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SPATIAL COMPATIBILITY EFFECTS IN DIFFERENT SPORTS

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The spatial relationships between stimulus and response is one of the most important determinants of speed of response in reaction time tasks. They give rise to the phenomenon of spatial compatibility, which shows that spatially congruent (i.e., compatible) responses are faster than spatially incongruent (i.e. incompatible) responses.

The compatibility effect was measured in two groups of athletes who practiced two different sports, soccer and volleyball. It was found that the compatibility effect was much stronger for volleyball players than soccer players. This difference can be attributed to either the training method or the preferential use of different effectors in the two sports.

Introduction

This paper dealt with the problem of visuo-motor integration, whose importance is of obvious relevance for every sport. More specifically, the aspect of visuo-motor integration considered in this study was Stimulus-Response (S-R) compatibility (Fitts, 1951). In choice reaction time (RT) tasks the type of S-R pairing is of paramount importance in determining the speed of response. Those pairings that yield the shortest RTs are said to be the most compatible ones (see, e.g., review in Teichner & Krebs, 1974). When the property of S-R pairing that brings about compatibility is the spatial relationship between the stimulus and the response, two types of compatibility can be distinguished, namely, spatial compatibility and the Simon effect (see Nicoletti, Anzola, Luppino, Rizzolatti & Umiltà 1982; Nicoletti & Umiltà, 1984; Simon, Sly, & Vilapakkam, 1981; Umiltà & Nicoletti, 1985 see also Hedge & Marsh, 1975, who proposed the term Simon effect).

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Spatial compatibility proper is observed when the location of the stimulus provides the relevant cue for selecting the correct response. For example, in a condition in which the right or left position of the stimulus requires a response with the right or left key, RTs are faster when the spatial locations of stimulus and response correspond (right-right and left-left) than when they do not (right-left and left right). The Simon effects is observed when the stimulus provides a locational cue that is not required for selecting the correct response. For example, even if it is color that indicates the side of the correct response (e.g., red light-right key and green light-left key), RTs are faster when the position correspond (i.e., stimulus and response are both on the right or left side) than when they do not (i.e., the stimulus appears on one side and the key is located on the other side). The distinction between spatial compatibility and the Simon effect is important from a theoretical point of view, but is not relevant for the purposes of the present study. Therefore, although in it we measured the Simon effect, we will use, for sake of clarity, the more general term spatial compatibility.

The experiment reported here investigated whether S-R compatibility is different in athletes performing different sports. More precisely, it was asked whether the advantage in speed of response of compatible over incompatible S-R pairings depends on the training methods specific of different sports.

Soccer and volleyball were chosen because soccer players were trained according to the symmetry of movement method, whereas volleyball players were trained in a nonsymmetrical way (Starosta, 1984, 1985). Futhermore, irrespective of the specific method of training adopted, in soccer there is already a natural tendency toward symmetrical training since the use of both feet is highly desiderable. Accordingly, every player, regardless of his preferred foot, is given the same amount of practice to both legs. Of course, that should favour visuo-motor integration equally on both sides of space.

In contrast, volleyball is characterized by a strong specialization of the preferred arm (e.g., to serve, hit and dink). In other cases, volleyball players tend to use the two arms as they were a single effector (e.g., to set, defend and block). Apparently, the roll phase is the only one for which the player would need a symmetrical training. This is because he is asked to defend with either the right or left arm, depending on the side from which the ball comes.

In conclusions a soccer player trained with the symmetry methods is required to maximize efficency of visuo-motor integrations on both sides of the body. By contrast, volleyball players, trained in the traditional way,

tend to strengthen the visuo-motor integrations of the dominating arm.

The goal of the present study was that of showing differences in S-R compatibility between two groups of athletes who were trained in a symmetrical or nonsymmetrical way, depending on the type of sport they performed.

Method

Fifty-five athletes between the ages of 15 and 17 (35 for volleyball and 20 for soccer) took part in the experiment. All were right handed, had normal visual acuity, and were naive as to the purpose of the experiment. Their level of skill was very good: all of them played in the junior teams of professional clubs. Soccer players were trained according to the symmetry of movement method, whereas the volleyball players were trained according to a traditional that is a nonsymmetrical, method.

Apparatus and Procedure

The subject sat in front of a CRT screen driven by an Apple IIe computer. The head was positioned in an adjustable head-and-chin rest, so that the distance between the eyes and the screen was approximately 50 cm. The visual display comprised the following items. One fixation cross. 0,5 × 0,5 deg in size, shown at the geometrical center of the screeen; a small square, 1,43 × 1,43 deg, and a small rectangle, 1,34 × 1,46 deg, both shown at 3,43 deg from the fixation point. The square and the rectangle were the stimuli and were presented either on the right or the left of the fixation cross for a duration of 100 msec. Side of presentation and type of stimulus were determined according to a quasirandom sequence that allowed a maximum of three consecutive trials of the same type. An acoustic warning signal preceded the stimulus by an interval of 1 sec. From the warning signal to the execution of the response the subject had to mantain his gaze on the fixation point. Interstimulus interval was 1 sec. The subject was instructed to press the left side button for the square and the right side button for the rectangle.

The procedure was that usually employed for studying the Simon effect (see, e.g., Simon et al., 1981; Umiltá & Nicoletti, 1985). The experiment was run individually and each subject participated in three experimental sessions. The first and the third session took place at resting, the second session took place immediately after a two-hours period of heavy training.

Each session comprised two conditions of S-R pairing. Half of the 100 trials were compatible, in the sense thast the stimulus commanded a response with the key located in spatial correspondence with it (i.e., the right-side stimulus was responded to with the right-side key and the left-side stimulus was responded to with the left-side key). The other 100 trials were incompatible because the stimulus commanded a response with the key located on the opposite side (e.g., the right-side stimulus was responded to with the left-side key and the left-side stimulus was responded to with the right-side key). The instructions were given in terms of the shape of the stimulus (i.e., the square required a response with the left side key, whereas the rectangle required a response with the right-side key) and stressed both speed and accuracy. Feedback was given about both speed and accuracy.

Results

For the soccer group errors were about 4% for compatible and 5% for incompatible trials, whereas the corresponding figures for the volleyball players were 3% for compatible and 6% for incompatible trials.

For both groups the correct mean RTs were entered into a three way within-subjects analysis of variance. The factors were Session (rest 1, training and rest 2), Visual Field (right or left) and responding Hand (right or left).

The main factor Session was significant, $F(2,28) = 18.11$, $p<0.001$, only for soccer player. As shown in Figure 1, RTs were faster in the second session (training) than in the other two (rest 1 and rest 2). For volleyball players this factor did not reach significance, although the data showed the same trend (see Figure 1). The interaction between Visual Field and responding Hand was significant for both groups: $F(1,19) = 5.09$, $p<0.05$, for soccer players, and $F(1,14) = 29.26$, $p<0.001$, for volleyballa players. In both cases, as can be seen in Figures 2 and 3, compatible responses (i.e., those emitted on the same side of the stimulus) were faster than incompatible responses (i.e., those emitted on the opposite side in relation to the stimulus). In the case of volleyball, also the interaction among Session, Visual Field and responding Hand was significant, $F(2,28) = 8.23$, $p<0,005$. This was because the compatibility effect (i.e., the advantage of compatible over incompatible responses) decreased from the first to the last session (see Figure 4).

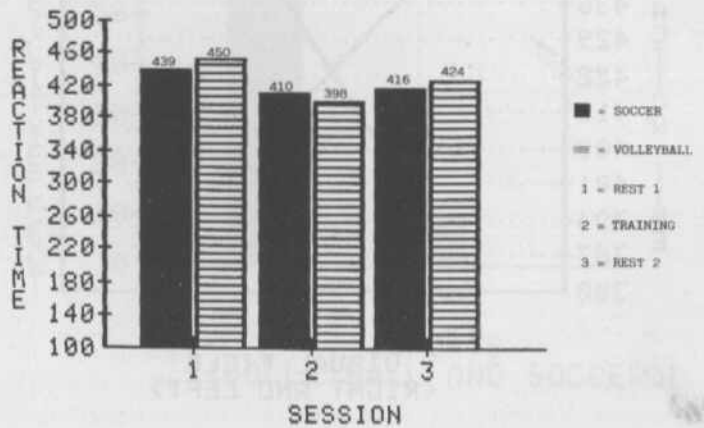

Fig. 1. - RTs in milliseconds as a function of type of sport and session of testing.

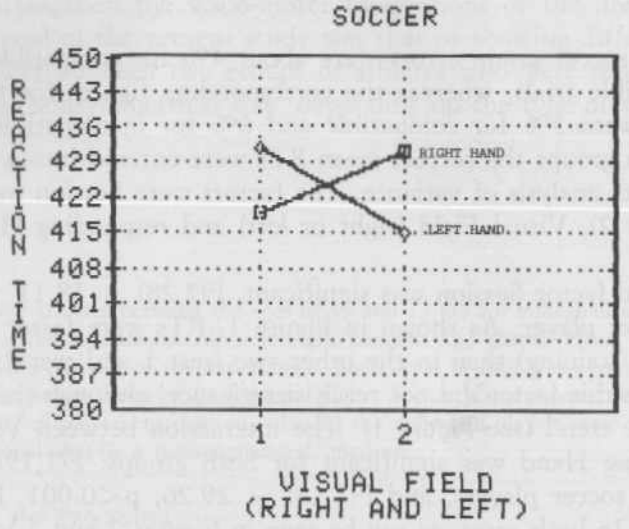

Fig. 2. - Soccer. RTs in milliseconds as a function of side of stimulation and responding hand.

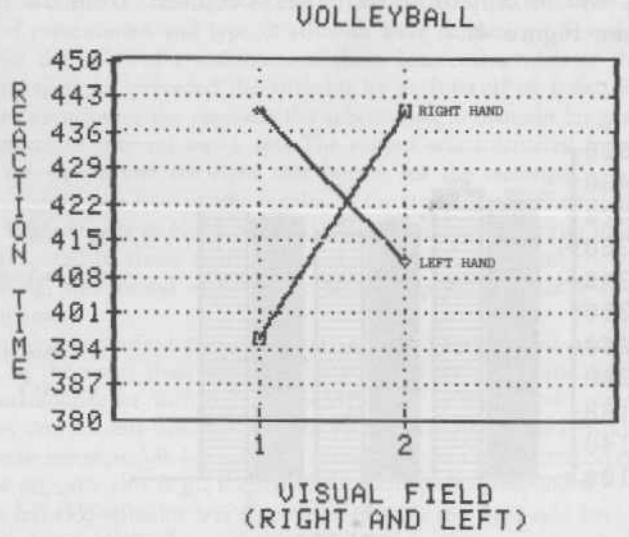

Fig. 3. - Volleyball. RTs milliseconds as a function of side of stimulation andresponding hand.

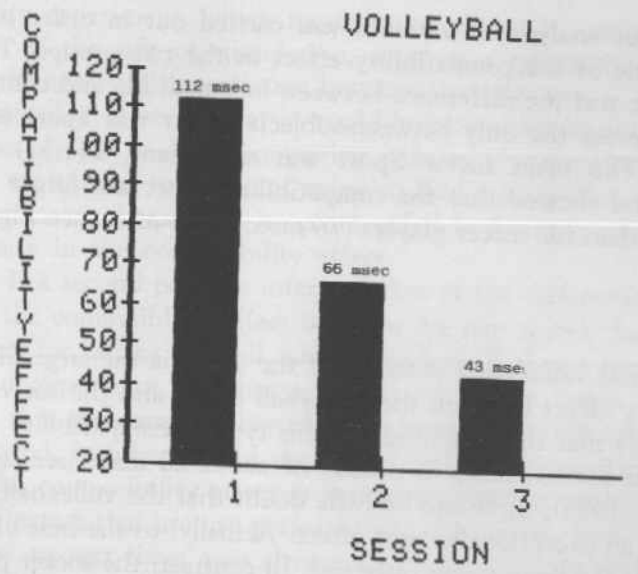

Fig. 4 - Compatibility effect (in milliseconds) in the three sessions for volleyball players.

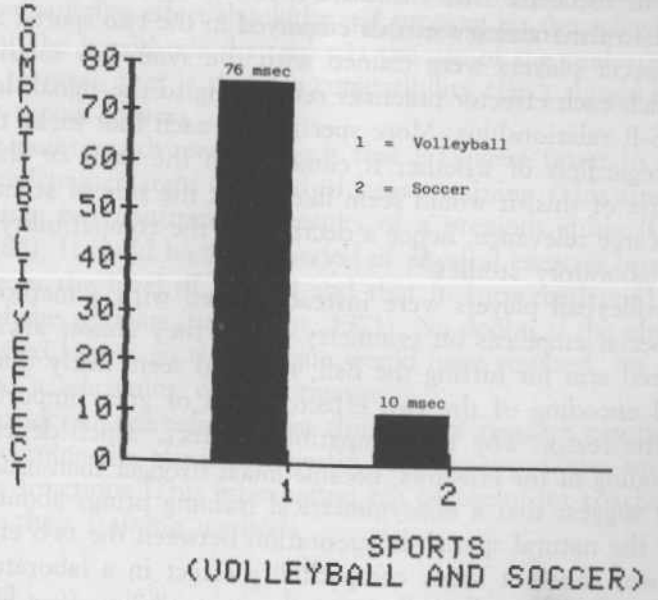

Fig. 5. - Magnitude of the compatibility effect (in milliseconds) for volleyball and soccer players.

A further analysis of variance was carried out in order to compare the magnitude of the compatibility effect in the two groups. The dependent variable was the difference between incompatible and compatible responses, whereas the only between-subjects factor was Sport (soccer and volleyball). The main factor Sport was significant, $F(1,53) = 19.48$, $p < 0.001$, and showed that the compatibility effect was larger for volleyball players than for soccer players (76 msec vs 10 msec; see Figure 5).

Discussion

The most interesting outcome of the study is the large difference in compatibility effect between the volleyball group and the soccer group. If one considers that the magnitude of this type of compatibility effect (i.e., the so-called Simon effect) is usually of about 20 msec (see, e.g., Umiltà & Nicoletti, 1985), there can be little doubt that the volleyball players demonstrated an exceptionally large effect. Actually, to the best of our knowledge, this is the largest ever observed. In contrast, the soccer players, showed a compatibility effect that, if anything, was smaller (10 msec) than usual.

One can speculate that the difference in the compatibility effect is attributable to the training methods employed in the two sports. As said before, the soccer players were trained with the symmetry method, according to which each effector practices responding to the signal, irrespective of spatial S-R relationships. More specifically, each foot kicks the ball effectively, regardless of whether it comes from the same or the opposite side. Because of this, it would seem likely that the side of stimulation becomes of scarce relevance, hence a decrease in the compatibility effect observed in laboratory studies.

The volleyball players were instead trained with a method that did not put special emphasis on symmetry. Since they almost always employ the preferred arm for hitting the ball, it would seem likely that for them the spatial encoding of the two effectors was of great importance. This could be the reason why the compatibility effect, which depends on the spatial encoding of the effectors, became much stronger than usual. In other words, we suggest that a nonsymmetrical training brings about an enhancement of the natural spatial differentation between the two effectors and this, in turn, causes a larger compatibility effect in a laboratory setting.

The fact that for volleyball players the compatibility effect became smaller from the first to the last session (see Figure 4) can be taken as supportive of this hypothesis. in some sense, it can be argued that the present

compatibility experiment, which requires the subject to use each effector irrespective of the side of stimulation, acted as a symmetry training and decreased the spatial differentiation between the effectors.

In conclusion, it seems that it would be interesting to extend the findings of the present study by comparing athletes who practice in different sports and are trained in different ways, to find out whether the development of symmetrical reactions is accompanied by better performance and by a decrease in the compatibility effect.

There is a second possible interpretation of the difference in the magnitude of the compatibility effect between the two sports. Soccer players use their feet for hitting the ball, whereas volleyball players use their arms. Since in our experience the effectors were always the hands, it could be maintained that the compatibility effect is stronger for the effectors more often employed. In other words, the spatial differentation of the effectors, on which the compatibility effect is known to depend, could be stronger for those effectors that are use preferentially. Of course, there is a straigh forward way to test these two alternative hypotheses. In an experiment identical to that described here but in which the effectors are the feet instead of the hands, the two hypotheses make different predictions. The hypothesis that stresses the importance of the symmetry training predicts that the compatibility effect should be still stronger for the volleyball players. In contrast, the hypothesis that stresses the use of the preferred effectors predicts a reversal, that is that the compatibility effect should become large for the soccer players.

A last point worth mentioning is that RTs were faster in the session that followed immediately a period of heavy training. This finding might seen puzzling, but confirms the results of a previous study (Castiello & Umiltá, 1985). It could be that a period of physical exercise brought about an increase in the level of arousal and that in turn renderend easier the detection of the stimulus (Broadbent, 1971). No doubt, if the physical exercise had lasted lorger, so that fatigue would have resulted, we should expect instead a worsening of performance.

All considered, we believes that this type of research can provide empyrical concerning the effects of specific training procedures on elementary cognitive functions. This information can be useful for coaches in order to improve their training methods.

Acknowledgment

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RÉSUMÉ

Dans les temps de réaction de choix à des stimulations visuelles latérales, lorsque la position de la stimulation et la position de l'effecteur sont du même côté on obtient des réponses plus rapides par rapport à la situation dans laquelle la stimulation et l'effecteur sont placés dans de s positions opposées. Dans le premier cas la rapport spatial entre la stimulation et la réponse est dit «compatible», tandis que dans le deuxième cas il est dit «incompatible». La facilité des réponses compatibles par rapport à celles incompatibles est définie «effet de compatibilité S-R».

L'effet de compatibilité a été mesuré sur deux groupes d'atlètes pratiquant des disciplines sportives différentes, football et volley-ball. It a été trouvé que l'effet de compatibilité est beaucoup plus accentué pour les joueurs de volley-ball que pour les joueurs de football. Cette différence peut être attribuée aussi bien à la méthodologie différente d'entraînement adoptée par les deux groupes qu'à l'emploi d'effecteurs différents pour pratiquer les deux sports.

RESUMEN

Cuando en los tiempos de reaccion de elección a estímulos visivos lateralizzados la posición del estímulo y la posición de quien efectúa están de la misma parte se obtienen respuestas más veloces con respecto a la situación en la que el estímulo y el que efectúa están situados en posiciones opuestas. En el primer caso la relación de espacio entre el estímulo y la respuesta se denomina «compatible», mientras que en el segundo caso se denomina «incompatible». La facilitación de las respuestas compatibles con respecto a aquellas incompatibles se denomina «efecto de compatibilidad S-R».

El efecto de compatibilidad ha sido medido en dos grupos de atletas que practican disciplinas deportivas diferentes: fútbol y volibol. Se ha econtrado que el efecto de compatibilidad es mucho más acentuado para los voleibolistas que para los futbolistas. Se puede atribuir esta diferencia tanto a la diferente metodologia de entrenamiento adoptada por los dos grupos así como al uso de diferentes para desempear los dos deportes.

ZUSAMMENFASSUNG

In den Reaktionszeiten der Wahl des seitlichen visiven Anreizes, wenn die Position des Anreizes und die Position des Effektors auf der gleichen Seite sich befinden, arhält man schnellere Antworten als wenn der Anreiz und Effektor sich in gegenübergestellten Positionen befinden. Im ersten Fall ist die räumliche Benziehung zwischen dem Anreiz und der Antwort vereinbar wärend sie im zweiten Falla nicht vereinbar ist. Dei Erleichterung der vereinbaren Antworten bezüglich jener nicht zu vereinbarenden wird als «Effekt der Kompatibilität S-R» bezeichnet.

Der Kompatibilitäts-Effekt wurde bei zwei Athleten-Gruppen gemessen, die verschiedene Sportdizziplinen ausüben, Fussball und Volleyball. Dabei wurde herausgefunden, dass der Kompatibilitäts-Effekt wesentlich stärker ist bei den Volleyball-Spielern als bei den Fussball-spialern. Dieser Unterschied Kann sei es der verschiedenen Traininga-Methodologie der zwei Gruppen zugeschrieben werden wie aber auch dem Gebrauch verschiedener Effektoren, fum beide Sporterten auszuüben.

RIASSUNTO

Nei tempi di reazione di scelta a stimoli visivi lateralizzati, quando la posizione dello stimolo e la posizione dell'effetore sono dalla stessa parte si ottengono risposte più veloci rispetto alla situazione in cui lo stimolo e l'effettore sono situati in posizioni opposte. Nel primo caso il rapporto spaziale tra lo stimolo e la risposta è detto «compatibile», mentre nel secondo caso è detto «incompatibile». La facilitazione delle risposte compatibili rispetto a quelle incompatibili viene definita «effetto di compatibilità S-R».

L'effetto di compatibilità è stato misurato su due gruppi di atleti praticanti discipline sportive differenti, calcio e pallavolo. È stato trovato che l'effetto di compatibilità è molto più accentuato per i pallavolisti che per i calciatori. Questa differenza può essere attribuita sia alla diversa metodologia di allenamento adottata dai due gruppi che all'uso di effettori differenti per svolgere i due sport.

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