Blink reflexes and the state of arousal

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SUMMARY Blink reflexes were studied in 40 subjects at rest and during the performance of a task. The early reflex (R1) showed an increase of amplitude of action potential during the task, the late reflex (R2) did not. The latency of R1 did not change within the 45 minute test period; R2 showed an increase of latency during task. R1 showed a systematic decrease in amplitude within rest and task periods, presumably because of habituation. R2 amplitudes decreased throughout the whole experiment, independent of task or rest.

Activation, due to the performance of a mental task, can be measured by several physiological parameters. Two types of recordings are generally used: first, registration of spontaneous activity of the organism in different circumstances as, for example, heart rate or skin resistance; secondly, recording of changes in responses after certain stimuli, evoked responses in EEG and reflexes being an example of the second kind. After the work of Paillard (1955) many experiments have been done using the amplitude of muscle action potentials evoked by a monosynaptic reflex to estimate the excitability of motoneurons. Differentiating effects have been obtained with different reflexes during a task. The action potential amplitude of tendon reflexes (TR) increased during the performance of a task, whereas Hoffmann reflexes (HR) did not, pointing to a lack of alpha-gamma co-activation (Brunia, 1971). With increasing time on a task, a systematic smaller increase in amplitude of TR has also been recorded and has been interpreted as a habituation phenomenon. Polysynaptic reflexes have also been investigated. Bathien (1971) found an increase of polysynaptic flexion reflexes in the biceps femoris muscle while performing a task.

Blink reflexes show striking similarities with flexor reflexes in general (Shahani, 1968; Shahani and Young, 1972). They consist of two components, an ipsilateral early reflex (R1) and a bilateral late reflex (R2). Although the discussion on the extero- or proprioceptive nature of the first component is not closed definitively, the majority of the arguments are in favour of the first possibility (Shahani, 1968; Shahani and Young, 1968; Penders and Delwaide, 1973).

R1 is oligo-, R2 polysynaptic and R2 especially decreases in amplitude and duration after repeated stimulation. This so-called habituation is maximal if

subjects are allowed to evoke their own blink reflexes (Shahani and Young, 1972). Gregorič (1973) states that R1 does not habituate at all. There are strong indications that the magnitude of the blink reflex depends on the vigilance level of the organism. Amplitudes are smaller during synchronised sleep (Ferrari and Messina, 1972; Kimura and Harada, 1972). Moreover, blink reflexes are diminished or absent during comatose states (Kimura, 1973) and blinking plays an important role in the so-called orientation reaction (Sokolov, 1963). Shahani and Young (1972) mention that fear, unrelated to the stimulus, causes an increase of R2. The same reaction is mentioned by Penders and Delwaide (1973) during stress and arithmetical calculation tasks. Gregorič (1973) reports a slower habituation when attention is distracted from the stimulation. No systematic research on the reaction of the blink reflex during mental tasks has yet been done. Activation and habituation effects are, however, indicated in the literature. In the present experiment the task previously used by Brunia (1971) has been employed.

Methods

The experiment included two different series. Forty healthy volunteer students of both sexes were used, 20 subjects in each series. Subjects sat in a comfortable chair in a shielded soundproof cabin. Both experimental series were subdivided into three periods: the first had 10 minutes rest, 20 minutes task and 10 minutes rest; the second had 10 minutes task, 20 minutes rest, and 10 minutes task. During the task periods subjects performed an auditory binary choice task. High (2400 Hz) and low (800 Hz) tones were presented in random order *via* a loudspeaker, using a frequency of 70 tones per minute. Two response buttons were located on the arms of the chair.

Subjects were instructed to press the right button when they heard the high tone and the left when they heard the low tone. The tones were not related to the electrical stimuli.

Electrical stimulation was applied using a Grass S88 stimulator and a Grass CCU 1A constant current unit. Two Ag-AgCl surface electrodes (EEG type) were placed on the left side of the forehead: the cathode on the supraorbital branch of the trigeminal nerve, the anode about 1 cm above this. The stimulation frequency was 1/7 s, and the duration 0.1 ms. Shock intensity differed for individual subjects so that R1 was maximal and approximately stable during 10 test stimuli with the chosen stimulation frequency. EMG responses were recorded by means of two Ag-AgCl surface electrodes placed on the medial portion of the left orbicularis oculi inferior muscle and on the left side of the nasal bone.

The responses were amplified by a Hellige EE preamplifier and recorded on a Hewlett-Packard instrumentation recorder (type HP3960, recording velocity 15/16 inch/s). Trigger-pulses from the stimulator were recorded on the second channel. Both the response and the trigger-pulse were monitored during the experiments on a Tektronix oscilloscope (single beam, type 5106/D10 with option P7).

The EMG of every seventh response was digitalised off-line using a DEC Lab 8/e computer. The sample frequency was 5 kHz. The digitalised signal was displayed graphically and by means of cursors the latency of R2 could be measured. Using a data-communication system, the digitalised responses were sent to a DEC PDP 11/45 computer for final calculations. After trend removal to correct for possible baseline drift, the latency of R1, the maximum peak-peak amplitude and the integral (full wave rectification) of both R1 and R2 were calculated. For each parameter, means and standard deviations per subject were computed over periods of five minutes. Means were transformed to standard z-scores for every subject. Mean z-scores of 20 subjects were computed, as were the concomitant 0.95 confidence limits. Student's *t* test for two dependent groups was used to investigate the differences between task and rest for all measured parameters.

Results

Results are summarised in Figs. 1 and 2 and the Table. Because the curves of the action potential amplitudes and the integral of the reflexes are approximately the same, the latter are not shown.

EARLY REFLEX

In both series the action potential amplitude is

larger during the task period (Figs. 1 and 2). This rest-task difference is significant ($p < 0.01$). Similar results have been observed for the integrated amplitudes, where the task scores are also significantly larger than the rest values. There is no significant task-rest difference for the latency of R1 (Table).

The amplitudes show a systematic decrease over time within both rest and task periods.

LATE REFLEX

In both series no task-rest differences have been observed for the action potential amplitude. The latency is always significantly prolonged during the task periods (Figs. 1 and 2 and Table).

The amplitude shows a systematic decrease over time in both series throughout the whole experiment, and not only within each rest and task condition as has been observed with R1. Almost no difference can be observed between the curves of series 1 and 2. The latency shows a continuous increase within both the rest and task periods, excluding the last five minutes of the rest period in series 2.

Discussion

Any performance presupposes a certain arousal level apart from the specific demands of the task under consideration. The increase of the amplitude of the early reflex is most likely to be an indication of a shift of the arousal level. So it is presumably part of a more general disinhibition or facilitation of the different motoneurone pools in the brainstem and spinal cord. An increase of monosynaptic reflex amplitudes has been previously mentioned by Bathien (1971) using different tasks, and also by Brunia (1971) using the same task. As far as monosynaptic reflexes are concerned, a differentiating effect of a task on H and T reflexes has been found (Bathien, 1971; Brunia, 1971). The only explanation of the results found by Brunia seems to be a lack of alpha-gamma coactivation (to be discussed elsewhere). Polysynaptic reflexes again show differentiating effects of tasks. Thus Bathien (1971) mentions an amplitude increase of the early component for a polysynaptic flexion reflex, without any change of the late response. This is in agreement with the R1 data presented in this paper. So the similarity of the organisation of the blink reflex and the flexion reflex, mentioned by Shahani (1968), holds also for the changes during arousal. It seems worth while to use the blink reflex because there is at least one aspect in which this does not follow the general reaction pattern of most reflexes. Beck *et al.* (1973) and Kimura and Harada (1972) mention a decrease of blink reflex amplitudes in sleep which agrees with other reflex data (Hodes and Dement, 1964). In stage REM, however, when

Fig. 1 Amplitudes and latencies of R1 and R2 action potentials during the first experimental series (see text), averaged over five minute periods (20 subjects). Vertical lines indicate the 0.95 confidence intervals.

other reflexes have their smallest amplitudes, blink reflex amplitudes increase again. Although the motor control of the blink reflex seems to be different from spinal reflexes in sleep, R1 follows the general activation pattern of mono-synaptic reflexes and first components of poly-

synaptic reflexes. R2 shows no effect of the arousal shift. The only finding is a continuously decreasing amplitude throughout the whole experiment. Presumably because of a greater number of synapses involved in the reflex arc of R2, a clear effect of the task cannot be expected. This is the more so as there

Fig. 2 Amplitudes and latencies of R1 and R2 during the second experimental series (see text), averaged over five minute periods (20 subjects). Vertical lines indicate the 0.95 confidence intervals.

is no direct relation between the specific systems activated to perform the task and the neural connections of the blink reflex. If a blink should be the demanded response to a given signal—for example, a tone—so that the output channel of the task is the same as that of the blink reflex, a more specific effect

might be expected. Requin (1969) and Gerilovsky and Tsekov (1975) have already carried out similar experiments with monosynaptic reflexes. In the near future we hope to present such data on the blink reflex as well.

The latency of R1 does not show any systematic

Table Student's *t* test values (two-tailed) of the integral, amplitude and latency for R1 and R2 in both experimental series (rest minus task)

	Blink reflex	
	Early	Late
Series I (rest-task-rest)		
Integral	-3.04*	+0.78
Amplitude	-3.18*	+1.49
Latency	-0.30	-3.94*
Series II (task-rest-task)		
Integral	-5.56*	-1.17
Amplitude	-4.56*	-0.92
Latency	+0.68	-3.46*

t values (rest-task).

**p* < 0.01.

differences between rest and task. Action potential amplitudes increase during the task. Thus our results indicate no correlation between latency and amplitude. This is contrary to the findings of Macarez and Henane (1974, 1975), who mention that in most of their subjects there was a negative correlation between the above-mentioned parameters in both H and T reflexes. R2 latency is larger during the task than at rest in both series. The presentation of the task is supposed to have caused a shift in the arousal level and—at least in the first experimental series—a change in the ongoing habituation. If anything, one would expect a smaller latency of R2 during the task than at rest, and also a systematic increase during the task. In fact we found a larger latency during the task. Indeed a systematic increase was found within the task period together with a systematic decrease of R2 amplitudes (Fig. 1). So our results are in agreement with those of Macarez and Henane for monosynaptic reflexes only during the task period in our first series.

Most authors agree on habituation of R2, but Gregorič (1973), in an investigation of habituation of the blink reflex, denies this phenomenon for R1. Our data show a systematic decrease of R1 amplitudes within both the rest and task situation. We think that this is due to habituation, although it does not meet all the criteria of Thompson and Spencer (1966).

The systematic decrease of amplitudes at rest will be more easily accepted as habituation than the same phenomenon during the performance of a task. Nevertheless, we are prepared to interpret our data during the task in the same way. A more detailed discussion on the differences and similarities between decrease of activation *versus* habituation is beyond the scope of this paper. For the time being, a decrease of activation is a less controversial interpretation of our data.

The authors wish to thank F. J. J. van Bussel (Department of Psychology, Tilburg) for the development of the computer programs and Henri de Haan for his assistance throughout the experiments.

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