Breaking Down
The Blink

How the eyeblink affects the corneal surface and what factors impact our blink rate.

There are many lines of defense protecting the ocular surface from harm, beginning with reflex-gestures and brow line, and culminating with the eyelashes, lid, tear film and epithelium. Blinks, which last between 300 and 400 milliseconds, are integral to ocular surface health, as they help maintain the tear film. However, blinks are highly variable across tasks, such as reading, computer use, TV, driving, conversation and gazing. Blinking is also influenced by internal factors including fatigue, medications, stress and affective state. Clinically, it is crucial to consider the role of the blink when investigating ocular conditions, as behavior modifications can be important for treatment. This article will examine the task-dependent nature of the blink rate and its relationship to ocular surface conditions.

Physiology

The spontaneity of the eyeblink has piqued the curiosity of many scientists, and more than 80 years of research has been devoted to unraveling the mechanism behind the human eyeblink. Scientists have proposed various theories for the spontaneous nature of the blink: Some have suggested the presence of an internal blink pacemaker regulated by the brain stem, while others have alleged that the dopamine-related circuitry of the hypothalamus and of the caudate nucleus are involved. Research on non-human primates has demonstrated the direct relationship between cortical levels of dopamine and spontaneous blinking. The amplification of dopamine receptor 1 activity with D1 agonists has been shown to result in an increased blink rate. Correspondingly, blocking the dopamine receptor results in a decreased blink rate. Some researchers have also proposed that the blink rate is connected to mental load and is regulated by the rate of cognitive processing. According to a paper presented by State University of New York-Oswego researcher Kara Wallace at the XVth Biennial International Conference on Infant Studies in Kyoto, Japan, in 2006, speaking, memorizing and mental arithmetic have all been linked to an increased blink rate, while daydreaming, directing and redirecting one’s attention and stimulus tracking have been associated with a decreased blink rate. The reason why certain cognitive processes and activities affect blink rate depends on the...
Table 1. The Task-Dependent Nature of Blink Rate

<table>
<thead>
<tr>
<th>Task</th>
<th>Blink rate range (blinks/minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video display unit/computer use</td>
<td>1.8 - 4.4</td>
</tr>
<tr>
<td>Reading</td>
<td>1.4 - 14.4</td>
</tr>
<tr>
<td>Gazing</td>
<td>8 - 21</td>
</tr>
<tr>
<td>Conversation</td>
<td>10.5 - 32.5</td>
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**Endogenous Influences**

One’s blink rate may also be influenced by internal factors, such as fatigue, stress, medications, ocular surgery and surface conditions. Research, including a paper presented at a meeting for the Society for Psychophysiological Research more than a decade ago, has demonstrated that fatigue and stress induce an increased blink rate in normals. Medications may also affect blink rate; for example, women on a birth control pill blink an average of 32 percent more than those not on the pill. Post-LASIK surgery patients may experience a reduced blink rate; this is partly the result of decreased corneal sensitivity. Ocular anesthetics can also cause decreased corneal sensitivity, which can lead to dry-eye disease and keratitis.

**Dry Eye and Blink**

Patients with dry eye can find their symptoms exacerbated by the additional ocular exposure caused by a decreased blink rate. A decreased blink rate causes an increase in the rate of tear-film breakup, along with a decrease in tear and mucin production and meibomian secretions in both normals and dry-eye patients with the disruption of tear-film components. As such, dry-eye patients are at a particular disadvantage during reduced-blink-rate activities, such as working on the computer, reading, driving, etc. Exacerbation of dry-eye signs and symptoms from a reduced blink rate can lead to visual function disturbances. We must keep in mind that a normal tear film protects the integrity of the ocular surface from keratitis and protects our vision: it is difficult to see through a broken tear film, especially with the presence of
keratitis (Ousler GW et al. IOVS 2007;48: ARVO E-Abstract 410). Furthermore, a reduced tear-film breakup time (TFBUT) and the prolonged exposure of the ocular surface produce a disrupted air-fluid interface, which in turn disrupts light transmission to the retina. Hence, visual function is impacted.

**Implications for Visual Function**

Patients with ocular surface dysfunction are at a serious disadvantage when performing tasks that are typically linked to a prolonged interblink interval. This is not to say that patients with a short tear-film breakup time experience great discomfort during regular conversation; rather, ocular surface dryness and irritation are more likely exacerbated during tasks that require greater visual attention and therefore are associated with a lower blink rate. The dry-eye patient with a TFBUT of three seconds is at a specific disadvantage when working on a computer-oriented task, where the interblink interval can slow to as long as 12 seconds. Over the course of an hour, the ocular surface conditions may worsen, and keratitis may increase as a result of the successive, extended interblink intervals.

To date, it has been difficult to quantify the decay of visual acuity within the interblink interval. A new test, however, has been specifically developed and validated by our researchers at ORA Clinical Research and Development here in North Andover to provide an accurate measure of visual function. The interblink interval visual acuity decay (IVAD) test provides the necessary measurement of visual function in real time (Walker PM et al. IOVS 2007;48: ARVO E-Abstract 422). A study that investigated the relationship between central corneal staining and visual function in dry-eye patients used IVAD measurements to assess functional visual acuity in real time. Resulting data showed that patients with central corneal staining could not maintain their BCVA for as much time in between blinks as patients without central staining (Ousler III GW et al. IOVS 2007;48: ARVO E-Abstract 410). Consequently, problems can arise over time with rate of information recognition, perceptual processing, fatigue and function.

**Future Research**

Clinically, investigating blink rate in relation to patients with ocular surface conditions must be constrained within a specific task and meaningful to the functional outcome of the patient's everyday life (e.g., reading). If a relevant blink rate is not measured, as is frequently the case, no connection may be drawn between the patient's blink rate and the interference of ocular symptoms with everyday life.

Hence, researchers must make distinctions between blink rates. As no single "normal" blink rate exists, ranges of blink rates on specific tasks are a good starting point. It may be that a patient is an avid reader, a task associated with a long interblink interval. Awareness of the task-dependent nature of blink rates can greatly aid in treating patients with ocular surface conditions, who in turn require more frequent blinking to replenish the ocular surface. Ernest Lowenstein, OD, PhD, of the New England College of Optometry, has proposed a blinking exercise routine for such a purpose. Nevertheless, awareness of such blink patterns themselves can provide insight into the patient's daily routine and therefore the ability to suggest modifications, such as alternating long interblink interval tasks with shorter ones.

Further environmental influences must also be investigated. The association between scotopic vision and blink rates may also provide further insight into the underlying mechanisms. Blinking during tasks such as
night driving may elucidate the role of external lighting influences on blink rate. The impact of air quality (i.e., the amount of irritants and pollutants that are present) must also be considered in relation to the dynamic blink rate.

The ability of drug therapies to treat individuals with ocular surface conditions and normalize their blink rate can have an enormous impact on their quality of life. Therapies that can extend tear-film breakup time can provide a protected ocular surface during the interblink interval, allowing dry-eye patients to go about their daily lives without having to worry about ocular discomfort, irritation or blurring.

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