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## *Brief Communication*

### **EYEBLINK FREQUENCY, REHEARSAL ACTIVITY, AND SYMPATHETIC AROUSAL**

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Previous studies have suggested that the endogenous eyeblink rate (EBR) is inhibited by visual attention and increased by sympathetic arousal as well as by verbalization. As for the latter variable, it has been suggested that verbalization increases EBR by spreading of electric activity in efferent adjacent vocal and eye-motor pathways. The present study was designed in order to examine whether subvocal ("rehearsal") activity also elicits an increase in EBR. Subjects saw slides depicting either verbal or pictorial information. Subsequently, they were asked to rehearse this information silently. Spontaneous electrodermal fluctuations (SF<sub>e</sub>) were monitored throughout the experiment. The results clearly show that slide presentation ("information uptake") is accompanied by decrease in EBR, while silent rehearsal of information is accompanied by increase in EBR. Furthermore, this increase in EBR was found to correlate positively with SF<sub>e</sub>. Thus, results confirm the modulatory influences of visual attention, arousal and (sub)vocal activity on EBR. Furthermore, they suggest an explanation for the relationship that has been found between depressive mood and increased EBR. That is, heightened EBR in depression may reflect subvocal activity ("rumination").

*Keywords: eyeblink rates, subvocal activity, arousal, depression*

The term "endogenous" eyeblinks refers to those blinks which occur spontaneously in humans and animals. It is unknown which factors are precisely responsible for these nonreflexive eyeblinks. However, previous research has identified a number of psychological processes which are associated with changes in endogenous eyeblink rates (EBR). For example, attentional processes as well as cognitive activities like reading and arithmetic induce a decrease in eyeblink rate (Holland & Tarlow, 1972; 1975; Stern, Walrath & Goldstein, 1984). On the other hand, Schuri and von Cramon (1980; 1981) demonstrated that verbalization is accompanied by an increase in EBR. In their studies, subjects had to perform a mental arithmetic task; only when verbalization of results was required, did significant blink rates occur. In addition, these authors found a larger increase in EBR when a task required more complex articulatory processing. In line with Meyer's theory on the interaction of simultaneous responses (Meyer, 1953), they speculated that "motoric overflow" in the neocortex (or even in subcortical motor relay nuclei) might offer an explanation for the close relationship between speech motor and lid motor activity. The representation of the eyelid and eyeball in the primary motor cortex is bordered by that of the tongue, larynx, and face. Thus, by way of "spreading" of electrical activity from cortical areas representing vocal musculature to areas representing eye(lid) movements, vocalization may induce (or stimulate) endogenous eyeblinks.

Although the "motoric overflow" hypothesis makes sense, the results presented by these researchers are somewhat ambiguous at this point. It should be noted that

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vocalization is not an "all or none"-phenomenon. Electromyographic research has shown that subvocal speech is accompanied with increased activity of muscles involved in verbalization (McGuigan, 1979). Consequently when the increase of EBR is really mediated by "motoric overflow" subvocal speech should also raise the eyeblink frequency. Meanwhile, this implication is not confirmed by the study of Schuri and von Cramon (1981). That is to say, subjects in the control condition of this study (arithmetic task without verbalization of results) did not show an increase in EBR. It could be argued that this failure to find a subvocalization-linked increase in EBR refutes the "motoric overflow" hypothesis. On the other hand, it may well be that the control condition was not successful in eliciting subvocal activity in the control subjects. After all, the subjects were not required to carry out a postexperimental task in order to examine how well they processed information during the "silent" arithmetic task.

The present study was undertaken in order to evaluate further the empirical creditability of the "motoric overflow"-hypothesis. More specifically it aimed at the relationship between subvocal speech and EBR. A second point that was addressed in this study concerned the relationship between eyeblink frequency and "arousal" as indexed by skin conductance. There are some indirect observations which suggest a positive relationship between autonomic arousal and EBR (Stern, Walrath & Goldstein, 1984).

## METHOD

### *Subjects*

Twenty-four healthy volunteers, mainly students, were paid for their participation in this experiment. Mean age was 23 years (s.d. = 2 years). There were 12 males and 12 females.

### *Assessment and Apparatus*

Eye Blinks (E.B.) were recorded by means of a vertical electrooculogram (EOG). For this purpose Beckman Ag-AgCl miniature surface electrodes were attached to the supra- and infraorbital ridges of both eye-sockets. The electrodes were connected with a Beckman Voltage Coupler (type 9878). Skin conductance (SC) was used as an index of "arousal." Beckman Ag-AgCl electrodes ( $\phi$  8 mm) were placed on the ventral part of the distal phalanges of the third and fourth fingers of the nondominant hand. The electrodes were connected to a Beckman Skin Conductance Coupler (type 9844). Depth of breath and respiration rate were used as control variables for the SC. They were recorded from a Beckman Respiration Belt fastened around the subject's chest and connected to a Beckman Voltage/Pulse/Pressure Coupler.

Physiological signals were fed to a Beckman R 611 polygraph. A PDP Minc II microcomputer controlled response registration and analyses.

Visual Analogue Scales (VAS) were used for determining the number of thoughts the subjects had during the pertinent parts of the experiment (scales ranged from 0 mm = "I have not had any thoughts at all during the last three minutes" to 100 mm = "I have been thinking all the time during the last three minutes").

### *Procedure*

After the subjects had been introduced to the laboratory, the procedure of the

experiment was explained. Next, electrodes and respiration belt were attached. During the experiment, subjects were seated in a comfortable armchair, placed in a sound-attenuated chamber. The apparatus was located in an adjacent room.

The experiment consisted of two comparable phases of 9 minutes each. The first phase (pretest) was used for obtaining baseline measures. In the second phase "rehearsal-activity" was elicited by means of a task. Subjects were instructed to relax during the first phase without closing their eyes. During this phase of the experiment, the lights were dimmed for three minutes (A; baseline I), lit (B), and dimmed again (C) successively. After this phase had been terminated, subjects were asked to complete a VAS concerning the frequency of "thoughts" during C.

During the second phase, a slide was shown (B') after three "dark" minutes (A'; baseline II), for the rest both parts were identical. During B' half the subjects were confronted with a slide depicting a compressed text. The other subjects saw during B' a slide depicting a compilation of familiar faces (mostly actors) with salient attributes like pipes, cigars, moustaches, and spectacles. Both slides had a high information-density. Subjects were instructed to process the information depicted by the slides as well as possible and to try to keep the information in mind during the last three "dark" minutes (C') ("rehearsal"). They were told that their memory concerning details of the slide would be tested afterwards. After termination of the second phase, another VAS concerning frequency of "thoughts" had to be completed (in relation to C'). Finally, the subjects had to answer some pro forma questions about the slides.

#### *Data Reduction and Analysis*

For each subject, EBs during the 3-min periods were summed. EBs were corrected for baseline differences by subtracting the baseline frequencies from the EBR of the pertinent phases (i.e., B-A, C-A and C'-A', B'-A'). In the statistical analysis, a within-subject design was used. Because EBR is known to be unevenly distributed, a nonparametric test was performed (Wilcoxon paired comparison test, one-tailed) for testing the differences between the baseline-corrected eyeblink data of the first phase and those of the second phase of the experiment. If subvocal activity facilitates EBR, EBR would be expected to be elevated during the "rehearsal" period (C') as compared to the last three "dark" minutes of the first phase (C).

Spontaneous fluctuations (SFs) of the SC were used as an index of sympathetic arousal. SFs were defined as deflections exceeding a criterion of  $0.1 \mu\text{mho}$  within 2 seconds. SFs during respiratory irregularities as described by Stern, Ray and Davis (1980) were excluded from final analysis. For each subject, SFs during the 3-min periods were summed. Differences as to the frequency of SFs between the periods were analyzed with *t*-tests (one-tailed). The association between the increase in EBR and the increase in SFs was examined with a Spearman rank-correlation.

The "thought" data were analyzed with a Wilcoxon paired comparison test (one-tailed) and used as an index of rehearsal activity.

## RESULTS

### *Eyeblinks*

Figure 1 shows EBRs during the 6 periods of the experiment. A Wilcoxon paired comparison test revealed that the EBR during the slide (B') was significantly lower than during its counterpart of the first phase of the study (B) ( $p < .01$ ). During the

### eyeblinks

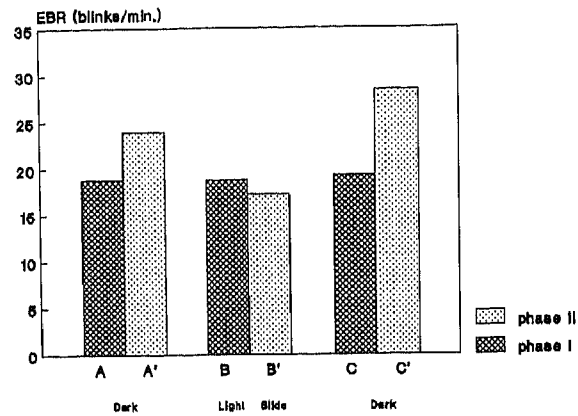


FIGURE 1 Mean EBR during the 6 periods of the experiment

last three "dark" minutes ("rehearsal-periode" i.e., C'), EBR was significantly higher than during its counterpart C (Wilcoxon paired comparison test;  $p < .05$ ).

### Skin Conductance

More SFs occurred during period C' than during its counterpart C [ $t(23) = 3.51$ ,  $p < .01$ ]. The increase of SFs was positively correlated with the increase in EBR ( $R = .51$ ,  $p < .05$ ). As can be seen in Figure 2, subjects showed more SFs during the slide (B') than during the light period of the first phase (B) [ $t(23) = 3.68$ ,  $p < .01$ ].

### spontaneous skin conductance fluctuations

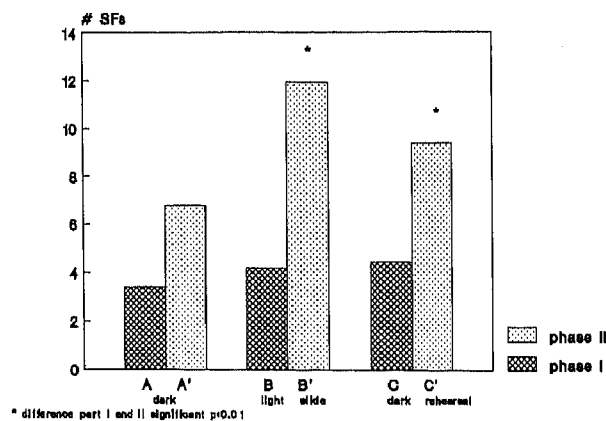


FIGURE 2 Mean number of spontaneous skin conductance fluctuations (summed over 3 minutes) during the 6 periods of the experiment.

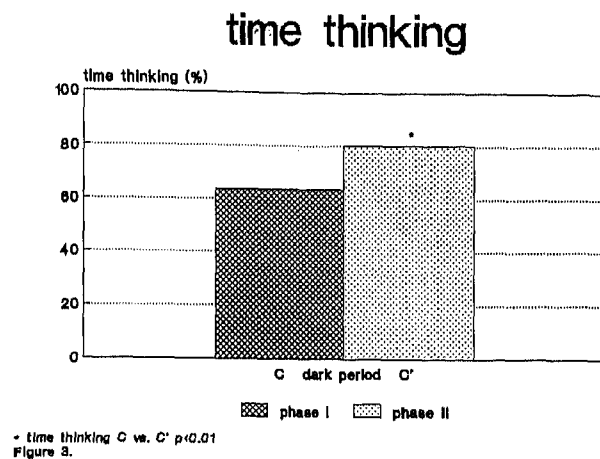


FIGURE 3 Mean time thinking during the dark period following the period in which the subjects sat in a normally lit room (C) and following slide presentation (C').

#### *Rehearsal activity*

The VAS data (Figure 3) showed that subjects had significant more "thoughts" during the three dark minutes following slide presentation (C') than following the period in which they sat in a normally lit room (C) (Wilcoxon paired comparison test  $p < .001$ ).

Neither for the EBR data, nor the SC data or data concerning rehearsal activity did it make any difference which of the two slides (pictorial vs. verbal) subjects saw.

#### DISCUSSION

The subjects reported more rehearsal-activity (as indexed by VAS scores) during the dark period following slide presentation (C') than following the period in which they sat in a normally lit room (C). Therefore, it can be safely concluded that the experimental manipulation was successful. In line with the "motoric overflow"-hypothesis, the EBR during period C' was higher than during period C.

One could counter that the increase of the EBR in period C' is a "rebound"-effect, that is, a compensation for the low blink frequency during the preceding period (slide presentation, B'). Another possibility is that subjects employed blinking as a strategy to preserve the visual image of the presented slide. Kinsbourne and Warrington (1963), for example, pointed to the fact that intermittent illumination of the visual projection field by blinking may prolong or revive the afterimage. Both explanations imply that blinking bursts are to be found during the first seconds after slide-offset. However, as EBs were evenly distributed during the postslide period (C'), a "rebound" or "reviving-imagery-through blinking" interpretation of the EBR increase is unlikely.

In sum, the present findings strongly suggest that experimentally induced subvocal speech may increase EBR. This result may shed new light on the remarkable finding reported by Mackintosh, Kumar, and Kitamura (1983): These authors found that patients with depressive disorder exhibited higher EBRs than healthy control subjects. This difference disappeared after successful treatment. The EBR of depressive pa-

tients was found to be independent of medication. Thus, the heightened level of EBR could not be attributed to the well documented effect of tricyclic antidepressants (Karson, 1979). On the basis of the results presented above one could hypothesize that the heightened level of EBR in depressives is due to the subvocal ruminations and worries (by spreading of electrical activity in adjacent vocal and eye-motor pathways) that characterize these patients (Carter, Johnson, & Borkovec, 1986). In a similar vein, it would be interesting to examine the EBR of obsessive-compulsives because they are supposed to be an outstanding example of ruminating patients.

The decrease of EBR during the slide with information (B') is in line with earlier research suggesting that endogenous blinking is inhibited by attentional processes (Stern et al., 1984). This EBR decrease can probably be attributed to the fact that blinking interferes with the uptake of (visual) information.

The significant correlation between the increase of SFs and the increase of EBR between C and C' (the last dark periode second part vs. pendant first part) confirms previous, indirect observations (Stern et al., 1984) that EBR increases parallel arousal increases. The most parsimonious explanation for this parallel is that one underlying cognitive process (e.d. "rehearsal") induces both an increase in EBR and an increase in SFs.

#### REFERENCES

- Carter, W. R., Johnson, M. C., and Borkovec, T. D. (1986). Worry: An electrocortical analysis. *Advances in Behaviour Research and Therapy*, 8, 193-204.
- Cramon, von D., & Schuri, U. (1980). Blink frequency and speech motor activity. *Neuropsychologia*, 18, 603-606.
- Holland, M. K. & Tarlow, G. (1975). Blinking and thinking. *Perceptual and Motor Skills*, 41, 403-406.
- Holland, M. K. & Tarlow, G. (1972). Blinking and mental load. *Psychological Reports*, 31, 119-127.
- Karson, C. N. (1979). Oculomotor signs in a psychiatric population: A preliminary report. *American Journal of Psychiatry*, 136, 1057-1060.
- Kinsbourne, M., & Warrington, E. K. (1963). A study of visual perseveration. *Journal of Neurology, Neurosurgery, and Psychiatry*, 26, 468-475.
- Mackintosh, J. H., Kumar, R., & Kitamura, T. (1983) Blink Rate in Psychiatric Illness. *British Journal of Psychiatry*, 143, 55-57.
- McGuigan, F. J. (1979). *Psychological measurement of covert behavior: A guide for the laboratory*. Hillsdale NJ: Erlbaum.
- Meyer, J. R. (1953). On the interaction of simultaneous responses. *Psychological Bulletin*, 50, 204-220.
- Schuri, U., & Cramon, von D. (1981). Heart rate and blink rate responses during mental arithmetic with and without continuous verbalization of results. *Psychophysiology*, 18, 650-653.
- Stern, J. A., Walrath, L. C., & Goldstein, R. (1984). The endogenous eyeblink. *Psychophysiology*, 21, 22-33.
- Stern, R. M., Ray, W. J., & Davis, C. M. (1980). *Psychophysiological Recording*. Oxford: Oxford University Press.