CHRONOMETRIC ASPECTS OF INFORMATION PROCESSING IN HIGH LEVEL FENCERS AS COMPARED TO NON-ATHLETES: AN ERPS AND RT STUDY

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SUMMARY This study has investigated the chronometric aspects of Information Processing (IP) in high level fencers as compared to a non-athletes control group. Both RT and brain Event-Related Potentials (ERPs) were recorded.

The experimental task consisted of a go/no-go RT task, with two levels of stimulus discrimination difficulty.

The behavioural results showed that athletes are, on the whole, faster than the control group. Furthermore, the electrophysiological data evidenced that, whereas the athletes dealt with the task using a stable speed strategy in both the difficulty levels, the control group switched from a speed strategy in the easy discrimination task to an accuracy strategy when dealing with the difficult task.

This suggests the existence of interindividual differences on IP based on the individual skills.

Keywords: Fencers, chronometry, information processing

INTRODUCTION

Fencing is a sport discipline particularly involving attentional and informational processes on the part of the athletes. On the one hand,

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this high standard workload is common to all "Open skills" sport disciplines (Poulton, 1957): the relatively high "inconsistency" of this sport situation, actually, induces a conspicuous mental effort since it requires a continuous controlled mode of processing (Fisk, Ackermann and Schneider, 1987). From a practical point of view, however, an expert fencer may acquire a consistent previsional advantage leading the assault and making his opponent emit a foreseeable response. After a long period of training, an expert athlete may also elaborate heuristic rules towards processing of incoming information and, due to experience, may acquire a psychosemantic analytical ability which allows him to extrapolate, from the complexity of the situation, cues which grant him a decreasing use of the output coming from relatively slow decisional stages, and automatically trigger out the most useful responses from a visual pattern (Saibene et al., 1986).

On the other hand, if compared with other Open skill disciplines, fencing requires a higher level of accuracy and also extremely fast triggering off and execution response times, since the distance of the two competitors is particularly reduced.

Due to the extreme importance that Fencer's mental processes seem to have toward success, this discipline has been repeatedly studied by neuro-psychophysioligists and psychologists.

By means of psychophysiological methodologies mainly the sensorial aspects have been investigated, and prevalently from an energetical point of view: again, the experimental paradigms mostly requested the subjects to be behaviourally passive in respect to the experimental situation. For example, recent studies carried out recording visual evoked potentials (VEP) investigated the effect of boredom and fatigue conditions on activation levels (Rossi and Mecacci, 1988), and the effect of the time of the day over the early stages of Information Processing (IP) in fencers having different circadian typology (Mecacci and Rossi, 1987).

These studies have shown that (1) high level athletes as compared to non-athlete control groups are able to cope in a better way with situations of boredom and tiredness, investing in a more subtle way their resources over the day and (2) that the boredom affects only the early stages of sensory-perceptual IP.

The perceptual basic operations of visual IP have also been studied by means of VEP and some differences between fencers and control subjects have been evidenced in processing times of stimuli presented in peripheral and central visual fields. These data suggests the interesting hypothesis that the peripheral visual field may be more rapidly analyzed by these athletes, probably due to the advantage that this kind of
analysis produces in terms of fencing performance (Taddei et al., 1991).

Furthermore, through eye movements recording techniques, a significant difference in the modality of visual acquisition of information between fencers of various performance level has been evidenced (Bard, 1981).

Notwithstanding these psychophysiological findings, however, there is a lack of results regarding more complex cognitive aspects or the IP strategies adopted by these athletes to actively deal with various kinds of attentional psycho-motor tasks. Up to day, infact, only one study has been carried out aimed at investigating the dynamics of cognitive anticipation of administered stimulus-information (Dehousse and Timsit-Berthier, 1986). The experimental paradigm of this study, consisting in a choice RT to visual stimuli whose perceptual ambiguity were varied, was founded on the recording of the so called Contingent Negative Variation (CNV) or Expectancy Wave, and took in consideration its early, late and terminal phases. The results suggested to the authors that fencers as compared to long and middle distance runners, are more capable of modulating attentional resources in relation to the task demands dealt with, thanks to their greater emotional stability.

In spite of these interesting “energetical” results, however, the mental chronometry of the covert flow of IP subserving the motor output in these athletes is left almost completely open.

This is quite unfortunate, because the knowledge of the timing of the flow of IP in these athletes might help to understand, (1) the “features” of the skills subserving their psychomotor performance, and (2) the neurofunctional processes underlying the differences in motor speed revealed between them and athletes practicing other disciplines, or non-athletes group.

From some behavioural studies founded on Choice and simple RT to visual and acoustic stimuli recording, in fact, it has become evident that, unlike the majority of athletes practicing other sport disciplines, fencers resulted always faster in response time as compared with non-athletes control groups (Surkov, 1986).

Furthermore, an investigation based on the classic Posner paradigm, showed also that left-handed fencers as compared to the right-handed, are faster in responding with the preferred hand to unexpected peripheral stimuli. This result has been interpreted by the authors in terms of an attentional advantage, since the right hemisphere (controlling the left hand) is notoriously involved in sustained attentional processes (Bisiacchi et al., 1985).

Interestingly enough, in a more complex experimental situation, in
which both RT and movement time (MT) connected with the action of
touching a target with the weapon were recorded, higher levels fencers
appeared more rapid than fencers of lower level in MT, but not in RT.
This was true both in the condition in which the target had to be simply
touched, no matter the spatial precision of the touch, and when a higher
level of precision was requested. In interpreting these results the authors
suggested that, when a more complex movement is necessary, the best
athletes prefer to pre-program their action in a more complex manner
rather than starting it off hurriedly and to be forced to slow down the
execution to be able to end it up efficiently (Nougier et al., 1990).

Worth of notice is the fact that these studies consider only the
behavioural output (reaction time or movement time), i.e. the “product”
of IP, and, therefore, give no direct indications on the chronometric
dynamics of the various covert stages of Information Processing (Zani
and Rossi, 1991a).

Following the previous considerations, we carried out a first study on
the chronometric aspects of IP in high level fencers, advancing the
hypothesis that the possible greater rapidity of fencers as compared to a
control group might consist not only in a greater muscular fitness and
fluidity, but also in a different dynamics of IP stages underlying the
decision and triggering off of the response. We also assumed that this
different use might be further evidenced during a situation in which,
notwithstanding the experimental instructions (e.g., “press the button as
fast as possible”) the augmented discriminative difficulty of the stimuli
brought about a different balance of the speed-accuracy trade off.

To verify these hypotheses we utilized an experimental paradigm
based on the recording of both RTs and brain Event Related Potentials
(ERPs) in the context of an auditory discrimination task with two levels
of difficulty.

So far, in fact, the joint recording of the RTs and ERP bioelectrical
components represents the most fruitful method for gaining knowledge
of the chronometric dynamics (McCarthy and Donchin, 1981; Kutas
and Hillyard, 1984) and workload of IP covert stages (Wickens et al.,
1977) intervening between stimulus and response, and further, when the
subject is requested to actively deal with an experimental situation
(counting, choosing to emit or not the response, etc.) utilizing his
personal strategies and his experience in relation to the specific task
demands (Donchin, 1980; Zani and Rossi, 1991a, b).

More in detail, the N2 and the P300 components of ERPs have been
monitored because they have shown to index different processes under-
lying the emission of motor response.

The N2 recorded from brain central areas has, in fact, shown to be
related to the sensory discrimination necessary for the motor response (tactical component) (Ritter et al., 1979; Renault et al., 1982).

Conversely, the P300 component is interpreted as the expression of the conceptual comparison between incoming information and its model contained in the short term memory (Donchin, 1980; Donchin et al., 1986).

More specifically, it would represent the contextual updating of the mental schemata whenever the incoming information conceptually mismatch with the latter. This, of course, is aimed at the best prosecution of the task which is being performed (strategical component) (Donchin, 1980; Zani, 1988).

This component has shown different temporal relations with RT depending on whether the task is dealt with a speed criteria (the peak latency of the P300 follows the RTs) or an accuracy criteria (the peak latency precedes the RTs and shows a strict temporal contiguity with them) (Kutas et al., 1977; Rossi and Zani, 1991).

Previous studies, carried out by us on high level athletes of different sport disciplines (clay-pigeon shooting and modern pentathlon), utilizing these psychophysiological tools have suggested the existence not only of different "attentional styles" bound to the specific cognitive skills related to their specific sport practice (Zani and Rossi, 1990, 1991), but also, in general, of different IP modes even when the RTs are identical (Rossi and Zani, 1991).

Since this kind of differences become evident only during active experimental tasks in which the subjects were requested to actively process the information and, conversely, were absent during the passive reception of the latter, empirical support is given to the hypothesis that an important part of the performance advantage in high skill athletes (especially in some sport disciplines) could depend on the development of a more apt software rather than on the "priori" presence of a better hardware (Starkes and Deakin, 1984; Allard and Burnett, 1985; Rossi, 1991).

**Method**

Eleven fencers of the Italian National Team (four practicing the foil, three the sword and four the sabre; age = 23.5, sd = 3.7) and ten control subjects (same cultural and social level; age = 24.1; sd = 3.9) volunteered in this study.

The laboratory task consisted of two auditory discrimination experimental conditions controlled by an Apple IIe microcomputer: an "easy" and a "difficult" conditions.
In the "easy" condition, the run consisted of a randomized sequence of 65 dB SPL 1,000 Hz (low pitch) and 2,000 Hz (high pitch) tone bursts, whereas in the "difficult" condition the run consisted in a sequence of 1,000 Hz (low pitch) and 1,050 Hz (high pitch). In both conditions the high-pitch stimuli occurrence probability was 20%. Subjects were requested to press as fast as possible a lever with their preferred hand in response to the rare tones for the measurements of their RTs.

Rare tone-related brain potentials were also recorded by means of an Ag/AgCl electrode placed on the Vertex of the scalp (Cz), referred to the linked earlobes, and grounded at the forehead according to the International 10–20 system (Jaspers, 1958).

A second pair of electrodes placed above and below the right eye allowed the rejection of the trials contaminated by eye movements and blinking.

The interstimulus interval (ISI) was 1-65 sec. Selected 1-6 sec epochs of EEG data were sampled at a rate of 4 msec/pt. Stimulus onset occurred 0-8 sec after the start of each sampled epochs. EEGraph low-pass and high-pass filters were set at 0.16 and 30 Hz, respectively. Each run continued until 20 artifact-free target related EEG epochs had been recorded and averaged.

Both RTs and ERPs were recorded on disk for off-line analysis.

The N2 and P300 peak latency were measured within the following latency range: 200–300 msec, and 250–500 msec, respectively.

RESULTS

A two-way repeated measures analysis of variance with "group" (fencers vs control) as between factor, and the "task difficulty" (easy vs difficult) as within factor were performed both on the RT and N2 and P300 latency measures.

The ANOVA regarding the RTs evidenced that the fencers attained consistency earlier RT than the control group (F(1, 19) = 20.9, p < 0.001) and that the difficulty interfered on the response speed (F(1, 19) = 29.6, p < 0.001). The ANOVA also revealed a significant interaction between group and task difficulty (F(1, 19) = 5.82; p < 0.02).

The simple effect analyses showed that whereas fencers show a quite stable behavioural output no matter the discriminative difficulty of the task (F(1, 19) = 4.3; n.s.), the control subjects were strongly influenced by the latter (F(1, 19) = 29.5; p < 0.01).

As concerns the N2 latency peak a significant difference between the group (F(1, 19) = 11.53, p < 0.05) and the two task difficulties (F(1, 19) = 4.5, p < 0.04) was evidenced.
As regards the P300 latency, instead the ANOVA showed a significant difference between the groups ($F(1, 19) = 7.85, p < 0.01$) and the task difficulty levels ($F(1, 19) = 11.26, p < 0.003$).

**Discussion**

On the whole, this study has, evidenced a better performance of fencers than the control group in terms of response speed, independently of the task difficulty. It has also shown the existence of interindividual differences in the timing of IP stages indexed by the N2 and P300 ERP components.

The behavioural data are in agreement with what already evidenced in previous studies (see Surcov, 1986 for a review) showing that, unlike the majority of athletes practicing different sport activities, the high level fencers are always more rapid than non-athletes on each laboratory paradigms using simple and choice RTs recording.

This result reinforced the hypothesis that the peculiar characteristics of this discipline request particular speed abilities in elaboration and execution, even if it does not shed light over the question whether these skills are acquired or not.

It is worth of notice that, while the task difficulty is significantly influent on the control group response latency, the fencers appeared to be quite stable in their behavioural output although evidencing a slight tendency toward a slowing down.

This let one infer the existence of a better dealing with the processes resulting in the acting out of the motor response. The N2 and P300 latency results converge to backing this hypothesis.

In despite of the fact that globally both fencers and controls seem to use a strategy based on speed and that, refers to the same IP stage (i.e., N2), the two groups show already at the stage indexed by this component, a different efficacy.

The analysis of the data relative to the N2 latency (which further show to be strictly linked with the decision about the acting out or not of the motor response to each single stimulus consistently with the results of Ritter et al. (1979) and Renault et al. (1982)) shows that fencers are faster in the conclusion of this IP stage.

Furthermore, they are capable of maintaining the same timing in respect to the increase of the discriminative task difficulty. This result reveals remarkably consistent with what has been previously found in high level athletes practicing clay-pigeon shooting and modern pentathlon (Rossi and Zani, 1991; Zani and Rossi, 1991a).
As regards the P300 latency, what becomes evident is a significant slow down of its peak as a function of the task difficulty.

This further supports the well known idea (Donchin, 1980) that this component may reflect the categorization processes dependent on the stimulus evaluating operations, but not the processes linked to the response system.

This idea is also backed by the relationship shown by the P300 peak and RTs. The data show that, on the whole, the peak latency of this component follows the RTs. This result might be interpreted as the effort on the part of the subjects in respecting the experimental instructions, utilizing a strategy privileging response speed rather than accuracy and which, consequently, bases the response emission on a less complete evaluation of information.

This strategy, however, is shattered in the control group when the difficult task is faced: in this case, because of the uncertainty due to the scarce discriminability of the target-stimulus, this group seems to be compelled to postpone the response execution after the P300-peak latency. This is probably aimed at utilizing, besides encoding and identification processes, also the results of the concluded categorization processes. As a consequence, this slows down the response.

Conversely, the fencers seem to prefer in any case to emit the response quickly, also in the difficult task, respecting the experimental in-
P300 LATENCY AND RT

Figure 2. P300 latency and RT in msec in fencers and control group as a function of the two levels of task difficulty.

Strications and assuming some risks in terms of accuracy. Furthermore, they keep on utilizing the psychosemantic processes in solving "a posteriori" the uncertainty about the decision on the stimulus nature.

On the whole, these data seem to back the idea that IP and motor response processes are parallel, and that their temporal relations are dependent on tasks, stimulus conditions, subject's strategies, etc.

Thus, the advantage evidenced by fencers could be linked to their better efficiency in managing, in a "parallel" manner, the motor and elaboration processes as suggested also by the faster P300 peak latency shown by these athletes. This is probably due to the great psychomotor automatization based on their sport skills of producing particularly fast responses.

In the difficult task, therefore, the greater speed of their RTs in comparison to that of the control group, might be interpreted as a consequence of this automatization, probably reflected by the N2, which is, in the same way, more rapid than in the control group.

In conclusion, the present findings suggest that it is probable that the fencers might have adopted a processing strategy mainly based on stimulus encoding and identification operations. This may be due to the fact that in their specific sport task it may be preferable to respond also
when the certainty is low rather than to wait, thereby missing once for all the possibility to do it.

Conversely, the data suggest that the control group, already slow in the easy task, seems to be compelled to change its strategy in the difficult task, trying to use the output of the psychosemantic stage before the acting out of the behavioural response. This strategy makes their performance even worse.

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REFERENCES


