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TITLE

Information processing and performance in clay-
pigeon shooters: An Event-related Brain Potentials

and Reaction Time study.

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DISCIPLINARY AREA

Sport Psychology
Rather recently, sport psychologists have devoted a great deal of effort to study athletic performance from the Human Information Processing viewpoint. The interest has grown, in fact, in the way skilled performers handle information in perception, decision and organization of motor actions according to task demands (Marteniuk, 1976; Kelso, 1982).

In this theoretical framework, experimental research has focused mainly on attentional and cognitive processes (Alain & Proteau, 1980; Nougier, Ripoll & Stein, 1987; Abernethy, 1987).

A sport discipline in which the intervention of attention has been particularly stressed is clay-pigeon shooting because in both the specialties of this discipline (trap and skeet) the attentional resources expenditure is thought to be very high. However, up to date not much information is available, to our knowledge, about attentional processes in these athletes.

Thus, we addressed this question by means of electrophysiological techniques which permit continuous monitoring of the electrical potentials of the brain associated with stimulus and cognitive events ("Event-related cerebral potentials" or ERPs) (Donchin, Karis, Bashore, Coles, & Gratton, 1986).

We found evidence that, in order to spare attentional resources, clay-pigeon shooters recur to short-term displacements upon a continuum between an automatic and a

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controlled mode of processing, focusing their processing activity on relevant information while ignoring irrelevant information (Zani & Rossi, 1987). In addition, further results indicate that in these athletes the stages of information processing seem to be affected in a different manner by the specific sport task, in a way that it seems possible to talk about two different attentional "styles". Whereas, in fact, trap shooters give the impression to make mainly use of a bottom-up or data-driven processing mode related to perceptual evaluation of incoming information, skeet shooters appear to make mainly use of a top-down or knowledge-driven processing mode (Zani & Rossi, 1988: in press).

This view is suggested by the fact that trap shooters show consistently larger amplitudes than skeet shooters for the N2 component of the ERPs, a component that has been related to perceptual processing of information (Näätänen, Alho, & Sams, 1985) and motor-related decision making (Kitter, Simson, Vaughan & Friedman, 1979; Renault, Ragot, & Remond, 1982). The contrary appears to be true for the P300 and slow wave, two components that have been related to short-term memory updating and cognitive evaluation of incoming information (Donchin, Karis, Bashore, Coles, & Gratton, 1986; Ruchkin & Sutton, 1983).

As a part of a project to investigate attentional mechanisms in clay-pigeon shooting, the present study attempted to shed some light on the temporal aspects of the flow of information processing in these athletes by means of an experimental

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paradigm based on ERPs and reaction time (RT) recording. Relatively to the behavioral output, in fact, ERPs have shown to provide reliable information about the timing of neural events which intervene between stimulus and response because they allow a more direct access to sensory and cognitive channels (Kutas, McCarthy, & Donchin, 1977; McCarthy & Donchin, 1981).

METHOD

Three skeet and 3 trap shooters from the Italian National Team were studied. They were all right handed. The laboratory task consisted of two experimental conditions controlled by an Apple IIe microcomputer: "easy" and "difficult" auditory discrimination. An "easy" run consisted of a sequence of 65 dB SPL, 1000 Hz (low pitch) and 2000 Hz (high pitch) tone bursts, whereas a "difficult" run consisted of a sequence of 65 dB SPL, 1000 Hz (low pitch) and 1050 Hz (high pitch) tone bursts, delivered binaurally through headphones at a rate of one every 1650 msec. In both conditions, high pitch stimuli occurrence probability was 20%. Subject's task was to press a lever as fast as possible in response to high pitched tones for the measurements of his reaction times.

High pitch tones related brain potentials were recorded from the Vertex of the scalp by means of an Ag/AgCl electrode referred to linked earlobes and grounded at the forehead. 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

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each sampled epoch. Both the RT and ERPs were recorded on disk for off-line analysis.

Later on, peak latencies for the N2 and P300 components were measured in fixed latency ranges. On the basis of visual inspection of individual ERPs and of automatic cursor alignment on the microcomputer monitor display, peak latency criteria were fixed allowing measurement reliability for the greater number of curves. These criteria were 180-300 msec for N2 and 250-500 msec for P300.

RESULTS

Both reaction time and N2 and P300 latency measures were submitted to a two-way repeated measures analysis of variance (ANOVA) with specialty (skeet vs trap) as between factor and task difficulty (easy vs difficult) as within factor.

The ANOVA revealed that skeet shooters attained consistently earlier latencies than trap shooters for both the N2, F(1,4)=84.75; p<0.0005, and P300, F(1,4)=7.81; p<0.05, components, as can be clearly seen in Fig. 1. In addition, a significant interaction between specialty and task difficulty, F(1,4)=16.62; p<0.01, was obtained for the reaction time measures.

Tests for simple effects showed that the increment of the difficulty of the auditory discrimination task slowed down the behavioral response of skeet, F(1,4)=22.98; p<0.01, but not of trap shooters.

Further tests clearly showed that whereas the easy task did

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not yield significant differences in the RT speed between the two specialties, the difficult task yielded significantly slower RT in skeet, \( F(1,4)=13.47; \ p<0.025 \), than in trap shooters.

**DISCUSSION**

Present results seem to confirm our previous findings showing a skill-based behavior in trap and a knowledge-based behavior in skeet shooters strictly bound to the temporal uncertainty characterizing the skeet task and the spatial uncertainty characterizing the trap task, respectively (Zani & Rossi, 1987; 1988).

Independently of the task difficulty, the use of a bottom-up strategy allowed the trap shooters to obtain a constant output in terms of reaction times. As a consequence, this strategy permitted them to respect, as a whole, the instruction of speed in both the tasks.

On the contrary, the top-down strategy adopted by skeet shooters compelled them to trade speed with accuracy when the discrimination of the target stimulus was made difficult. In this condition, in fact, the a posteriori uncertainty about the nature of the stimulus is high and, for this reason, skeet shooters seem obliged to recur in a more consistent way to knowledge schemas to emit their motor response.

This view is strongly supported by the fact that in these athletes the RT follows the P300 peak in the difficult discrimination task, whereas in the easy task the RT precedes this peak following immediately the earlier N2 peak. These

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findings show a close agreement with the results obtained by Kutas, McCarthy & Donchin (1977) showing a speed-accuracy trade-off according to the instruction given to the subjects to cope with task demands. However, going further, they suggest the existence of interindividual differences in this trade-off strategy systematically related to the specific skills showed by the individuals.

Altogether, then, the present results give further support to our previous findings showing neat individual differences in attentional "styles" between the specialties of clay-pigeon shooting (Zani & Rossi, 1987; 1988). In addition, this seems to confirm the view, gained from field experience, that for top level clay-pigeon shooters it is rather difficult to obtain high scores when performing the specialty for which they are not skilled (i.e., trap shooting for skeet shooters and vice versa). However, this seems to be particularly true for skeet shooters.

In conclusion, even though these results have to be further confirmed, it seems possible to suggest that, beyond a theoretical interest in the study of individuals particularly efficient from the information processing point of view, i.e., the top-level athletes, the experimental research in this field can help to single out additional training methods, for example simulated lab tasks, suited to further improve the performance and/or to make easier the learning processes in young categories.

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Fig. 1 - N2, P300, and RT latencies for skeet and trap shooters as a function of the difficulty (E = Easy and D = Difficult) of the auditory discrimination task.