupt memory. *Frontiers in Psychology*, *5*, 362. https://doi.org/10.3389/fpsyg.2014.00362

Uchiyama, T., & Mitsudo, H. (2020). No benefit of eye-closure rehearsal in a unimodal recognition memory test for word items. *Japanese Psychological Research*, *62*, 161–171. https://doi.org/10.1111/jpr.12248

Vredeveldt, A., Baddeley, A. D., & Hitch, G. J. (2012). The effects of eye-closure and "ear-closure" on recall of visual and auditory aspects of a criminal event. *Europe's Journal of Psychology*, *8*, 284–299. https://doi.org/10.5964/ejop.v8i2.472

Vredeveldt, A., Hitch, G. J., & Baddeley, A. D. (2011). Eyeclosure helps memory by reducing cognitive load and enhancing visualisation. *Memory & Cognition*, *39*, 1253–1263. https://doi.org/10.3758/s13421-011-0098-8

Vredeveldt, A., & Penrod, S. D. (2013). Eye-closure improves memory for a witnessed event under naturalistic conditions. *Psychology, Crime, & Law*, *19*, 893–905. https://doi.org/10.1080/1068316X.2012.700313

Wagstaff, G. F., Brunas-Wagstaff, J., Cole, J., Knapton, L., Winterbottom, J., Crean, V., & Wheatcroft, J. (2004). Facilitating memory with hypnosis, focused meditation, and eye closure. *The International Journal of Clinical and Experimental Hypnosis*, *52*, 434–455. https://doi.org/10.1080/00207140490889062

Wais, P. E., & Gazzaley, A. (2014). Distractibility during retrieval of long-term memory: Domain-general interference, neural networks and increased susceptibility in normal aging. *Frontiers in Psychology*, *5*, 280. https://doi.org/10.3389/fpsyg.2014.00280

Wais, P. E., Rubens, M. T., Boccanfuso, J., & Gazzaley, A. (2010). Neural mechanisms underlying the impact of visual distraction on retrieval of long-term memory. *Journal of Neuroscience*, *30*, 8541–8550. https://doi.org/10.1523/JNEUROSCI.1478-10.2010

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APPENDIX

Word lists presented visually and aurally.

List 1	List 2
juice	water
penguin	ant
beaver	crocodile
hammer	street
jacket	telephone
swing	trampoline
tennis	chess
tree	grass
moss	rose
doctor	teacher
heat	artist
rain	autumn
holidays	thunderstorm
relaxation	hiking
interest	beach
patience	ambition
birth	politeness
relocation	separation

Note: The words were presented in German, yielding a comparable mean number of syllables in each list (i.e., 2.1 vs. 2.2).