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Effects of illumination and meter on spontaneous eyeblinks

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The hypothesis that blinking acts as a mask on visual information processing was tested. Twenty-four undergraduates listened to verbal presentations of poetry and random digits under illuminated or darkness conditions. Results indicated that the subjects' blink rates were significantly depressed during presentation of material relative to dead space paused. Results were contrary to the masking hypothesis.

It has been suggested by Holland and Tarlow (1972, 1975) and Wegmann and Weber (1973) that changes in illumination caused by spontaneous eyeblinks may constitute a disruptive influence during the processing of visual information. The reason for this might be a masking process associated with blink-induced illumination change. There is some evidence bearing on this hypothesis. Yarbus (1967) states that the entire blink response, which begins with a slight upward rotation of the eyeballs, continues with the closing of the lid, the blackout period, and the opening of the eyelids to the full open position, will occupy up to .2 sec. (The blackout period is defined as the period in which the upper and lower eyelids touch.) Lawson (1948) reported that the blackout period itself occupies between .03 and .10 sec. Thus, these figures taken together indicate that the blackout period of the eyeblink constitutes from 15% to 50% of the entire eyeblink process. Additional literature also has a bearing on the hypothesis. Telford and Thompson (1933) determined that spontaneous blink rates vary with the type of mental task. This finding was extended to include the difficulty of the task (Gregory, 1952; Holland & Tarlow, 1972, 1975; Luckiesh, 1944). Typical results show a U-shaped curve across the time course of a single trial which indicates an intermediate-level blink rate during times of no concentration, followed by a depression of blink rates during both the presentation and processing of information, followed by a flurry of eyeblinks at the completion of the mental task. Quite often the recovery interval blink rates appear to exceed the base blink rates, suggesting that there is an effort to "catch up" on one's blinking after release from a mental processing task. Ponder and Kennedy (1927) determined that blinking responses continue even in instances of total blindness or in darkness. They present evidence that blinking is an internally generated activity which is only minimally influenced by peripheral external conditions, such as dryness of the cornea or illumination levels. But it remains to be determined whether the subjects' blink function in different illumination conditions can be related to information processing requirements during a trial.

In this paper we propose several hypotheses relating blink rate and information processing. The masking hypothesis is concerned with why the blink rate during a trial decreases when information is presented and processed. It would state that blinking diminishes during information processing because blinking-induced illumination changes will serve to mask ongoing information processing. Blinking avoidance would then have the adaptive function of not interfering with ongoing processing. This hypothesis can be tested by comparing blink rates during information and dead space intervals during darkness and light conditions. The hypothesis would predict lower blink rates during light than darkness for information processing intervals but comparable blink rates during light and dark for dead space intervals. This would mean a significant Illumination by Interval interaction.

If blink rate varies inversely with cognitive load, we would expect blink rates under comparable conditions to vary with practice. The practice effect hypothesis would predict an increasing blink rate (up to the point of the base resting rate) with increasing practice on the same information. In addition, the blink rate should increase more for information than dead space intervals, and more for light than dark intervals. Thus, there should be a three-way interaction of Illumination by Information by Trials.

Finally, a comparison of two materials, poetry and digits, is made to determine if blink rates vary with grammatical or rhythmic structure.

METHOD

Subjects

The subjects were 24 undergraduate volunteers enrolled in an introductory experimental psychology course. All subjects

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received extra course credit for participating in an experimental session that lasted about 20 min.

Stimuli

The stimuli consisted of a tape-recorded set of instructions to the subject and three readings of a poem, the first four verses of Lewis Carroll's (1946) "The Jabberwocky," and a list of random digits from zero to nine, read in iambic dimeter. For example, whereas the meter of the poem would read, with appropriate accents,

Be 'ware the 'Jab ber 'wock my 'son/
The ' jaws that ' bite, the ' claws that 'catch/. . .

the meter of the random digits was presented,

Five ' three eight ' two/ Nine 'five five 'two/ . . .

In an earlier pilot study the digits were read in an iambic tetrameter meter, identical to the poem; however, it was determined that there were too many digits for the subject to concentrate upon, so the rate of digit presentation was cut in half for the experiment. Each single presentation of the digits or the poem lasted about 45 sec, including the reading of the title and the pauses between trials.

Apparatus

All eyeblinks were monitored with a modulated infrared eye movement monitor, Biometrics Model SGH/V-2. The infrared photocells were mounted on special glasses frames which were fitted and calibrated to each subject. Output from the eye movement monitor was fed directly to a Harvard chart recorder apparatus. A stereo two-channel tape recorder apparatus recorded the verbal presentation. The second microphone of the stereo tape recorder was placed directly in the line of movement of the event recorder needle, so that when the subject blinked, the needle struck the microphone. In this manner of recording, a subject's eyeblink response was a very distinct and audible click on the tape recording. Maximum lag in equipment response was calculated to be no greater than .055 sec.

Instructions and Procedure

All subjects were instructed that this was an experiment designed to measure small but involuntary eye movements while they simultaneously listened to some verses and numbers. The subjects were instructed, furthermore, to listen carefully to the verbal material because they would be asked some questions about the material at the end of the experiment. In addition, each subject was told that he should feel free to breathe normally, blink his eyes, or scratch as he felt the need to do so, but that he should avoid any large head or body movements. He was instructed to keep his point of visual fixation confined to the region of a small black spot printed on a white card placed directly in front of him.

The subjects who listened to the poetry and digits in total darkness were dark adapted for approximately 7 min in red light during the first half of the experiment, while the equipment was being calibrated. This brief dark-adaptation process was to insure that the subjects' vision would not be influenced by residual afterimages.

Each subject was told to relax and look straight ahead for 30 sec at both the beginning and end of the experiment while the equipment "stabilized." These periods were used to establish a base blink rate for each subject. However, at no time during the experiment was the subject informed that the purpose of the experiment was to record eyeblinks, nor at the conclusion of the experiment did any subject suggest the purpose of the experiment when questioned. Furthermore, the eyeblink recording microphone and chart recording needle were placed in a section of the laboratory out of sight and sound of the subject. All blink responses were scored by playing the tapes back at one-quarter of the original speed. This method of slow replay was judged to be quite accurate in the scoring process, as it was quite easy to determine not only the word or the space the eyeblink occurred on, but even the syllable of the word on which the blink appeared

The time of information presentation and the dead space (pauses) were similarly determined by slowing the tape to one-quarter of the original speed and measuring the intervals with a stopwatch. Examples of information (verbal) and dead space (pause) real-time intervals are illustrated as follows:

" 'Twas brillig, and the slithy toves" (2.45 sec)
/Pause/ (.35 sec)
"Did gyre and gimble in the wabe" (2.30 sec)
/Pause/ (.70 sec) . . .

Scoring reliability in determining the time of verbal information presentation and pauses (dead space) in four test-retest trials ranged from $r = .920$ to $r = .998$.

The experimental group of 12 subjects listened to both the poem and digits in total darkness, while the 12 subjects in the control group listened to the poetry and digits in an illuminated room. The order of presentation of poetry and digits was counterbalanced for both groups, and all subjects listened to both the poetry and digits three consecutive times.

RESULTS AND DISCUSSION

An analysis of variance was conducted for the four treatments: 2 illuminations (light, dark) by 2 intervals (information, dead space) by 2 materials (poetry, digits) by 3 trial blocks. The main effect for illumination was not significant [$F(1,22) < 1$]. This was somewhat surprising, given the graphic results of Figure 1. Examination of the raw data revealed the probable reason. The blink rate distributions showed great variability. There were many zero entries as well as extreme scores. More importantly, the Illumination by Interval interaction was not significant [$F(1,22) = 2.92$, $p > .05$]. The masking hypothesis is clearly not supported. The changes in blink rate that occur are opposite the direction predicted by the hypothesis. As Figure 1 indicates, there is actually a tendency for higher blink rates during light than dark intervals. The hypothesis would predict the opposite result: Lower blink rates under illumination would be required to prevent masking effects produced by blinking-induced illumination changes.

There is a tendency for blink rates to increase with successive trial blocks [$F(2,44) = 3.27$, $p < .05$]. The trial block results are consistent with a hypothesis that would predict a steadily increasing blink rate as stimulus events become more familiar and require less processing capacity. However, there was no three-way interaction [$F(2,44) < 1$] of Illumination by Information by Trials that would be required for the practice effect hypothesis. Thus, with increased practice the blink rate for information conditions ought to increase and approach that of the dead space conditions (at least for light intervals); this is not the case.

The complete absence of a materials effect [$F(1,22) < 1$] suggests that the blink process is re-

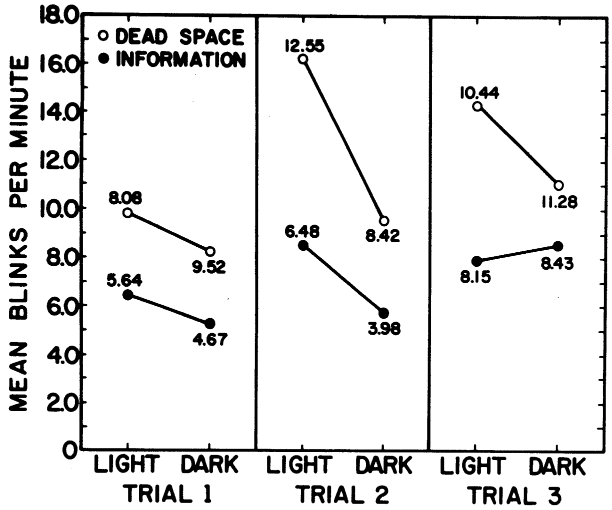

Figure 1. Mean blink rates for information and dead space intervals under both illumination and darkness conditions, collapsed over digits and poetry. The value adjacent to each point represents the SD of the subject means for that condition.

sponding to predictable rhythmic pauses in vocal messages and not to the grammatical structure of the materials. The material condition is pooled with the other conditions of Figure 1.

The findings of lower blink rates during information than during dead space intervals [$F(1,22) = 30.89$, $p < .001$] indicates that blink suppression can be observed in passive or receptive processing situations requiring no overt responding. The inhibition of spontaneous blinking appears to be an excellent and robust indicator of cognitive activity. There were no other significant interactions.

A general comment on the blink response is in order. A substantial difficulty resides with the number of zero entries (no blinks during an interval). Until this problem is solved, either statistically or by experimentally inducing a higher base blink rate, it will be difficult to test fine-grained hypotheses about information processing using a blink response.

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