Movement Disorders
Vol. 12, No. 6, 1997, pp. 1028–1034

Analysis of Blink Rate Patterns in Normal Subjects

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Summary: The present study measured the normal blink rate (BR) variations in relation to behavioral tasks in 150 healthy volunteers (70 males and 80 females; aged 35.9 ± 17.9 years, range 5–87 years). The subjects were videotaped in a standard setting while performing three different tasks: resting quietly, reading a short passage, talking freely. The mean BR was computed during each task; the data were compared by means of analysis of variance and Student's *t* tests. Mean BR at rest was 17 blinks/min, during conversation it increased to 26, and it was as low as 4.5 while reading. As compared with rest, BR decreased by −55.08% while reading ($p < 1 \times 10^{-15}$) and increased by 99.70% during conversation ($p < 1 \times 10^{-9}$). As compared with reading, BR increased during conversation by 577.8% ($p < 1 \times 10^{-17}$). The distribution curves were highly reproducible in each task. The best curve fit was represented by a log-normal distribution, with the upper tail of each curve having a normal distribution. Eye color and eyeglass wearing did not influence BR. Women had higher BR than men just while reading. No age-related differences were found. The most common BR pattern was conversation > rest > reading, which occurred in 101 subjects (67.3%); 34 subjects (22.7%) had the pattern rest > conversation > reading; 12 (8.0%) had the pattern conversation > reading > rest. This study identified three normal behavioral BR patterns and showed that BR is more influenced by cognitive processes than by age, eye color, or local factors. The present findings provide a normal reference for the analysis of BR in movement disorders such as dystonia or tics. **Key Words:** Blinking—Blepharospasm—Dystonia—Tics.

Investigations of eyelid dynamics have identified three types of eye blinks: spontaneous, reflex, and voluntary (1). Available data on spontaneous blink rate (BR) are not consistent. Hart (1) estimated blinks to occur, on average, about 12–15 times/min. According to Karson (2), the normal rate in adults is 19 ± 14 (SD)/min. It has been reported that blinking is virtually absent at birth, increasing steadily until adolescence, when it reaches a plateau that is maintained throughout adult life (3). This observation, however, has not been further confirmed.

There is evidence that BR is influenced by cognitive processes. Following initial suggestions that BR depends upon cognitive and emotional states (4), several investigators have estimated the effects of cognitive tasks on blinking. Tasks involving speech or memory increase BR, while those requiring visual fixation (such as reading) reduce BR (2,5,6). Daydreaming, which produces visual fixation, is associated with low BR (7). Other factors besides cognitive, visual, and memory tasks also influence BR. During conversation each individual punctuates his or her speech by blinking between phrases and at the end of sentences. Even sensory stimuli (8) and local eye conditions (conjunctivitis, tear break-up time) (9) can modify BR.

Flurries of blinking and associated sustained eye closure are characteristic signs of two neurological conditions: blepharospasm and motor tics. At onset, blepharospasm may present only with increased eye blinking. Spasmodic contractions of the eyelids usually occur as the disease progresses. A reliable clinical diagnosis of blepharospasm can be made only when spasmodic movements are observed. Simple motor tics often present with eye winking or increased BR in relatives of patients affected by blepharospasm (10) or in subjects with Gilles de la Tourette disease. Karson et al. (11) observed that

Received February 16, 1996; revision received July 31, 1996. Accepted August 30, 1996.

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BR did not differ in ticqueurs from a control population and that it was related either with the number or with the severity of tics. Increased BR has been observed in patients with Gilles de la Tourette disease, who also had dystonic features (12). These authors considered increased BR as a mild form of blepharospasm and suggested that some patients with tics may have an increased risk for dystonia. Involuntary eye closure in these disorders may not be blinks, but abnormal involuntary movements.

To better understand the relationship among BR, tics, and dystonia, the normal variations of blinking with relation to different motor and behavioral tasks must be ascertained. Therefore, this study is aimed at measuring BR values in normal healthy individuals engaged in three common behavioral conditions: resting, reading, and conversation.

MATERIALS AND METHODS

One hundred fifty healthy volunteers of either sex (70 males and 80 females) were included. The subjects represented a wide spectrum of ages, ranging from 5 to 87 years. They were enrolled among doctors, nurses, and students of the Catholic University and among relatives and friends of the investigators. Exclusion criteria were family or personal history of movement disorders, obsessive-compulsive disorder, mental diseases, ocular allergy, any other cause of conjunctival distress occurring during the last month, and current use of psychoactive drugs. Children under 5 years were not included as they were unable to read. Subjects' consent was obtained.

All the subjects agreed to be videotaped unaware of the purpose of the study. All videotapes were recorded indoors with artificial lighting and standard temperature (21°C). All subjects were sitting; they were not required to maintain any specific position of the body, head, or eyes. None wore corneal lenses during the evaluation; eyeglasses were used by the habitual wearers. Three videotape segments were recorded, in the following order, which was meant to minimize the emotional impact of the camera: (a) free conversation on trivial subjects, requiring no memory recall; (b) reading aloud a standard passage: a short tale was selected for children and a difficult short passage by Hermann Hesse (Italian translation) that required mental and visual concentration was chosen for adults; (c) quiet rest with eyes open. Each videotape segment lasted for 2 min 30 s.

Two independent observers reviewed the videotapes and measured the number of blinks for 2 min during each segment. The first 20 s of recording was not analyzed to allow for adaptation to the environment. The two independent measures were averaged.

The average BR per minute, counted in each segment, was compared by means of analysis of variance (ANOVA). In addition, subgroups of subjects were identified based of the following variables: (a) gender, (b) eye color, (c) eyeglass wearing. The data measured in each subgroup were compared by means of one-way ANOVA and Student's t tests. Resting was assumed to be the basal condition, and it was compared as such to BR while reading or talking. The correlation index between age and BR was also computed. Finally, the overall population was divided in age ranges of 10 years each. Population data with a normal distribution were expressed as average ± SD or ± SEM; BR data with log-normal distribution were expressed as average, 5%, and 10% critical values.

RESULTS

The population under study included a large spectrum of ages, ranging from 5 to 87 years, averaging 35.9 ± 17.9 years. This population was divided into seven groups, based on decades, from 5 to 64 years. Eight subjects were over 64, and they were considered as a group. Each of the remaining six groups included an average of 21.4 ± 11.9 subjects each; each group included a comparable number of subjects, with the exception of decade 25–34, which was composed of a higher number of subjects (45). The ethnic origin was non-Jewish caucasian (145 subjects, 97%) or Ashkenazi Jewish (5 subjects, 3%). Most subjects (101, 67%) were dark-eyed; 49 subjects (33%) were light-eyed. Eyeglasses were used by 35 (24%) individuals when resting, 51 (34%) while reading, and 36 (24%) while talking.

The data measured in the three experimental conditions (i.e., at rest, while reading, and during conversation) had similar distribution curves. The best fit for these distributions was represented by a log-normal curve, with the upper curve tail for the observed values falling above the ideal curve of the log-normal distribution (Fig. 1). The upper-tail unfitting was observed for BR values over 24 (at rest), over 10 (while reading), and over 40 (during conversation). All these upper-tail values were best fitted with a normal distribution. It was concluded that the best curve fit for the data was with a log-normal curve, representing 70% of the measured values at rest and during conversation and 80% of those measured while reading, the remaining values being best fitted with a normal curve.

Between-group statistical comparisons were therefore performed using BR log values. Mean BR at rest was 17 (5 and 10% critical values were 4–48 and 6–40, respec-

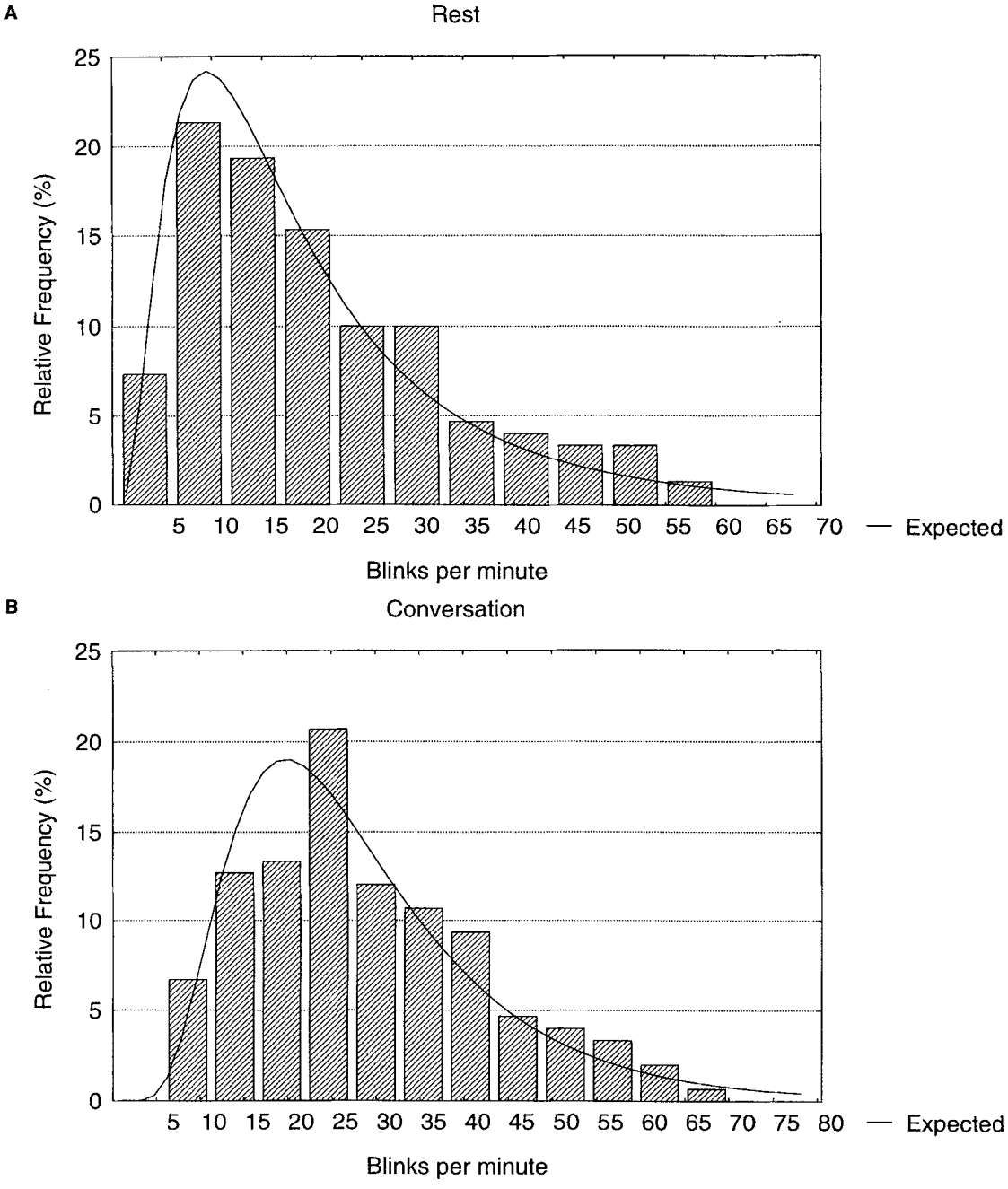

FIG. 1. Relative frequency of blink rate values at rest **(A)**, during conversation **(B)**, and during reading **(C)** are fitted with a log-normal distribution.

tively). Mean BR during conversation was 26 (5 and 10% critical values were 11–53 and 13–47). Mean BR while reading was 4.5 (5 and 10% critical values were 0.7–22 and 1–16).

As compared with rest, BR while reading was decreased by −55.08% ($p < 1 \times 10^{-15}$) and BR during conversation was increased by 99.70% ($p < 1 \times 10^{-9}$). As compared with reading, BR during conversation was increased by 577.8% ($p < 1 \times 10^{-17}$) (Table 1). There were no BR variations with reference to eye color or to eyeglass wearing. Women had a higher BR than men, but this was significant only while reading ($p < 1 \times 10^{-5}$). In men, mean BR while reading was 3.0 (5 and 10% critical values: 0–13 and 0–10); in women it was 6.2 (critical values: 0–26 and 0–20; Table 1). There was no correlation between BR and age; BR values during conversation

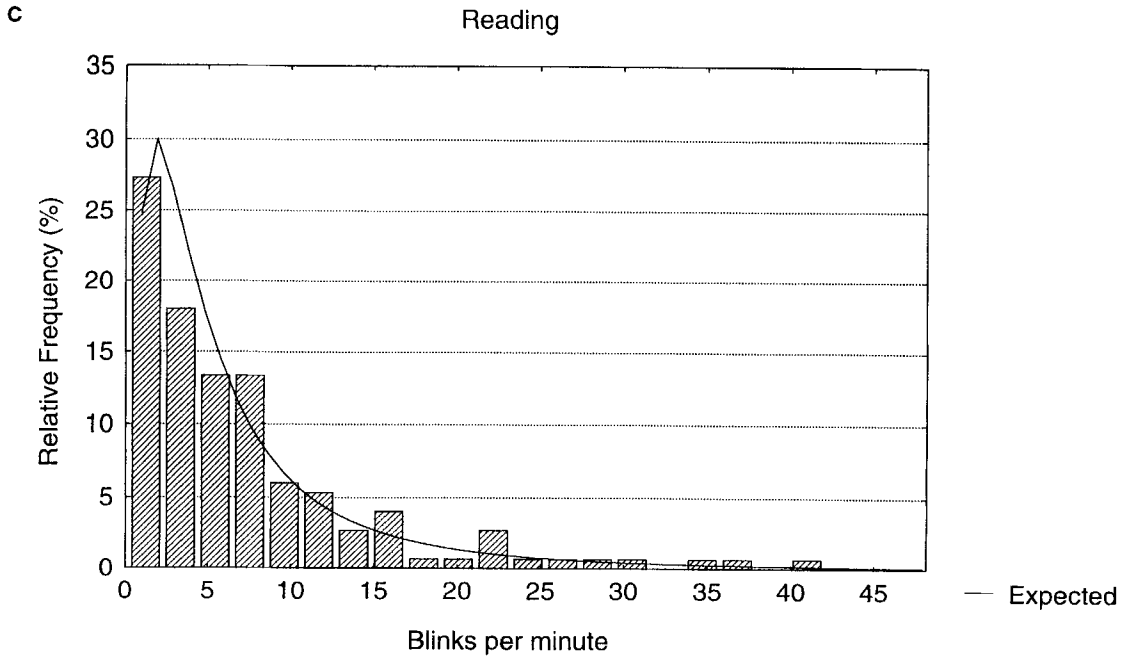

FIG. 1. (*Continued*)

first increased and then decreased as age progressed (see Fig. 3), but statistical analysis of data did not show differences.

Comparison of different behavioral conditions showed that BR during conversation was higher than BR at rest in 111 subjects (74% of the population studied) and than BR while reading in 148 subjects (98.7%); BR at rest was higher than BR while reading in 134 subjects (89.3%). Between-task comparison showed that the most represented pattern was "conversation > rest > reading," which occurred in 101 individuals (67.3%). Thirty-four subjects (22.7%) had the pattern "rest > conversation > reading"; 12 subjects (8.0%) had the pattern "conversation > reading > rest" (Tables 2 and 3).

DISCUSSION

The present study shows that BR varies in normal subjects according to behavioral tasks and provides a standard reference for normal BR values. Figure 2 displays percentiles for BR in normal subjects. Using rest as the reference condition, we found that BR decreased by 74% during reading and increased by 100% during conversation. This observation is consistent with earlier data comparing BR in two behavioral conditions (13,14) or in the three together (2). In 68% of the normal population, BR is lower while reading and increases progressively at rest and during conversation (Fig. 3). This typical BR pattern is not found in the remaining 32% of normal subjects, who demonstrate the less common pattern of having the highest BR frequency at rest rather than during conversation or of having the highest BR at rest rather than during reading. Not considering three cases, each one with an individual pattern that was not found in other subjects, only 3 combinations of behavioral BR variations were observed out of a total theoretical number of 21 (Table 3). The three populations characterized by different BR patterns did not differ in

TABLE 1. *Mean blink rate (5, 10% critical values) in population under study*

	Average	Men	Women
Rest	17 (4–48, 6–40)	15.6	18
Reading	4.5 (0.7–22, 1–16)[a]	3.0 (0–13, 0–10)[b]	6.2 (0–26, 0–20)
Conversation	26 (11–53, 13–47)[c]	24	26.7

[a] Significantly different from rest ($p < 1 \times 10^{-15}$).
[b] Significantly different from reading in women ($p < 0.00001$).
[c] Significantly different from rest ($p < 5 \times 10^{-6}$), and from reading ($p < 1 \times 10^{-17}$).

TABLE 2. *Mean blink rate (5, 10% critical values) in population under study*

Condition	Subjects	Mean age (yrs)	Average blink rate	Average blink rate	Variation (%)
			Rest	Reading	
Rest > reading	134	35.9	21.5	6.0	−64
Rest < reading	16	35.4	9.64	12.9	45
			Rest	Conversation	
Rest < conversation	111	35.2	16.8	30.8	141
Rest > conversation	37	38.6	30.6	22.2	−28
Rest = conversation	2	20.5	15.9	15.9	0
			Conversation	Reading	
Reading < conversation	148	36.2	28.7	6.0	−76
Reading > conversation	2	11.5	11.5	14.1	21

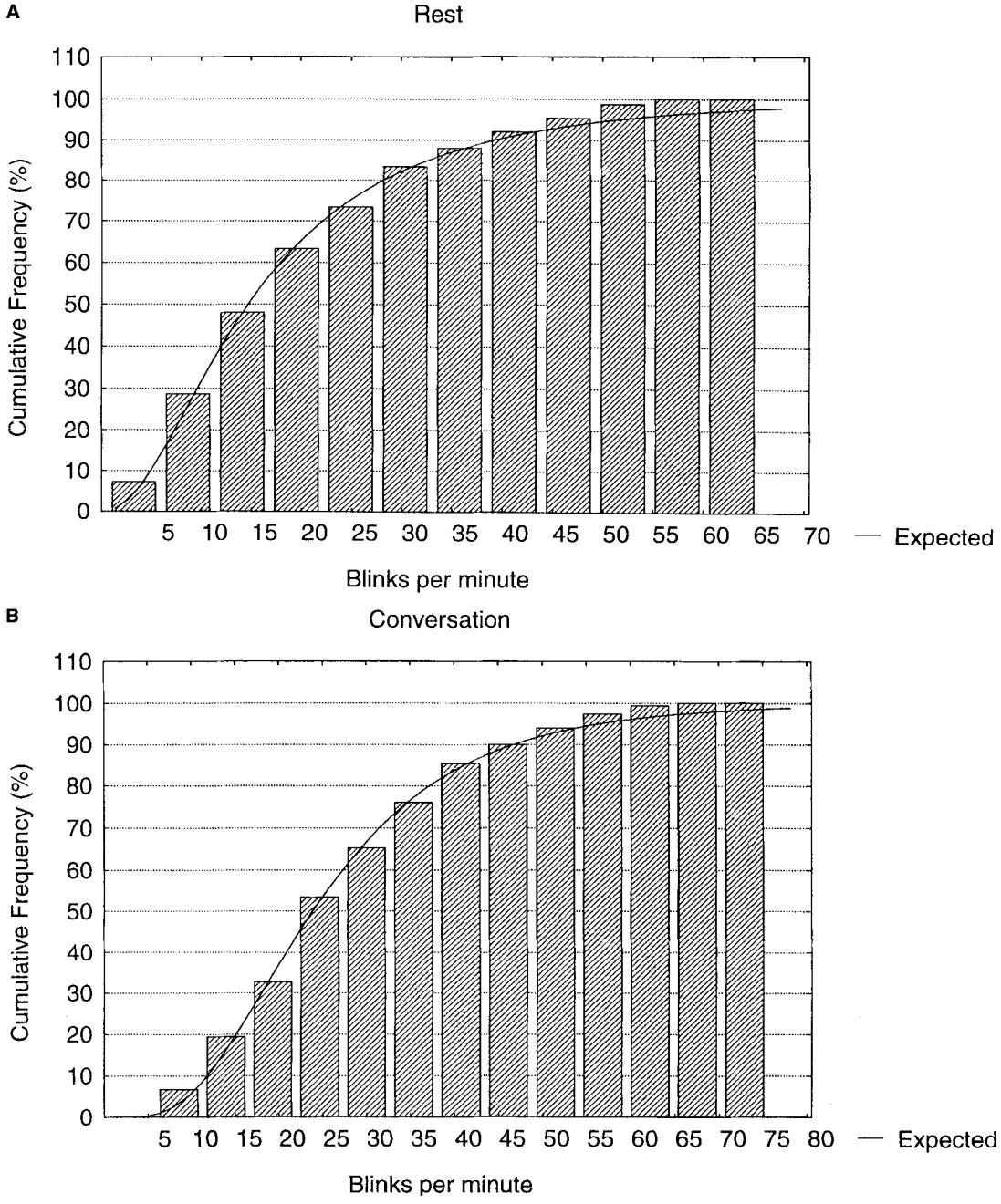

FIG. 2. Cumulative frequency of blink rate values at rest **(A)**, during conversation **(B)**, and during reading **(C)** are plotted with the expected percentiles.

TABLE 3. *Patterns of blink rate listed according to their decreasing incidence in population under study*

Pattern	Subjects	Mean age (yrs)	Indicence (%)
Conversation > rest > reading	101	34.9	67.3
Rest > conversation > reading	34	39.1	22.7
Conversation > reading > rest	12	39.0	8.0
Rest > reading > conversation	1	5	0.7
Conversation = rest > reading	1	23	0.7
Reading > conversation = rest	1	18	0.7
Total	150	37	100

relation to any of the variables under study (i.e., age, gender, eye color, eyeglass wearing). Thus, these combinations represented three relationships between BR and behavioral tasks that occur in normal subjects.

One other important point clarified by the present study is that, under controlled environmental conditions, BR does not vary with age. This is at odds with an earlier observation reporting that BR gradually increases until adolescence to reach a plateau that is maintained throughout life (3). There are no other reports on this issue. Our observation, then, supports the view that each individual has his or her own BR that is maintained throughout life. In keeping with this, we observed a significant difference in BR between men and women during reading, with men having lower BR values than women. This observation has not been reported previously, although an earlier study (3) alluded to this finding. In addition, men can suppress blinking longer than women and can voluntarily increase their BR much faster than women (5).

The present study is consistent with earlier observations that there is a high degree of interindividual variability of BR (5). Variability of BR among different subjects may be due to environmental factors or may be the expression of phenotypic variations. In the present study, environmental factors were not varied. Notwithstanding, it was observed that some subjects were more embarrassed than others in front of the camera. This is at variance with other settings where the influence of the environment was significant but there was no impact from the camera, as when the patients were unaware of being videotaped (3). Another possible influencing factor in our study is that some people were more skilled than others in reading. Still, the interindividual variability during reading was comparable with that measured during the other two behavioral tasks.

This study is the only report measuring BR in a large population of normal subjects in a controlled setting. This is the main reason why it is difficult to compare these observations with earlier studies in which environmental conditions were not carefully controlled. We observed no differences with reference to eye color or eyeglass wearing. Our hypotheses were that light-eyed people would have a different BR due to the higher amount of light reaching the retina and that variations in the eye microclimate associated with lenses wearing

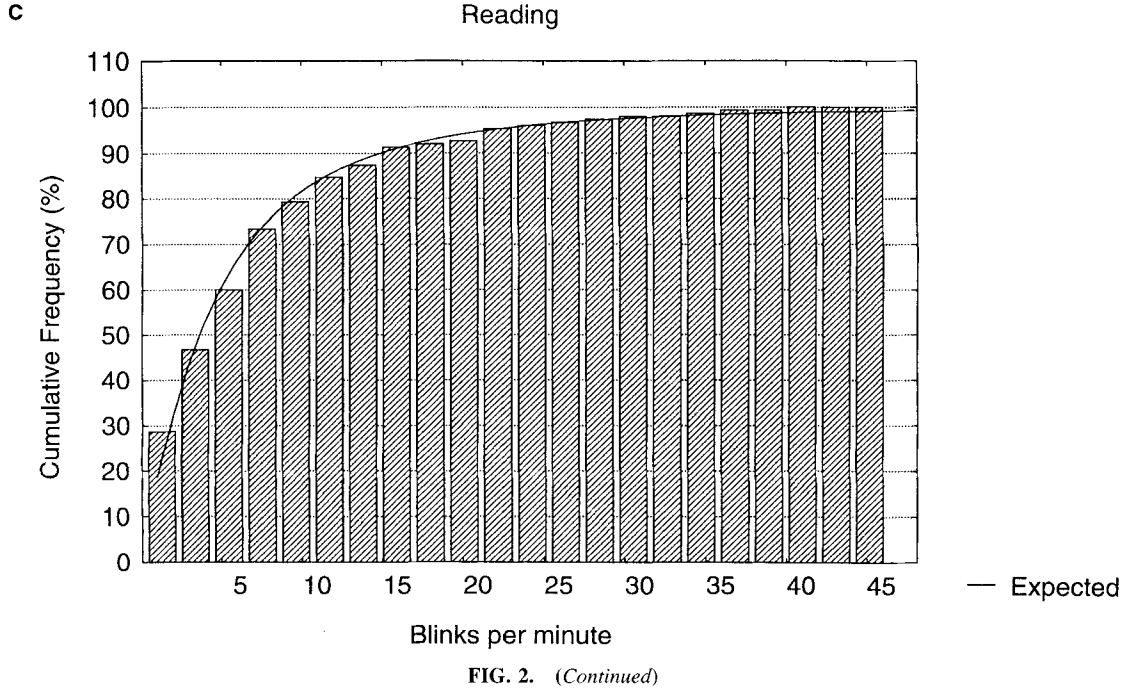

FIG. 2. *(Continued)*

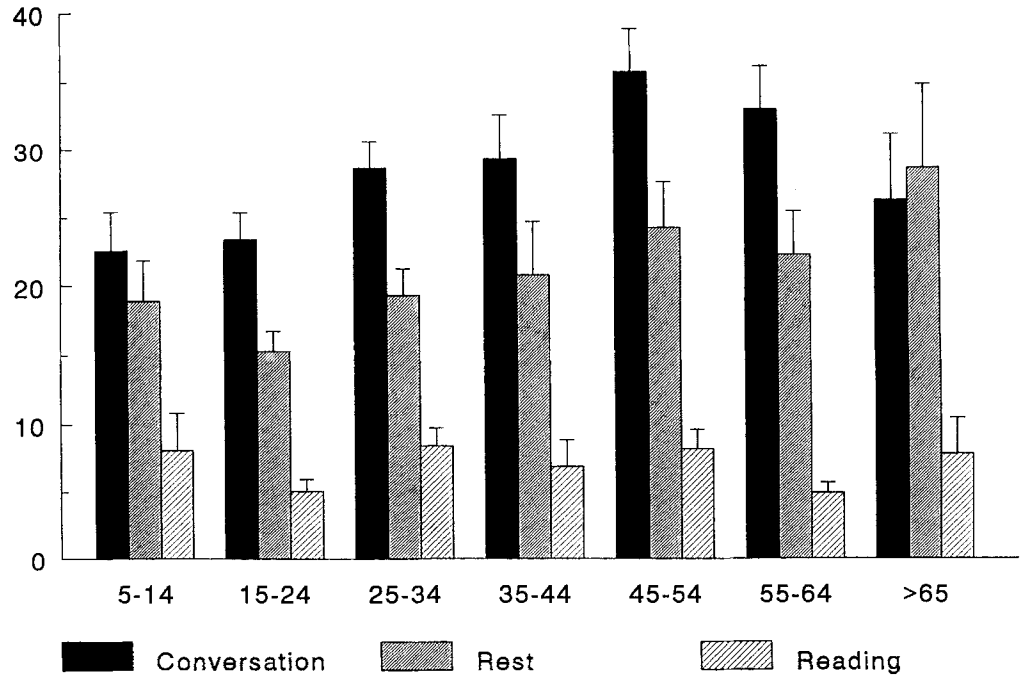

FIG. 3. Blink rate values in seven defined age groups during the three behavioral tasks considered. Between-task differences are significant in each age group with the exception of conversation vs. rest at ages 5–14, 35–44, and >65.

would modify the lachrymal film. Since no differences were found in either case, this supports the idea that BR is modulated primarily by central mechanisms and cognitive tasks and that local ocular conditions are of limited relevance.

Why normal individuals should have three different behavioral patterns of BR is still unclear. We do not presently know whether any of these groups (namely, those with higher BR at rest) contains subjects with subclinical sporadic ocular tics or dystonia. Follow-up of this population will provide the relevant clinical information. The study of movement disorders affecting eye blinking (e.g., dystonia or tics) will also clarify whether such movement disorders are associated with different behavioral BR patterns than those found in normal subjects.

Acknowledgment: The authors are indebted to Prof. Francesco Andreasi Bassi for statistical analysis of the data; they also thank Dr. Bruno Gregori who performed some video recordings. This study was supported in part by Comitato Promotore Telethon grant E.113 to A. A.

REFERENCES

1. Hart WM. The eyelids. In: *Adler's physiology of the eye.* 9th ed. St. Louis: Mosby, 1992.
2. Karson CN. Spontaneous eye-blink rates and dopaminergic systems. *Brain* 1983;106:643–653.
3. Zemetkin AJ, Stevens JR, Pittman R. Ontogeny of spontaneous blinking and of habituation of the blink reflex. *Ann Neurol* 1979; 5:453–457.
4. Ponder E, Kennedy WP. On the act of blinking. *Q J Exp Physiol* 1928;18:89–119.
5. Karson CN. Physiology of normal and abnormal blinking. In: Jankovic J, Tolosa E, eds. *Facial dyskinesias.* New York: Raven Press, 1988:25–37. (Advances in neurology; vol 49).
6. Fogarty C, Stern JA. Eye movements and blinks: their relationship to higher cognitive processes. *Int J Psychophysiol* 1989;8:35–42.
7. Holland MK, Tarlow G. Blinking and thinking. *Percept Motor Skills* 1975;41:403–406.
8. Naillon M, Rémond A. Le clignement palpébral: indice électrophysiologique du comportement. *Rev Electroencephalogr Neurophysiol* 1979;4:377–384.
9. Yap M. Tear break-up time is related to blink frequency. *Acta Ophthalmol* 1991;69:92–94.
10. Elston JS, Russell RWR. Effect of treatment with botulinum toxin on neurogenic blepharospasm. *Br Med J* 1985;290:1857–1859.
11. Karson CN, Kaufmann CA, Shapiro AK, Shapiro E. Eye blink rate in Tourette's syndrome. *J Nerv Ment Dis* 1985;173:566–569.
12. Stone LA, Jankovic J. The coexistence of tics and dystonia. *Arch Neurol* 1991;48:862–865.
13. Hall A. The origin and purpose of blinking. *Br J Ophthalmol* 1945;29:445–467.
14. Telford CW, Thompson N. Factors influencing eyelids responses. *J Exp Psychol* 1933;16:524–539.