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Two Kinds of Endogenous Eyeblinks in an Adult with Blindness, Severe Motor and Intellectual Disabilities: A Case Study[1]

by
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Abstract

Eyeblink behaviors in a person with blindness, severe motor and intellectual disabilities were investigated by video data. The results showed that there are substantially no differences in blink rates compared with sighted adults, but remarkable differences were found in the characters of their waveform, much blinks associated with head swaying (blindisms) and therefore less sole blink rates, and more frequent blinks during head movements and less blinks during the cessation of head swaying (at the right and left ends of the movement). The most striking findings are the long duration of the closed phase (pause) phase in the sole blink situation and the extremely long duration in the blindisms situation. These findings are consistent with the recently reported findings, which have been confirmed in the Progressive Supranuclear Palsy and the Parkinsonism. The possible meanings of blinking in the case of a person who does not require blinking for the visual information processing are discussed.

Key Words: endogenous eyeblink, blindness, severe motor and intellectual disabilities, blindisms

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Introduction

Eyelid is basically an apparatus for visual information processing system. However, it is well known that many blind persons also blink at almost the same frequency as sighted adults (Ponder & Kennedy, 1927; Hall, 1945) and that the blind person blinks after the enucleation operation of both eyeballs (Records, 1992). However, two important questions remain regarding blinking in cases of blindness; what is the function of eyeblinks in people suffering from blindness? Why do blind people blink as frequently as people without impaired vision?

Numerous physiological and psychological functions of eyeblinks have been pointed out. (Hall and Cusack, 1972; Duke-Elder, 1968; Hart, 1992; Records, 1979). Blount (1927) provided the chiefly physiological functions including animal studies; 1) to distribute evenly the secretion of the lacrimal glands and to clear the cornea of foreign materials, 2) to allow alteration to take place in the tension of the ocular muscles, and thus to eliminate early fatigue, 3) as a protection against injury from the exterior, and 4) to guard the eye against continuous exposure to strong light. Duke-Elder (1968) considered three fold functions; 1) protective role in moistening the cornea and sweeping it clean, 2) drainage of tears, 3) to eliminate blurring of image during the actual movements of the eyes. Most of them are related to the peripheral functions of the visual system.

Meanwhile, Ponder and Kennedy (1927) and Stern, Walrath, & Goldstein (1984) emphasized the roles of the central nervous system origin, that is, psychological factors, like the arousal level, muscle tension, and especially the aspect of visual processing process. Ponder and Kennedy (1927) were concerned mainly with the issues that blinks were not affected by the impulse from the second cranial nerve such as light and dark, corneal dryness, and the completely anaesthesia of cornea and conjunctiva by cocaine. Especially they showed, as the most basic evidence, that 1) in case of bilateral primary optic atrophy, accompanied either by complete loss of sight or by perception of light only, blinking movements of the normal frequency were observed, 2) selecting cases of optic nerve atrophy of a congenital natures, they observed the movements of blinking to occur at normal rate, and 3) out of 200 cases of blindness examined, not one was observed in which blinking did not occur. Hall (1945) observed the blink behaviors in three children with blindness, two brothers were congenitally blind and another is a 9 years old boy, totally blind since 5 years of age. The blink rates of 3 blind children were 7.5, 14.7 and 22.5 bpm (blinks per minute), respectively and showed no distinguishable distribution from those of the sighted persons.

Stern et al (1984) emphasized the effects of many kinds of psychological factors on blink rates in normal subjects, especially the effect of visual task demands, which largely change the frequency and temporal distribution of blinks. It is easy to understand the relationships between vision and blink and indeed many studies have reported that these factors influence the blink rate. A study (Bonfiglio, Carboncini, Bongioanni, Andre, Minichilli, Forni, et al, 2005) reported that blink rate of patients in the persistent vegetative state remained stable but non-persistent vegetative state patients it decreased over time as the cognitive condition improved and they found the strong inverse correlation between blink rates and a level of cognitive functioning scale (LCFS).

The purpose of the present study is to report a case study of a person with blindness and severely physically impairments.

Method

A patient

We studied a 21-year-old male with congenital blindness due to brain malformation. Since 2 years of age, he has been admitted to the section of severe motor and intellectual disabilities. The patient did not gaze at objects, and showed no response to light. In addition, he was suspected to have hearing difficulties, because he exhibited no response to sound. The patient exhibited dysfunctional facial expressions, and could not recognise social situations around him. He was unable to sit without support. In the daytime he typically sat in a wheelchair and swayed his head left to right frequently while pronouncing meaningless words. The study protocol was approved by the ethics committee of the National Higashisaitama Hospital, where the study was conducted.

Recording and data analysis

The face of a patient was videotaped using a standard recording equipment (Sony DCR-PC1000), while he was awaking and sitting on the bed. Data collection was conducted during the day, between approximately 10:00 and 17:00, in accord with the recommendations of an article (Barbato, Ficca, Muscettola, Fichele, Beatrice, & Rinaldi, 2000). The videotaped blink data were transferred to a PC using Adobe Premiere (Adobe Systems Co., Tokyo), and DVgate Plus (Sony Co., Tokyo) software, and transformed data was analyzed using Blink Detection Program software (Mizuno Measurement Co., Sendai), which provide us to detect the blink by playing back and forward of video at optional speed and to determine the closing, pause and opening duration at frame unit by manual operation and the subsequent analysis were all automatically processed.

Results

The most distinctive characteristic of this person was the so-called blindisms (the frequent right-and-left head swaying) and therefore he moved frequently his head, which is shown in Table 1. We, furthermore, observed the frequent association of blinks with this head swaying and thus, we analyzed it by dividing into two types, associated with blindisms and not-associated with blindisms (sole blink). As shown in Table 1, the durations and percentage of blindisms and nonblidisms were 203 (70 %) and 87 (30 %), respectively. The frequency and percentage of blindism-related blinks and sole blinks were 74 (80.4%) and 18 (22.4%), respectively. As can be seen in Table 1, the totalized mean frequency of blinks is 19.0 bpm and this value is completely the same as healthy control adults (Karson, 1988; Sugiyama and Tada, 2005), whereas the blink rates between blindism and nonblindisms were markedly different. The blink frequency in blindisms case was approximate to the double score of sole blinks (21.9 bpm vs. 12.4 bpm).

Table 1. Durations, frequencies and rates of eyeblinks in an adult with blindness during blindisms and non-blindisms

	Blindisms	Non-Blindisms	Total (Mean)
Duration in sec.	203	87	290
Number of Blinks	74	18	92
Blinks Per Minute	21.9	12.4	19.0

Secondly, we observed a remarkable uniqueness in blink durations compared with those of healthy control. Table 2 illustrated the blink duration divided into three phases; closing, closed (pause) and reopening of blinks as a function of blindisms, sole blink, and the sighted control group. Control data was based on 617 adults data, which was recorded and analyzed by almost

Table 2. Closing, pause, reopening and total durations (in msec) in an adult with blindness during blindism and non-blindism, compared with the control

	Closing	Pause	Opening	Total
Blindisms	166.2	826.1	309.8	1302.1
Non-Blindisms	164.7	29.3	237.1	431.1
Control*	121.5	?	303.0	424.0

*Control data were based on Sugiyama and Tada (2008)

the same methods as the present study, during watching a 180 sec video stimulus (Sugiyama and Tada, 2005). Usually pause phase duration of endogenous blinks in healthy control adults is so short to neglect, that is, almost no time. Most of studies have been neglected it to measure. In fact, we couldn't get almost no blinks of pause over 1 frame duration in this control data. Furthermore, according to our definition of blinks, the blinks over 1 sec longer duration were omitted, but we have yet no strict standard to classify or detect the blink by these criteria. If we were accorded to this criterion, the eyelid behaviors during blindisms in the present study might be not the blink, but we will report it here, because of its uniqueness.

Table 2 indicated several differences between three conditions and durations. First of all, three durations during blindisms were markedly different from the previous reports, especially the duration of pause phase was beyond the normative value. Secondly, although those of sole blinks might be approximate to the control data, the pause phase duration of sole might be also unique, because control data did not provide no pause phase data. The most remarkable uniqueness was the extremely longer pause in blindisms. In addition, the other noticeable finding was that the most blinks associated with blindisms occurred during moving (65.6 %), not during the cessation of head swaying at right and left end (34.4 %).

Discussion

In this study, we confirmed the previous findings (Ponder and Kennedy, 1927; Hall, 1945) that there was substantially no differences in blink rates between sighted control adults and blind persons. However, we showed for the first time that the duration and the other characteristics of blink wave form were highly different from those of the sighted control, especially the duration of closed phase was extraordinarily longer. In addition, a person with blindness blinks more frequently during blindisms than during no head swaying, and he also blinks more frequently while head movements than while cessation of swaying.

The findings pointed out above except blink rates might be new and be considerably different from those of the sighted but have been not confirmed yet, because the detailed description of this type of blinks in the case of persons with blindness have been not reported in the previous reports. Most studies dealt with the relationship between blinks and head movements are the studies concerned with the visual information processing. Do the results obtained in the present study mean the same functions ? More frequent blinks associated with head movements was a characteristics of the youngest infants (Sugiyama, Kashiwagura, Ohsaga, Yuze, and Tada, 2008) and the poor reader (e.g., Stern, Brown, Wang, & Russo, 2005). The shorter duration of blinks is a feature for the visual information processing compared with auditory processing (e.g., Goldstein, Walrath, Stern, and Strock, 1985) and blinks is apt to accompany with the shift of gaze or saccade (punctuation), in order to minimize the information loss (e.g., Fogarty and Stern, 1989). These factors are all the characteristics of visual information processing, that is to say, for the purpose of visual task demands. Our data indicated the same blink rates in persons with blindness but its implication might be probably not the same.

The physiological functions for maintaining the eyeball mentioned above may be also to keep the visual system healthy in sighted persons. However, in the case of persons with blindness these functions need not to be essential. What is the purpose of blink for the person with blindness who need not process the visual information ? Hall (1945) observed the aural or acoustic-reflex blink in one of congenital blind boys. As it is well-known that the endogenous blinks originated from the central nervous system, so it is not so strange that persons with blindness blinks at certain frequency as a result of some another reason originated from a certain central nervous system. Healthy fetuses, who do not begin any kinds of visual information processing yet, also blinks every 10 minutes (Petrikovsky, Kaplan, & Hosten, 2003) and the youngest infants blinks infrequently and gradually increase upto adulthood or preadolescents (Ponder and Kennedy, 1927; Knorr, 1929; Zametkin, Stevens, & Pittman, 1979; Sugiyama, et al, 2008). Persons without visual impairments may develope their blink behaviors by these processes of learning and congenital blind people with normal blinks may also have learned their blink behaviors only as a motor learning, not as a tool for visual perception. The congenital blind person, however, might blink for the different purposes from the person with normal vision. The origins of their functions or purposes of blink could not make clear by the present evidences. It needs to collect more evidences.

The most striking finding in the present study is the extraordinary long duration of closed (pause) phase of blinks in this blind person. This finding is consistent with the previous studies, who investigated three kinds of blinks (voluntary, spontaneous and reflex blinks) of the patients with Parkinson's disease (Agostino, Bologna, Dinapoli., Gregori, Fabbrini, Accornero and Berardelli, 2008) and with Progressive Supranuclear Palsy (PSP; Blologna, 2009). They also found the marked longer duration of this pause phase, which is almost 8-fold of the sighted control, in the case of PSP patients. They interpreted that the switching between the closing and opening phases of blinks reflects the fine coordination of the time and reciprocity of orbicularis oculi and levator palpebral superiosis muscle activation and, in patients with PSP, this coordination might depend on the partial co-contraction of the antagonist orbicularis oculi and levator palpebral superiosis muscle. Therefore, they suggested that this prolonged durations of the switching processes between the closing and opening phases might be a neurophysiological marker and reflect the diffuse cortical, subcortical and brainstem degeneration.

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