Blinking in Face to Face Communication

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Abstract. Initial results from the quantitative and qualitative analysis of blinking in dyadic face-to-face conversation are provided. Blink rate has previously been interpreted as an indirect index of cognitive load. Our results demonstrate that blinking is a highly individualistic behavior, with radically different blinking ‘styles’ evident, even in a small sample. An initial characterization of blinking based on gaze direction before and after closure is suggested. Blinks in which gaze direction is unchanged before and after eye closure are found to depend jointly on the gaze direction of both subjects, and on the speaking behavior of both subjects. Several informal observations that will guide further qualitative study of blinks in communicative situations are made.

Key words: blinking, embodiment, gesture, spoken communication

1 Introduction

We blink. Indeed, we blink all the time we are awake. Blinks are visible, typically unconscious, and very frequent. Some blinks may be reactions to irritants or reflexes due to nerve stimulation, but most blinks are not. Some blinks are necessary to maintain a tear film on the cornea, but most people blink much more often than this requires. Adults blink more often than children [1], although reflexive blinking is fully developed by 5 years of age [2]. Contrary to popular belief, blinking is relatively unaffected by ambient humidity [1].

Much research that has sought to characterize blinking has taken the Spontaneous Eye Blink Rate (SEBR) as a dependent variable [3, 4]. A primary gaze SEBR, in which the subject simply gazes at an unmoving target, may sometimes be taken as a baseline. Compared to this, reading SEBR and conversational SEBR are reported to be lower and higher, respectively [5, 4].

Many studies have linked blink rate to cognitive load [6, 7, 5, 8] during tasks such as reading, visual search, and even lying [9]. Typically, blink rate and cognitive load are found to be inversely proportional. For example, it was found that eye surgeons exhibited a greatly reduced blink rate while performing surgery, compared to their blink behavior during casual conversation [10], and it was observed that they frequently blinked at junctures that were characterized by a temporary reduction in cognitive load, e.g. when asking for an instrument,
or when pointing out anatomical structures to students. In a related finding, Nakano et al. observed that blinks among viewers of a relatively simple film were highly synchronized, and tended to occur at points which required less attention \cite{11}. One study has found an association between blink timing and syntactic structure in fluent American Sign Language signers \cite{12}, suggesting that blink occurrence may be more fully integrated into the ongoing stream of movement than mere rate measurements might suggest. Blink timing has also been found to be entrained by isochronous finger tapping, with the degree of entrainment roughly proportional to the force or effort expended. \cite{13}. Blinking is strongly associated with gaze shift, and it has frequently been reported that large changes in gaze direction are reliably associated with blinks \cite{14}. Studies of SEBR typically come with the unstated assumption that blinking is epiphenomenal, and not an essential and active part of the activity the subject partakes in. For example, subjects may be acclimatized to a room, and then asked to gaze fixedly at a single remote location to provide a baseline SEBR measurement \cite{3}. But vision is an active process, and the eyes are constantly searching out salient information as a function of both the ongoing stream of behavioral goals of the subject, and the attendant environmental circumstances. Fixed gaze is, in fact, a pathological behavior. Blink rate is a very crude, undifferentiated characterization of one observable characteristic of an active perceptual system \cite{15}, and the above studies point to a complex relationship that remains to be explored between blink behavior and the ongoing behavioral context.

One consistent finding in blinking studies is that there is a large degree of variation among individuals. For example, the finding that SEBR is elevated in conversation and lowered in reading \cite{4} is tempered by the observation that even the rank ordering of blink rates by condition exhibited substantial variation across subjects. Blinking, it seems, is a highly individualized activity.

The present study sets out to observe blinking in face to face communication. While communication, or conversation, has sometimes been taken as a neutral control condition, e.g. in \cite{10}, there is a growing awareness of the degree to which spoken communication is a whole body activity, with essential movement characteristics far beyond those required for speech sound articulation \cite{16, 17}. The ubiquity of gesturing while speaking on the phone, or among blind people, or speaking in the dark, is testament to the tight integration of body movement in the activity of speaking. It is thus \textit{a priori} plausible that blinking might bear a richer relationship to spoken communication than has previously been recognized. In a recent study of verbal communication, Bailly et al \cite{18} found that blink rate increased when speaking (n=9) and decreased when listening, and that blinks often occurred together with gaze shifts. This study used a simplified form of pseudo-communication with fixed roles and activities for speakers and listeners. This allowed clear categorization of blinks by “cognitive state”, and finessed complexities that might emerge, e.g. during negotiated turn taking, or unpredictable cognitive load. Notably, the average changes in blink rate as a function of speaking or not-speaking may not be a good reflection of the behavior.
of specific individuals, because of the large amount of inter-individual variability found in blink behavior.

2 Investigating Blinking in Face to Face Conversation

This report is an interim report of a novel investigation of blinking in face to face conversation. A suitable corpus for study has been found in the Dutch IFA video corpus [19]. This is a large corpus comprising 20 dyadic conversations of 15 mins each. Each pair sat facing one another with a video camera behind each participant, so that matched video streams provide full facial observation throughout (Fig. 1). Conversants were well known to each other, and conversation was free and unscripted.

Fig. 1. Video recording setup. A camera behind each participant allows good coverage of face and eyes. These are participants C and D from Pair 2.

So far, two pairs have been completely annotated. Annotation involves frame-by-frame observation of each participant, with notation of the time and type of each blink. In parallel, speaking turn and gaze direction are also annotated. Although speaking turn and gaze are annotated within the corpus as distributed, it was found necessary to reannotate these completely in order to ensure a consistent form of annotation. This allows us to separately document back channeling behavior (not separately annotated), and, crucially, to consistently document the relation of blinking and gaze change. Because this project is at an early stage, the reports provided here are preliminary and represent a snapshot of an evolving methodology and set of questions.

3 A Taxonomy of Blinks

Several attempts at categorizing blinks have been proposed. Most such attempts have focussed on the morphology of blinks, irrespective of the behavioral context
in which they occur. Thus, for example, Abelson and Holly [20] distinguished between complete and incomplete blinks, forced blinks, and twitches, while others have sought to distinguish between spontaneous, voluntary and reflex blinks [21].

In documenting blinks within a conversational situation, it quickly became clear that these physiological distinctions were of limited use. Eye closing behavior in a conversational setting exhibits functional variation that can only be understood with reference to the ongoing interaction among the participants. An initial discrimination was made between short and long closures, operationalized as 1-4 video frames and 5-10 frames of substantial closure at 25 frames/sec. respectively. Most of the longer blinks (5–10 frames) appear to be hybrid events, associated with emphatic feedback, and often accompanying short backchanneling utterances or head nods. They are not further reported here, as the data volume is as yet too small to permit any generalization. The short blinks were further subcategorized based on gaze direction at the start and end of the blink. Fixed gaze describes a blink with gaze direction unchanged before and after closure, while moving gaze can be moving towards the partner, moving away from the partner, or moving from one gaze direction to another, neither of which are partner-directed. Table 1 shows the number of blinks in each of these 5 categories for the two dyads so far completed.

<table>
<thead>
<tr>
<th>subject/pair</th>
<th>fixed toward</th>
<th>away</th>
<th>moving toward</th>
<th>away</th>
<th>neither</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 1</td>
<td>686</td>
<td>14</td>
<td>82</td>
<td>25</td>
<td>2</td>
</tr>
<tr>
<td>B 1</td>
<td>57</td>
<td>40</td>
<td>10</td>
<td>30</td>
<td>6</td>
</tr>
<tr>
<td>C 2</td>
<td>204</td>
<td>7</td>
<td>27</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>D 2</td>
<td>219</td>
<td>149</td>
<td>48</td>
<td>80</td>
<td>14</td>
</tr>
</tbody>
</table>

Table 1. Counts of blinks per subject in 15 mins of face-to-face conversation. ‘Fixed’ means that the direction of gaze was estimated to be the same before and after the blink. In a ‘moving’ blink, gaze direction changes. ‘Toward’ and ‘away’ refer to partner-directed gaze after the blink.

From Table 1 it is clear that by far the most common kind of blink is a short blink with unperturbed gaze, produced when both participants are looking directly at each other (67.4% of total blinks). The distributions also immediately illustrate considerable inter-subject differences.

In the two conversations fully annotated, and four others partially completed, an initial unmistakable observation is that blinking style in face-to-face conversation differs greatly from individual to individual. It is too early to say definitively just what the characteristics of any given individual are, and to what extent they are influenced by the partner in a dyadic setting. However, an example can be provided, as in Fig. 2, in which two speakers with very different behaviors are paired. Speaker A (top waveform, top blink track) blinks very frequently when
listening, as in the right hand side of the figure, and much more slowly when she speaks herself, as on the left. Her co-speaker, B, by contrast, blinks much less frequently overall and without any clear relation to the ongoing speech exchange. Neither behavior is found in the other two speakers, C and D. It is clear that at this early stage, no averaging across individuals would be appropriate, and a fuller characterization of the features of an individual blinking style is required. One might note in passing that reports in the literature comparing blink rates when speaking compared to some control, typically report increased rates when speaking. Speaker A can thus be seen as a cautionary case, suggesting that averaging across subjects is premature.

3.1 Dependence on gaze

Blink rates can be looked at as a function of either gaze or speaking behavior. We here examine just those blinks in which the direction of gaze of the blinker is the same before and after eye closure. Fig. 3 (left) shows blink rates as a function of gaze. Each of the four speakers appears as a well-differentiated individual. Subject A blinks vastly more when gazing at the partner (‘gg’ and ‘gx’) than when looking away (‘xg’ and ‘xx’). Furthermore, A’s blink rate is very substantially higher when her partner is looking away (‘gx’) than when she is looking towards her (‘gg’). Subjects B and D, in contrast, blink as much or more when they look away from their partner as when gazing directly at them. Subject C displays a qualitatively different pattern. His blink rate is higher when he gazes at his partner, and lower when he gazes away, but it is wholly unaffected by the partner’s gaze. In interpreting these blink rates, it should be borne in mind that the durations over which blinks are observed are very different for the four categories considered here. Blink counts, and associated observation intervals used in calculating the rates in Fig 3 are provided in full in Table 2.
Fig. 3. Blink rates as a function of gaze (left) and speech (right). Key: (left) ‘gg’: both gaze at each other; ‘gx’: subject gazes at partner & partner gazes away, etc. (right) ‘ss’ both speak simultaneously; ‘so’ subject speaks & partner is silent, etc.

### Table 2

<table>
<thead>
<tr>
<th>Subject/Pair</th>
<th>Gaze direction</th>
<th>G-g</th>
<th>g-x</th>
<th>x-g</th>
<th>x-x</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>count (dur)</td>
<td>count (dur)</td>
<td>count (dur)</td>
<td>count (dur)</td>
<td></td>
</tr>
<tr>
<td>A1</td>
<td>442 (615)</td>
<td>244 (157)</td>
<td>14 (123)</td>
<td>0 (3)</td>
<td></td>
</tr>
<tr>
<td>B1</td>
<td>45 (615)</td>
<td>12 (123)</td>
<td>40 (157)</td>
<td>0 (3)</td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>152 (638)</td>
<td>52 (203)</td>
<td>6 (42)</td>
<td>1 (7)</td>
<td></td>
</tr>
<tr>
<td>D2</td>
<td>199 (638)</td>
<td>20 (42)</td>
<td>145 (203)</td>
<td>4 (7)</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Blink counts and total observation interval duration (seconds) as a function of joint gaze direction. Key: g-g: both partners look at each other; g-x: subject gazes at partner, partner gazes away; x-g: subject gazes away, partner gazes at subject; x-x: both gaze away.

### 3.2 Dependence on speaking behavior

In similar vein, we can examine the dependence of blink rate on speaking behavior. Once more, only those blinks in which gaze direction is unchanged across eye closure are considered. Speaking annotation is based on an informal assessment of speaking turn, and one subject is considered to be speaking as long as he/she has not obviously surrendered the turn. Back channels are noted separately, but for the present purposes, we will not differentiate between speaking and back channeling. Fig. 3 (right) shows blink rate as a function of speaking behavior, and again, highly individual behavior is evident. A blinks more when listening, while C blinks more while speaking. B has so few blinks overall that it is difficult to discern a clear dependence on speaking, while D exhibits two distinct rates, one while a single person is speaking, and a lower rate when either both or neither talks. Table 3 again provides the counts and durations used in calculating
these rates. Unsurprisingly, far more time is spent with one person talking than either two or none.

<table>
<thead>
<tr>
<th>Subject/Pair</th>
<th>Speaking Behavior</th>
<th>count (dur)</th>
<th>count (dur)</th>
<th>count (dur)</th>
<th>count (dur)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>speak/speak</td>
<td>51 (79)</td>
<td>147 (421)</td>
<td>470 (345)</td>
<td>32 (48)</td>
</tr>
<tr>
<td></td>
<td>speak/listen</td>
<td>11 (79)</td>
<td>50 (345)</td>
<td>30 (421)</td>
<td>6 (48)</td>
</tr>
<tr>
<td>B1</td>
<td>listen/speak</td>
<td>52 (161)</td>
<td>72 (235)</td>
<td>82 (469)</td>
<td>5 (26)</td>
</tr>
<tr>
<td></td>
<td>listen/listen</td>
<td>45 (161)</td>
<td>212 (469)</td>
<td>105 (235)</td>
<td>6 (26)</td>
</tr>
</tbody>
</table>

Table 3. Blink counts and total observation interval duration (seconds) as a function of joint speaking behavior. Key: ‘speak/listen’ means, e.g. that the subject is speaking, while the partner is silent.

4 Beyond Blink Rate

Some further observations about blinking in face to face communicative situations may be made, even though at this stage of our investigations, it is not possible to quantify, or even unambiguously identify specific instances of every kind of blink observed.

Many studies have documented a large reduction in blink rate during times of heightened cognitive load, such as watching a particularly eventful part of a movie, or performing surgery [11, 10]. We have repeatedly found short blink flurries, typically of 3 to 8 blinks in rapid succession, that occur just as a speaker is experiencing lexical access difficulties, syntactic re-planning after an infelicitous partial sentence, or the like. These suggest that blinking may, in fact, also signal increased cognitive load. An important distinction between these situations and film watching or performing surgery is that syntactic or lexical problems must be resolved without reference to the immediate visual environment. Future work will seek to more precisely characterize this kind of speaker-related blink activity.

Some authors have sought to distinguish between partial blinks and complete blinks. Partial blinks are very frequent in the dyads examined to date, but there is no indication that their functional role is in any way different from that of a complete blink. Indeed, given that a partial blink is perfectly evident to the conversational partner, but is presumably not ideal in replenishing the corneal tear film, it might be surmised that partial blinks constitute circumstantial evidence that blinking is important in a communicative situation precisely because it is visible to the partner.

A full analysis of back channels and blinks remains to be done, but we have observed many cases in which back channels and blinks seem to co-occur. Fig. 4
Fig. 4. Apparent capture of blinks by backchannels.

illustrates one case in point, in which the two clear back channels of the upper speaker coincide with simple blinks. Blinks that co-occur with back channels are frequently longer than average, and may also be associated with a head nod. The communicative function here is inescapable.

Finally, there is reason to seek descriptive tools that go significantly beyond a state-based account of blink behavior [18]. Many blinks are found on the edges of steady states. Thus, as shown in Table 1, significant numbers fall at points in which gaze shifts towards or away from the partner, while at the same time, joint gaze behavior is found to be a significant determinant of blink frequency. The synchronization of blinks while watching a movie [11] and the observation that blinks during surgery occur at times of low cognitive load [10] may admit of an alternative interpretation in which blinks function as signals that demarcate transitions from one state to the next, or particularly dynamic points in a behavioral sequence. This is of particular relevance in the communicative situation.

5 Discussion

The results presented here are preliminary and incomplete, but they strongly suggest that blinking in naturalistic communicative situations is worthy of study. Far from being a reflex activity, blink timing and frequency are modulated as a function, inter alia, of joint gaze direction and of joint speaking behavior. The way in which blinking is so modulated appears to be highly individual, and there is much work to be done in identifying the dimensions of variation that are potentially available to speakers, and, relatedly, identifying any invariants in blinking behavior that may yet be discovered.

Prior research has emphasized the notable drop in blink frequency when cognitive load rises. Our work suggests that this picture might be seriously incomplete. It is at least plausible that the factor occasioning a fall off in blink frequency is not cognitive load per se, but the need to attend to the visual properties of the environment. Blinking does interrupt visual surveillance of the
immediate environment, and so a very straightforward account of the reduction in blinking is available. Conversely, we have pointed out that blink flurries may be associated with syntactic or lexical difficulties, neither of which rely on visual information for their resolution. Clearly, there is scope for much further work here.

References