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RESEARCH REPORT

Eye Closure Reduces the Cross-Modal Memory Impairment Caused by Auditory Distraction

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Eyewitnesses instructed to close their eyes during retrieval recall more correct and fewer incorrect visual and auditory details. This study tested whether eye closure causes these effects through a reduction in environmental distraction. Sixty participants watched a staged event before verbally answering questions about it in the presence of auditory distraction or in a quiet control condition. Participants were instructed to close or not close their eyes during recall. Auditory distraction did not affect correct recall, but it increased erroneous recall of visual and auditory details. Instructed eye closure reduced this effect equally for both modalities. The findings support the view that eye closure removes the general resource load of monitoring the environment rather than reducing competition for modality-specific resources.

Keywords: eye closure, distraction, modality, memory

When trying hard to recall something, people often spontaneously avert their gaze from the person they are talking to and sometimes close their eyes altogether (Doherty-Sneddon, 2004; Doherty-Sneddon, & Phelps, 2005). Research has shown that this behavior, which develops during childhood (Doherty-Sneddon, Bruce, Bonner, Longbotham, & Doyle, 2002), is strategic and can be beneficial to memory. Glenberg, Schroeder, and Robertson (1998) showed that the spontaneous use of gaze aversion and eye closure increases with the difficulty of the retrieval task and that those instructed to close their eyes recalled more those instructed to keep their eyes open.

Glenberg's (1997) embodied cognition account of memory explains why people only sometimes close their eyes or look away when recalling the past. This argues that cognition serves action, which is embedded within the current environment, and so cognition is normally constrained by, or clamped to, the environment in which we operate (see also Glenberg et al., 1998). Recollection of past events requires us to disengage from the current environment and is helped by removal of sensory information. But this reduces our ability to monitor the environment for threats and, therefore, whereas it may be possible for us to improve memory by closing our eyes, in evolutionary terms this is a risky strategy. Even the absent-minded professor, lost in thought, needs to avoid walking in front of oncoming traffic. Consequently, we do not engage in eye closure when the cognitive demands of retrieval are low enough for us to simultaneously monitor the environment without cost. Nor do we close our eyes if the perceived benefits of recall do not warrant the potential costs, either because good recall is not important or because the environment is too threatening.

Glenberg's (1997) embodied cognition account essentially recasts memory retrieval and environmental monitoring as competing tasks to be carried out either simultaneously as dual-tasks, or sequentially as tasks to be switched between. In this light, eye closure improves memory by increasing attention given to the retrieval task rather than by reducing modality-specific interference from environmental monitoring.

Instructing people to close their eyes should lead to better memory not only compared with an eyes-open condition, as demonstrated by Glenberg et al. (1998), but also compared with spontaneous utilization of the strategy. This idea was tested in a setting in which good recall is paramount—the eyewitness interview. Perfect et al. (2008) contrasted an instructed eye-closure condition with a no-instruction control condition in which participants could spontaneously engage in gaze aversion and eye closure (see also Wagstaff et al., 2004). This design was adopted to determine the applied utility of instructed eye closure. If recall is already optimized by spontaneous use, then instructing people to close their eyes would be of no use. Conversely, if it does improve memory then it is a simple instruction to add to the interviewer's tool kit.

In line with the predictions from Glenberg's (1997) embodied cognition account, instructed eye closure led to more correct details and fewer incorrect details being recalled compared with the no-instruction control. This pattern was found for videotaped events and for live interactions, tested with either specific questions or by free narrative, and equally for auditory and visual details of the events. On this basis, Perfect et al. (2008) recommended the usage of instructed eye closure as a memory aid. This conclusion is consistent with work by Phelps, Doherty-Sneddon, and Warnock (2006) in a different domain, with a different group. They found that instructing 5-year-olds to avert their gaze while thinking improved their problem-solving abilities. Thus, it appears

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that simple instructions to reduce access to the visual environment, through eye closure or gaze aversion, can have positive effects on cognition in both young children and adults.

Perfect et al. (2008) argued that the beneficial effects of eye closure were best understood as a general enhancement to memory functioning, rather than an increase in motivation, a change in response bias, or a reduction in visual interference. They ruled out the former two points because eye closure simultaneously increased hits and reduced errors, a pattern indicative of increased memory sensitivity rather than a change in response bias. Perfect et al. argued against a specifically visual account of the effects of eye closure for a different reason: Memory was enhanced equally (in four of five experiments) for visual and auditory details of previous events. They argued that if the benefits of eye closure were due to a reduction in interference, then memory for visual details should have been selectively improved. The equivalent improvement in recall for auditory details suggests that eye closure increases ability to concentrate on the retrieval task rather than reducing competition between ongoing visual processing of the environment and visual memory.

Collectively to date, studies of eye closure and gaze aversion have failed to distinguish between general and modality-specific effects on memory. For instance, Glenberg et al. (1998, Experiment 5) showed that recall was better with eye closure than with fixation of a simple static image, which in turn was better than fixation on a complex moving image (see also Perfect, Andrade, & Syrett, 2011). Doherty-Sneddon, Bonner, and Bruce (2001) showed that children performed better on visuo–spatial memory tasks when they closed their eyes or averted their gaze, compared with a condition in which they monitored the experimenter's face. More recently, Markson and Paterson (2009) showed that the ability to mentally travel though a 2D or 3D matrix was enhanced by eye closure relative to maintaining eye contact with the experimenter although, it is interesting to note, eye closure did not lead to superior matrix performance compared with fixation on static or moving images. Although each of these studies is consistent with a dual-task account, each of them is also consistent with a modality-specific-processing account, such as Baddeley's (1986) working-memory model. Indeed, it is clear that several of these studies are motivated by a modality-specific approach, because they interpret the effects of gaze aversion in modality-specific terms and do not explore cross-modal effects.

In the present study, we contrasted modality-specific and general dual-task accounts of eye closure by requiring participants to recall event details in either quiet or noisy conditions. Combining eye closure with a manipulation of environmental noise provides a compelling test of modality-specific and general-resource accounts because eye closure has no physical impact on the perception of noise. Thus, from a modality-specific view it should have no effect. Conversely, if eye closure is a technique for directing attention internally, it should reduce environmental distraction, whatever its source.

Negative effects of background noise on long-term memory have been shown from chronic exposure (e.g., Beaman, 2005) and acute exposure (e.g., Banbury & Berry, 1998; Perham, Banbury, & Jones, 2007), and standard eyewitness interviewer guidelines (Fisher & Geiselman, 1992) stress the importance of minimizing environmental distraction during interviews. Following Perfect et al. (2008), participants initially witnessed a live event in standard conditions and were later asked questions about visual and auditory details from the event, either with their eyes closed or under no specific instructions about eye closure. Half of the participants were tested in a quiet control condition, and half were tested under conditions of auditory distraction in which they heard bursts of white noise during the retrieval phase.

The auditory distraction provides a manipulation of the external environment that cannot physically be screened out by eye closure. Nonetheless, if eye closure has a general benefit of enabling greater concentration on internal sources of information, it should reduce the impact of external noise. Thus, the theoretical expectations derived from Glenberg's (1997) dual-task account were that (a) noise will impair recall, because it triggers more environmental monitoring; (b) memory impairment will be equivalent for both visual and auditory details of the event; and (c) eye closure will improve memory for both visual and auditory details equally because it shifts attention internally. Predicting the effects of eye closure on the effects of distraction was less straightforward because, a priori, we did not know how demanding the combination of recall with monitoring the test environment would be. Thus, although Glenberg's theory would clearly predict that (d) eye closure will help more in noise than in quiet, it is unclear whether it would predict an eye-closure effect in the quiet condition. This follows because participants may be able to combine the recall task with environmental monitoring without cost.

In contrast, a modality-specific hypothesis predicts that (a) auditory distraction will impair recall of auditory details more than visual details; (b) eye closure is likely to improve memory for visual details more than auditory details; and (c) eye closure will have relatively little effect on the negative impact of noise, because eye closure and auditory distraction operate in separate modalities.

Method

Participants

Sixty volunteers (11 male) participated either voluntarily or for course credit. All had normal or corrected to normal vision and hearing. The mean age of participants was 24.7 years (range = 18–59 years, SD = 9.87 years). No further demographic details were collected.

Procedure

Participants were initially presented with a standard script involving 20 fictitious statements read alternately by an experimenter and a confederate, who used props and actions associated with the statements. This staged event took place in an experimental room containing a number of props. Example statements included the following: "I support Manchester United and regularly go and watch them play," spoken while the confederate held up a Manchester United football shirt showing the number 7; and "I was born in Glasgow and loved visiting Victoria Park as a child," which involved no props. Participants were told that although the statements were spoken alternately by the two actors, half of the statements spoken by each actor applied to each person. The participants judged which person each statement applied to, thereby ensuring that they attended to the relevant actions, objects, and spoken details. The two actors wore the same clothes, carried the same props, and followed the same script for all experimental sessions.

Once the script was complete, the experimenter took the participant into a separate testing room and asked a series of 28 closed questions about the visual and auditory details of the event and the environment in which it took place. Example questions included the following: "What was the number shown on the Manchester United shirt?" and "There was a park mentioned that the actor used to go to. What was its name?" Visual questions targeted specific, unambiguous details that were seen, and auditory questions targeted specific, unambiguous details mentioned verbally. The questions were asked once, with no further prompts.

Participants were tested in either quiet or noise, providing their responses verbally at their own pace. Participants were able to indicate if they did not know the answer to a particular question. Control participants were tested in quiet conditions, whereas those in the auditory distraction condition wore headphones that played bursts of white noise lasting between 250 ms and 1,000 ms, ranging in frequency from 130 Hz to 2,093 Hz, separated by silent gaps ranging between 250 ms and 1,000 ms. For each question, the experimenter read the question to the participant in quiet conditions and immediately began the background noise by means of a mouse click on the computer. This remained on until the participant gave his or her answer or indicated that he or she did not know, at which point the auditory distraction was terminated. This process was repeated for all questions. The volume of the white noise was set at a comfortable level for normal hearing levels and was held constant across all participants.

Orthogonal to the manipulation of noise, participants were tested either in an instructed eye-closure condition or in a no-instruction control condition. Those in the no-instruction control condition were given no specific instructions about closing their eyes during retrieval, and no attempt was made to monitor or prevent spontaneous eye closure. Those in the instructed eye-closure condition were asked to close their eyes throughout the test phase and were reminded between questions if necessary.

Results

Although participants were asked 28 questions, there were not equal numbers of visual and verbal probes, and they were not matched for overall difficulty level. Consequently, in order to compare the effects of auditory distraction and eye closure across the effects of modality, we identified a subset of 20 questions (10 auditory, 10 visual) that showed no modality effects on correct recall, erroneous recall, or no-response rates in the no-eye-closure, no-noise control condition, $t(14) < 1$, $p > .640$, in all cases. Subsequent analyses focus on performance on these questions, with an alpha level of .05 used throughout.[1]

For correct recall, we conducted a Distraction (control vs. noise) × Eye Closure (control vs. instructed eye closure) × Modality (visual vs. auditory details) mixed analysis of variance, with repeated measures on the last factor. The means are illustrated in the top panel of Figure 1. There were no main effects of modality, $F(1, 56) = 1.16$, $MSE = 2.87$, $p = .286$, $\eta^2 = .02$; distraction, $F < 1$; or eye closure, $F < 1$. No higher order interactions were significant, $F < 1$ in all cases. On average, participants correctly recalled 4.12 ($SD = 1.45$) visual details and 4.45 ($SD = 2.02$) auditory details.

A different picture emerged for errors, as can be seen in the bottom panel of Figure 1. Overall, there was a main effect of modality with more incorrect answers to visual questions ($M = 2.78$, $SD = 1.93$) than to auditory questions ($M = 2.23$, $SD = 2.26$), $F(1, 56) = 6.34$, $MSE = 1.44$, $p = .015$, $\eta^2 = .10$. More errors were reported under conditions of noise ($M = 7.10$, $SD = 3.93$) than under quiet control ($M = 2.93$, $SD = 2.41$), $F(1, 56) = 29.14$, $MSE = 4.47$, $p < .001$, $\eta^2 = .34$, and more errors were reported for the control condition ($M = 6.03$, $SD = .4.89$) than for the instructed eye-closure condition ($M = 4.00$, $SD = 2.07$), $F(1, 56) = 6.94$, $MSE = 4.47$, $p = .011$, $\eta^2 = .11$.

The main effects were qualified by a significant two-way interaction between eye closure and distraction, $F(1, 56) = 6.06$, $MSE = 4.47$, $p = .017$, $\eta^2 = .10$. This was explored with simple main effects analysis. For the quiet control condition, there was no reliable effect of eye closure on number of errors, $F < 1$, but the noise condition showed a reliable eye-closure effect, $F(1, 56) = 12.99$, $MSE = 2.23$, $p = .001$, $\eta^2 = .19$. The two-way interactions between modality and eye closure and between modality and distraction, and the three-way interaction between modality, eye closure, and distraction were all nonsignificant, $F(1, 56) < 2.1$, $p > .110$, in all cases.

One potential criticism of the analysis of error rates is that the failure to find an interaction between distraction and eye closure occurred because error rates are close to the floor in the quiet conditions, which may have precluded the detection of an eye-closure effect in that condition. To test this idea we dropped participants who made two or fewer errors of any kind and re-ran the analysis. This criterion resulted in two participants being dropped from the quiet conditions (one from the instructed eye-closure condition, one from the no-instruction control) and 13 being dropped from the noise conditions (six from the instructed eye-closure condition, seven from the no-instruction control condition). The resulting error rates for this restricted sample are shown in Figure 2.

Although error rates in the quiet conditions were increased by this procedure, there is no evidence of an eye-closure effect emerging in the quiet control condition. The results of the analysis on the full sample were entirely replicated in the restricted sample. The main effects of modality, $F(1, 41) = 4.74$, $MSE = 1.79$, $p = .035$, $\eta^2 = .10$; noise, $F(1, 41) = 12.55$, $MSE = 3.96$, $p = .001$, $\eta^2 = .23$; and eye closure, $F(1, 41) = 8.08$, $MSE = 3.96$, $p = .007$, $\eta^2 = .17$, remained significant. As before, there was a significant interaction between eye closure and distraction, $F(1, 41) = 6.06$, $MSE = 4.43$, $p = .041$, $\eta^2 = .10$. Also as previously, the two-way interactions between modality and eye closure and between modality and distraction, and the three-way interaction between modality, eye closure, and distraction were all nonsignificant, $F(1, 41) < 1.90$, $p > .175$, in all cases.

Discussion

These findings support a general resource account of eye closure. Performance, as measured by error rate, was superior in the eye-closure condition compared with the no-instruction control condition, and this effect was equal for both visual and auditory

[1] Retaining all questions and analyzing proportional indices of performance gave main effects of modality but did not alter the pattern of findings with respect to distraction or eye closure. Full details are available from Timothy J. Perfect on request.

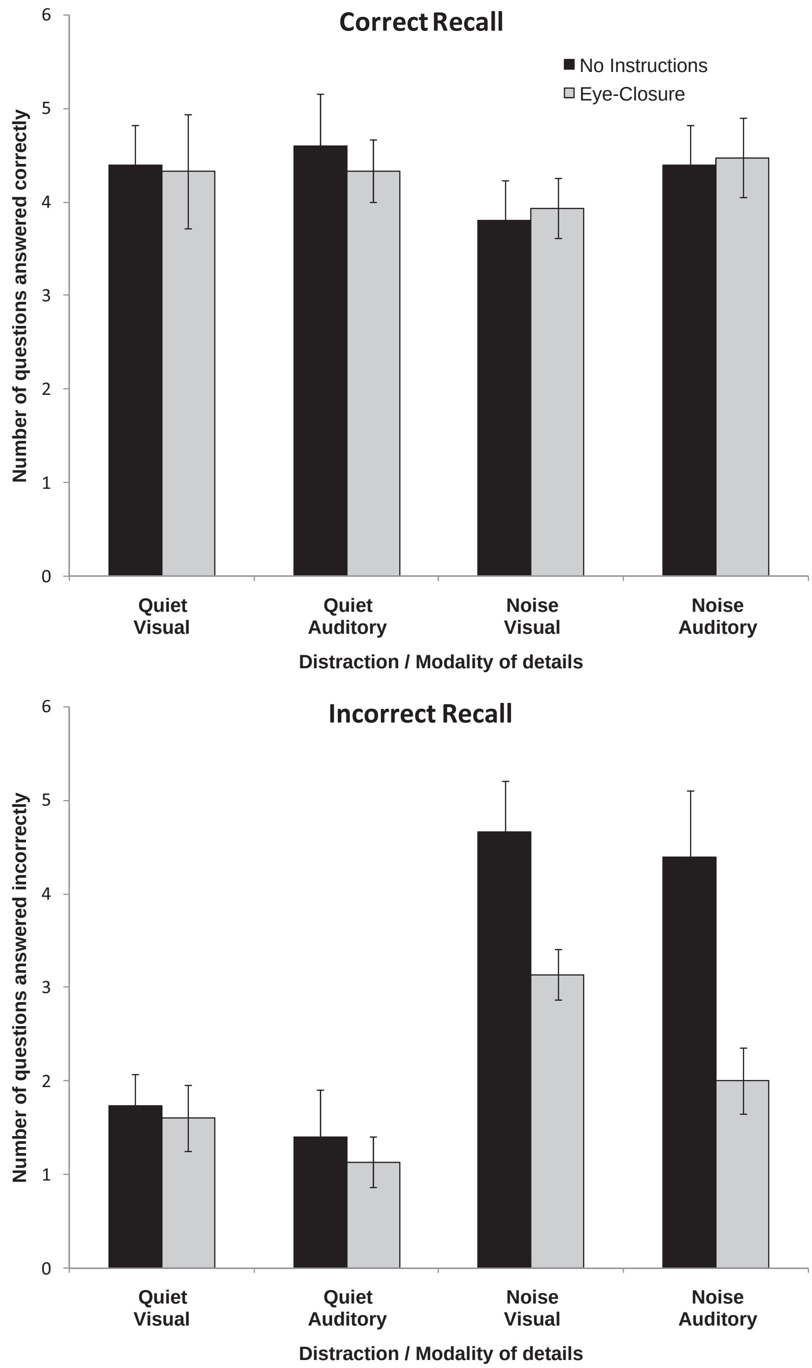

Figure 1. The number of visual and auditory questions that were answered correctly (top panel) and incorrectly (bottom panel) under conditions of auditory distraction or control, either with instructions to close eyes during recall or no-instruction control. Error bars represent standard errors of the mean.

details, replicating previous findings (Perfect et al., 2008). An important finding is that eye closure reduced the negative effect of auditory noise on erroneous recall and did so equally for auditory and visual details. There was no support for a modality-specific account: no evidence for modality specific effects of eye closure, or noise, and no evidence of a higher order interaction between the two.

Inspection of Figure 1 suggests that the noisy conditions may have produced a larger effect of eye closure for auditory questions than for visual questions, which might have been significant with a more powerful design. However, even if this interaction were reliable, it would not constitute evidence of a modality-specific effect, but rather a cross-modal effect, which is not predicted by

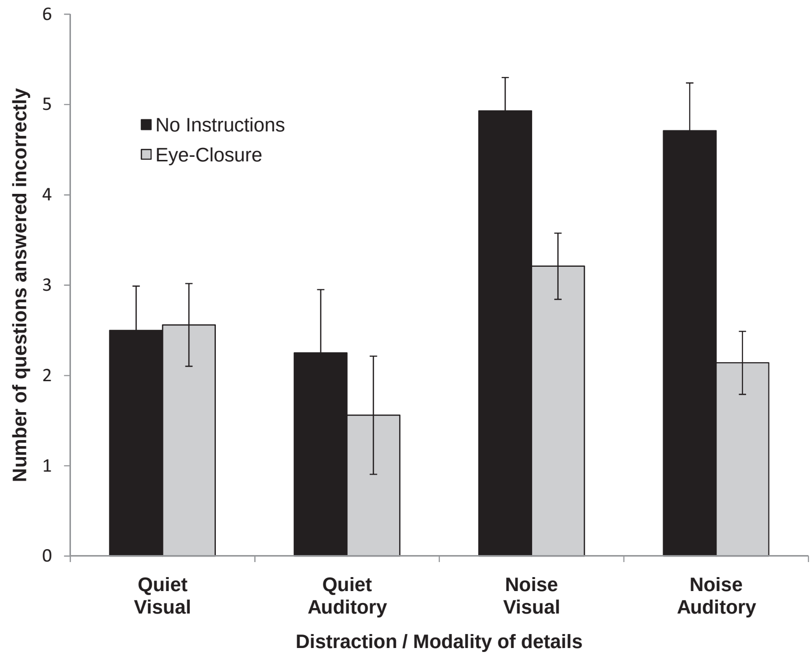

Figure 2. The number of visual and auditory questions that were answered incorrectly under conditions of auditory distraction or control, either with instructions to close eyes during recall or no-instruction control, in a subset of participants who made three or more errors. Error bars represent standard errors of the mean.

Glenberg's (1997) theory or modality-specific accounts. Compared with quiet conditions, auditory noise does not differentially increase errors to auditory questions. Compared with no instructions, eye closure does not differentially reduce errors to visual questions. Thus, neither potential modality-specific effect is present in our data. Instead, the trend is toward eye closure appearing to differentially benefit auditory questions, which would constitute a cross-modal benefit. Thus, we do not believe that a lack of power undermines our ability to detect a modality-specific interference effect in our data.

Although the lower rate of errors under eye-closure conditions replicated previous findings, the absence of an effect on correct recall did not do so. Participants generated as many correct answers whether in quiet or noise, with eyes closed or open. Given the prior demonstrations of impairment on correct recall with noise (Banbury & Berry, 1998) and improvement in correct recall with eye closure (Glenberg et al., 1998; Perfect et al., 2008; Wagstaff et al., 2004), this pattern was unexpected. However, we do note that a similar pattern was reported by Doherty-Sneddon and McAuley (2000) in a study comparing children's performance in face-to-face with video-mediated interviewing conditions. Although the two forms of media resulted in the same amount of correct information being recalled, video interviews resulted in fewer errors being reported.

Behaviorally, it appears that participants' ability to access details of the event were unaffected by the presence of environmental noise. However, noise reduced the participants' ability to monitor and control the accuracy of their memory reports. Recall that participants were free not to provide an answer to any question, and so errors were not inevitable in the absence of correct recall. Koriat and Goldsmith (1996) argued that retrieval involves both a generation phase, in which a candidate answer is generated to a cue, and a metacognitive phase, in which that answer is evaluated prior to being reported or withheld. Thus, the current data suggest that noise increases willingness to report an erroneous answer that would otherwise have been withheld, whereas eye closure reduces this propensity.

Further research is necessary to delineate the mechanisms behind these effects, but the differential effects of noise and eye closure on correct and incorrect response are informative. If the effects of noise and eye closure were due to willingness to respond, one might have expected to see similar effects on correct and incorrect responses, with noise increasing willingness to respond and eye closure decreasing it. However the absence of this effect on rates of correct answers rules out a simple response bias account. With respect to the eye-closure effect, the results of Perfect et al. (2008) also contradict a response bias account, because they showed an increase in correct responses coupled with a decrease in incorrect responses, contrary to any account based on willingness to respond.

The absence of an eye-closure effect in the quiet retrieval conditions was unexpected but not inconsistent with Glenberg's (1997; Glenberg et al., 1998) theoretical account, because it is possible that the quiet conditions did not provide sufficient sensory load to affect retrieval accuracy, either because the memory questions were too easy or because the visual environment was insufficiently distracting. In contrast, it is possible that the studies reported previously that did show an effect did combine sufficiently difficult questions with sufficiently distracting environment, even though testing occurred ostensibly in quiet conditions. However, this argument is unsatisfactory because it is circular: There is no independent measure of either retrieval task difficulty or environmental distraction, and this must be a priority for future research. Currently it is not possible to estimate these factors from published descriptions of previous studies. It is likely that environmental monitoring will be related to many factors, including the complexity and predictability of the physical environment, the appearance and behavior of the experimenter, and the internal state of the participants. Even in physically identical environments, it is possible that two experimenters could be differentially distracting, or experimental instructions could vary subtly in how much they encourage participants to engage in environmental monitoring.

Although the dual-task hypothesis can explain our data pattern with supplementary assumptions about the difficulty of the questions and the degree of environmental monitoring, modality-specific accounts fail entirely. Contrary to a broad range of research stemming from the working-memory tradition, there was no evidence that auditory distraction had more of an impact on auditory than visual memory and no evidence that eye closure reduced visual interference in particular.

The current findings mesh with other recent work on the role of brief eye closure (blinking) in the trade-off between external and internal processing demands. Recarte, Perez, Conchillo, and Nunes (2008) found that blink rate increased with the mental demands of cognitive tasks but decreased with the visual demands of the tasks. Smilek, Carriere, and Cheyne (2010) used a probe methodology to detect periods of mind wandering during an extended reading task. For 5-s intervals prior to an episode of mind wandering, participants showed elevated rates of eye blinking. Thus, increased blink rate is associated with more cognitive effort and with periods of off-task behavior, consistent with our claim that eye closure, either through spontaneous blinking or following instruction, frees cognitive resources to be directed toward internal processing, thereby reducing the impact of the environment on cognition.

An important point to stress is that our manipulation of sensory control (eye closure) had no physical impact on the processing of sensory distraction (noise). Indeed, it could be argued that eye closure might increase attention toward the auditory modality. Nevertheless, eye closure reduced the negative effects of auditory noise on cognition, consistent with the claim that eye closure helps shift attention toward internal processing. It is also worth stressing that this eye-closure benefit was apparent even though our control-group participants were free to close their eyes if they wished. Clearly, the presence of the eye-closure effect in the present data indicates that spontaneous eye closure does not optimize memory performance.

Our procedure was designed to model a scenario in which an eyewitness to an event was interviewed in a noisy and distracting environment (see Perfect et al., 2008). Drawing applied conclusions is therefore straightforward. The results support Fisher and Geiselman's (1992) warnings about the negative impacts of environmental distraction. An obvious strategy for the interviewer is to minimize environmental distraction, but this may not always be possible because uncontrollable noise is common in many environments. The current data suggest that when noise is a distraction to recall, the interviewer should instruct the witness to close his or her eyes.

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Correction to Perfect et al. (2011)

In the article "Eye Closure Reduces the Cross-Modal Memory Impairment Caused by Auditory Distraction," by Timothy J. Perfect, Jackie Andrade, and Irene Eagan (*Journal of Experimental Psychology: Learning, Memory, and Cognition*, 2011, Vol. 37, No. 4, pp. 1008–1013), there is an error reported in the Results section on p. 1010. The sentence appears in the fifth paragraph, and the correct sentence is as follows: "This criterion resulted in two participants being dropped from the noise conditions (one from the instructed eye-closure condition, one from the no-instruction control) and 13 being dropped from the quiet conditions (six from the instructed eye-closure condition, seven from the no-instruction control)."

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