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RESEARCH ARTICLE

Local contextual processing of abstract and meaningful real-life images in professional athletes

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Abstract We investigated the effect of abstract versus real-life meaningful images from sports on local contextual processing in two groups of professional athletes. Local context was defined as the occurrence of a short predictive series of stimuli occurring before delivery of a target event. EEG was recorded in 10 professional basketball players and 9 professional athletes of individual sports during three sessions. In each session, a different set of visual stimuli were presented: triangles facing left, up, right, or down; four images of a basketball player throwing a ball; four images of a baseball player pitching a baseball. Stimuli consisted of 15 % targets and 85 % of equal numbers of three types of standards. Recording blocks consisted of targets preceded by randomized sequences of standards and by sequences including a predictive sequence signaling the occurrence of a subsequent target event. Subjects pressed a button in response to targets. In all three sessions, reaction times and peak P3b latencies were shorter for predicted targets compared with random targets, the last most informative stimulus of the predictive sequence induced a robust P3b, and N2 amplitude was larger for random targets compared with predicted targets. P3b and N2 peak amplitudes were larger in the professional basketball group in comparison with professional athletes of individual sports, across the three sessions. The findings of this study suggest that local contextual information is processed similarly for abstract and for meaningful images and that professional basketball players seem to allocate more attentional resources in the processing of these visual stimuli.

Keywords Context · P3b · N2 · EEG · Professional athletes

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Introduction

Contextual processing enables extraction of relevant information from our environment in order to facilitate the selection of appropriate task-specific responses. Top-down control or "internal representation of context" (Cohen and Servan-Schreiber 1992) involves updating and maintenance of task-relevant information in a form that can be used to select or execute appropriate responses. Processing of local contextual information, such as short-term informative stimuli, delivered before the occurrence of target events, has been shown to be altered by aging (Fogelson et al. 2010) and Parkinson's disease (Fogelson et al. 2011a), and impaired in patients with lateral prefrontal cortex lesions (Fogelson et al. 2009a) and schizophrenia (Fogelson et al. 2011b). However, little is known regarding local contextual processing in subjects who may have superior abilities in dynamic second by second extraction of information and decision making, such as professional athletes. Past studies have suggested that athletes have enhanced psychomotor skills and an advanced ability to extract cues from a rapidly changing environment in order to make fast decisions (Hatfield et al. 2004; Iwadate et al. 2005; Di Russo et al. 2006; Aglioti et al. 2008; Nakamoto and Mori 2008). For example, elite basketball players have been shown to have a superior ability to predict the success of free shots at a basket that may be related to fine tuning of anticipatory mechanisms (Aglioti et al. 2008).

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In the present study, we investigated the ability to utilize predictive local contextual information in two groups of skilled athletes. The first group consisted of professional basketball players and the second group consisted of professional athletes of individual sports. Our aim was to compare the cognitive function of local contextual processing between athletes with comparable fitness levels, but with one group relying on dynamic extraction of information to guide their behavior while playing (basketball players), while the athletic performance of the other group does not depend on a constant utilization of cues in order to make time-constrained decisions (e.g., swimmers).

Contextual processing has been linked to the P300 component of the ERP (Donchin and Coles 1988; Polich and Criado 2006; Poulsen et al. 2005; Squires et al. 1976). The target P300, known as the P3b, is elicited, among other tasks, by targets in the classical oddball target detection task (Squires et al. 1975). P3b latency is a measure of the timing of mental processes reflected by the component, whereas P3b amplitude has been proposed to reflect the intensity of these processes (Kok 2001). P3b is also thought to reflect template matching (Squires et al. 1973; Chao et al. 1995) and monitoring processes mediating perceptual analysis and response initiation (Verleger et al. 2005). The closeness of template matching has been linked to the degree of decision confidence that a signal has occurred (Hillyard et al. 1971; Squires et al. 1973, 1975). P3b amplitude increases with increasing stimulus value or relevance to the task (Wilkinson and Morlock 1967; Johnson 1986). In addition, local predictive contextual information has been reported to affect P3b latency (Fogelson et al. 2009b; Fogelson and Fernandez-del-Olmo 2011). Past findings show variable effects of exercise and sports on P3b. P3b has been shown be affected by physical exercise, with greater P3b amplitudes induced as a result of both long (Polich and Lardon 1997) and short-term physical exercise (O'Leary et al. 2011). However, other findings have shown no P3b changes as a result of either fitness or acute bouts of exercise (Stroth et al. 2009). In addition, professional athletes have been shown to have both increased (Iwadate et al. 2005; Di Russo et al. 2006) and decreased P3b amplitudes (Radlo et al. 2001) compared with novices or non-athletes. In the present study, we investigated two groups of skilled athletes that had comparable years of experience and hours of daily practice, thus excluding possible confounds of differences in P3b amplitudes due to fitness level.

Previous studies have shown that predictive local context, defined as the occurrence of a short predictive series of visual stimuli before delivery of a target event, facilitates target detection (Fogelson et al. 2009b; Fogelson et al. 2010; Fogelson and Fernandez-del-Olmo 2011). These studies identified several neural correlates associated with the facilitation of local contextual processing. First, a P3b latency shift between predicted and random targets associated with faster reaction times. Second, local contextual processing was associated with the generation of a robust P3b to the final most informative stimulus of the predicting sequence. Finally, N2 ERP has also been shown to be attenuated for predicted targets compared with random targets (Fogelson et al. 2011a, b).

In the present study, we employed a previously reported paradigm (Fogelson et al. 2009b, 2010) to investigate the effect of a sequence of abstract stimuli versus a logical sequence of real-life images on local contextual processing. The objective of the study was to determine whether the faciltatory effect of predictive local context that consists of real-life images would be greater in comparison with utilization of abstract stimuli (Fogelson et al. 2009b; Hemsley 2005; Fenske et al. 2006; Eger et al. 2007). To this end, subjects performed three sessions of the same task. In each session, a different set of visual stimuli were presented. In one session, the stimuli consisted of triangles facing either left, up, right, or down (Fogelson et al. 2009b). In another session, four different images of a basketball player throwing a ball toward a basket were presented, while another session displayed four different images of a baseball player pitching a baseball. Thus, the triangles were abstract stimuli that did not have any meaning on their own, other than that imposed by the experimental setting, while each of the real-life images of the basketball and baseball players throwing or pitching a ball are meaningful in such a way that each image stands on its own and can be easily identified as a real-life situation from sports.

The aim of the study was twofold. First, we wanted to determine whether processing of local contextual information was similar for abstract versus real-life meaningful visual images, using both behavioral and electrophysiological indices of local contextual processing. Second, we wanted to investigate whether local contextual processing differed between professional basketball players whose performance depends on a dynamic second by second extraction of information to guide their behavior while playing, and between professional athletes of individual sports whose performance does not depend on making constant time-constrained decisions. Furthermore, we wanted to see whether these differences would be specific to representative stimuli from the practiced sport (basketball) or whether they generalize to other types of sport (e.g., baseball) or abstract stimuli.

Method

Subjects

19 right-handed male subjects participated in the study. 10 subjects were professional basketball players (mean age ± standard deviation = 22.7 ± 3.4 years, 7–14 years experience), and 9 age-matched subjects were professional athletes of individual sports (mean age ± standard deviation = 23.9 ± 5.6 years, 6–12 years experience): 5 swimmers, 2 exhibition wushu athletes, 1 rower, and 1 triathlete. All subjects had daily practices of 3–4 h and participated in national-level competitions. None of the subjects had experience in baseball, and all the athletes from individual sports did not have experience in basketball or in other sports that require dynamic second-by-second decision making. Subjects were right handed, had normal vision, and had no history of psychiatric or neurological problems. The Ethics committee of University of A Coruña approved the study.

Task

Subjects sat 110 cm in front of a 21-inch PC-computer screen. Stimuli were presented in the center of the visual field. Three sessions were performed by each subject (see Fig. 1): a session with visual stimuli consisting of triangles, a session consisting of images of a basketball player throwing a ball toward a basket (adapted from Aglioti et al. 2008), and a session of images of a baseball player pitching a baseball (adapted from website: http://www.chrisoleary.com/projects/PitchingMechanics101/Analyses/DaisukeMatsuzaka.html). Sessions were counterbalanced across subjects. Subjects were asked to centrally fixate throughout the recording. Stimuli consisted of 15 % targets and 85 % of equal amounts of three types of standards. In each block, a total of 78 stimuli (12 targets, 22 of each standard type) were presented each for 150 ms and inter-stimulus interval (ISI) of 1 s. Recording blocks consisted of targets preceded by either randomized sequences of standards or by sequences including a three-standard predictive sequence. In the triangle session, the target was a downward facing triangle, and the three standards were triangles facing left, upwards, and right, at 90° increments. The predictive sequence in this session always consisted of the three standards of triangles facing left, up, and right, always in that order (see Fig. 1a). In the basketball session, the 4 stimuli were four consecutive time points during the throw of a basketball. The target was the last frame, in which the ball is in the air. The three standards are the three preceding images (see Fig. 1b). The predictive sequence consists of these three frames (before the ball is in the air) displayed in consecutive order. In the baseball session, the 4 stimuli were four consecutive time points during a pitch of a baseball. The target consists of the last image where the ball is in the air. The three standards are the three preceding images (see Fig. 1c). The predictive sequence consists of these three frames (before the ball is in the air) displayed in consecutive order. Thus, the triangles were abstract stimuli that did not have any meaning on their own, other than that imposed by the experimental setting, while each of the real-life images of the basketball and baseball players throwing or pitching a ball are meaningful in such a way that each image stands on its own and can be easily identified as a real-life situation from sports. Figure 1 illustrates an example of a target preceded by a randomized sequence of standards and a target preceded by the predictive sequence of standards for each of the sessions. The predictive sequence was always followed by a target. Each block consisted of 6 different randomized sequences of standards (3–8 standards long) preceding the target; and 6 sequences of standards (3–8 standards long) with a predictive sequence preceding the target in each. Each recording session consisted of 10 different blocks, displayed in randomized order, each approximately 1.6 min long.

Subjects performed a brief training session to ensure they were able to detect the target accurately. Subjects were then shown the predictive sequence and were told that it would be a 100 % predictive of a target, but that targets would also appear randomly throughout the block. Subjects were asked to press a button each time a target was presented, to pay attention and look for the predictive sequence, and to avoid premature responses. Subjects then performed another brief training session to ensure that they were confident in the detection of the predictive sequence as well as the targets, before each of the recording sessions began. Stimulus presentation and response recordings were controlled using E-prime (Psychology Software Tools, Inc., Pittsburgh, USA).

Recording

EEG was recorded from a 64 Ag–AgCl electrode array using the ActiveTwo system (Biosemi, The Netherlands). External electrodes above and below the right eye monitored vertical eye movements and electrodes placed laterally to the left and right eyes monitored horizontal eye movements. Signals were amplified and digitized at 512 Hz. Post processing and ERP analysis of the data were performed using Brain Vision Analyzer (Brain Products GmbH, Germany). All channels were re-referenced to averaged linked earlobes.

Behavioral analysis

Accuracy was defined as the percentage of targets for which a button press was detected.

Reaction times were calculated by averaging correct trials for predicted and random targets in each subject for

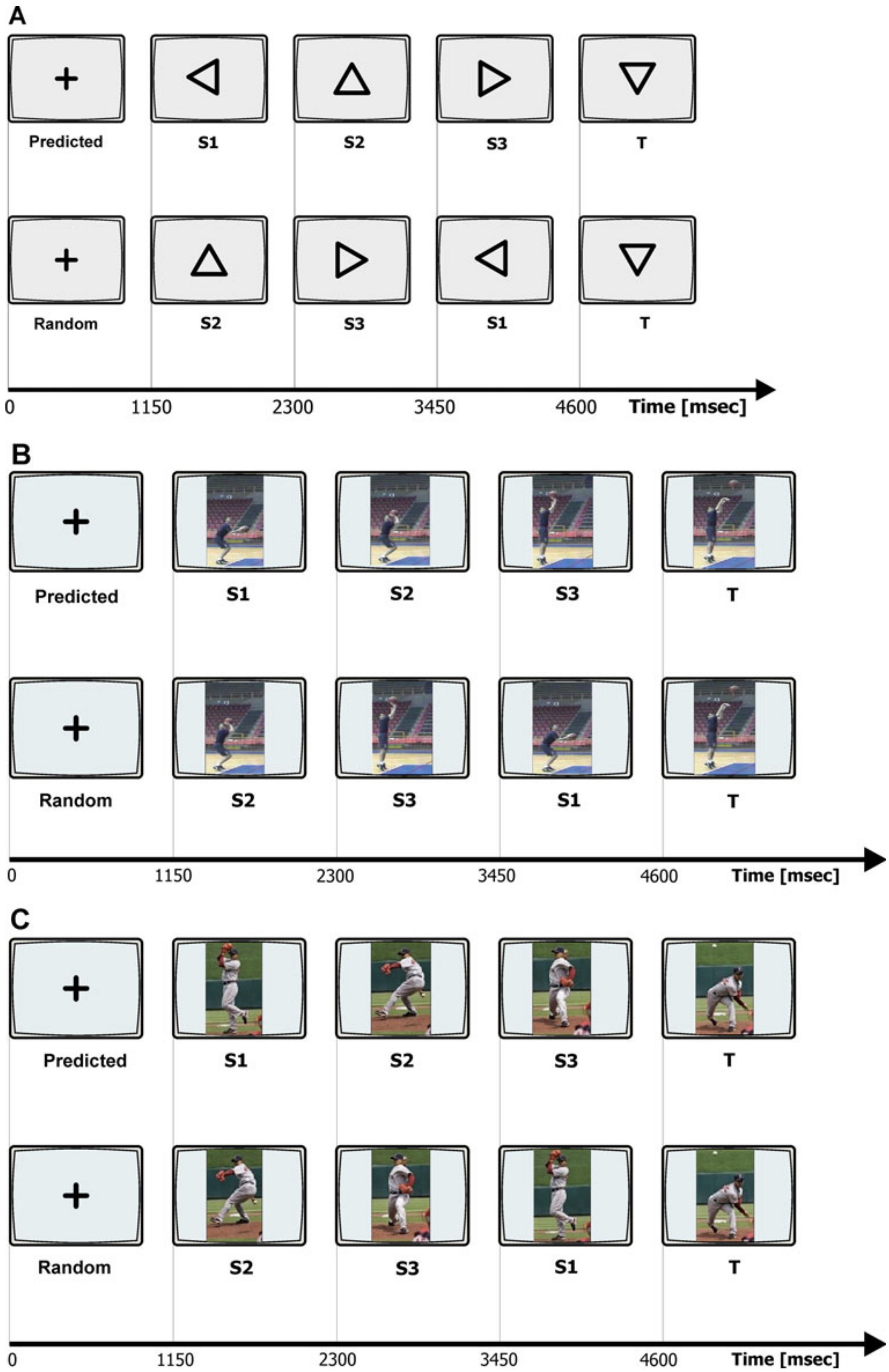

Fig. 1 Task timeline. Stimuli presented in the three sessions displaying triangles (**a**), images from basketball (**b**), or images from baseball (**c**). Sequences of standards S1, S2, and S3 with a predicted sequence (*top*) and in randomized order (*bottom*) preceding the target (T). The predictive sequence is always S1 followed by S2 and then S3 (n−1). Inter-trial intervals, including duration of stimulus presentation (150 ms) are displayed. Each block consisted of 6 different randomized sequences of standards (3–8 standards long) preceding the target; and 6 sequences of standards (3–8 standards long) with the predictive sequence preceding the target in each session. Misses (no button press 150–1,150 ms post-stimulus onset) were excluded from reaction time analysis. Premature responses were not taken into consideration in the analysis of reaction time. Reaction times were analyzed using E-prime (Psychology Software Tools, Inc., Pittsburgh, USA).

ERP analysis

Prior to ERP analysis, blinks were defined using ICA (64 EEG electrodes were included), and the component identified as a blink was removed using the linear derivation function in Brain Vision Analyzer. Epochs containing premature responses, misses (no button press 150–1,150 ms post-stimulus onset) and eye saccades were excluded from further analysis. EEG signals were filtered at 0.1–30 Hz for subsequent analysis. EEG signals were sorted and averaged relative to the stimulus onset, with epochs set from −200 to 1,000 ms relative to stimulus onset. EEG epochs with amplitude of more than 75 μV at any electrode were excluded.

P3b

P3b was determined as the most positive point in the latency range of 300–700 ms. For each subject peak, P3b amplitudes (measured in μV) at AFz, Fz, FCz, Cz, CPz, and Pz were evaluated for 4 conditions in each session: targets after predictive sequences (predicted), targets after non-predictive random sequences (random), random preceding standards (standards excluding those comprising of the predicting sequence), and the last most informative standard of the predicting sequence (n−1) for both groups. Peak P3b latencies (measured in ms) were evaluated for predicted and random targets at the electrode site with the largest P3b amplitude.

N2

To assess N2 amplitude differences between the two target conditions, peak N2 amplitudes (measured in μV) were determined at electrode sites AFz, Fz, FCz, Cz, CPz, and Pz, for predicted and random targets. N2 was defined as the largest negative peak in the time window starting with the P2 peak and ending 350 ms after target onset. N2 amplitudes were measured against the amplitude of the preceding P2, which was determined as the largest positive peak from 150 ms after target onset until the N2 peak.

Statistical analysis

Analysis of variance (ANOVA) was performed with the Greenhouse-Geisser correction, followed by post hoc parametric paired *t* tests, Sidak corrected for multiple comparisons unless otherwise stated. Mean values with ± standard error of the mean (SEM) are used throughout the text.

Results

Behavioral results

To compare accuracy for detection of targets, we performed an ANOVA for accuracy with group (basketball players, individual sport athletes) as the between-subject factor and with condition (predicted, random targets) and session (triangle, basketball, baseball) as the repeated measures factors. There was no significant main effect for condition or session, nor a group effect. Overall mean accuracy for predicted targets was 99.2 ± .4 %, 98.0 ± .8 %, and 96.6 ± 1.1 % and for random targets 98.8 ± .7 %, 98.8 ± .4 %, and 98.7 ± .5 % for the triangles, basketball, and baseball sessions, respectively. There were no significant differences in accuracy between predicted and random targets in both groups. To compare the reaction times (RT) for the targets between the groups, we performed an ANOVA with group (basketball players, individual sport athletes) as the between-subject factor and condition (predicted, random targets) and session (triangle, basketball, baseball) as the repeated measures factors. There was a main effect for condition ($F(1,17) \pm 63.44$, $p < .0001$) and for session ($F(2,34) = 4.17$, $p = .034$). However, there were no significant interactions or a group effect. RTs for predicted targets (overall mean RT = 261 ± 18 ms) were faster than RTs for random targets (overall mean RT = 393 ± 18 ms) across the two groups in all three sessions. Overall mean RTs for the baseball session were faster than those for the basketball session. RT comparisons are displayed in Fig. 2a.

P3b amplitude

Waveforms of the grand-averaged ERPs across the 10 basketball players and across the 9 individual athletes, at electrode site CPz elicited by predicted and random targets, standards and n−1, the last most informative stimulus of the predicting sequence, are shown in Fig. 3.

To compare peak P3b amplitudes, we performed an ANOVA with group (basketball players, individual sport athletes) as the between-subject factor and with condition (predicted, random targets, n−1, and standards), electrode site (AFz, Fz, FCz, Cz, CPz, and Pz), and session (triangle, basketball, baseball) as the repeated measures factors. There was a significant main effect for condition ($F(3,51) = 38.47$, $p < .0001$) and for electrode ($F(5,85) = 61.86$, $p < .0001$), but no significant main effect for session ($F(2,34) = 1.30$, $p = .283$). There were no significant group interactions. However, there was an overall group effect ($p = .012$). Post hoc tests, corrected for multiple comparisons, showed that peak P3b amplitude was larger for predicted targets (mean peak P3b amplitude = 18.42 ± 1.35 μV), random targets (mean peak P3b amplitude = 17.76 ± 1.31 μV), and n−1 condition (mean peak P3b amplitude = 13.17 ± .93 μV) compared with standards (mean peak P3b amplitude = 8.35 ± .61 μV, $p < .0001$) and that P3b amplitudes were also larger for predicted and random targets compared with n−1 condition across the three sessions ($p < .001$). There was no significant difference in P3b amplitude between random and predicted target

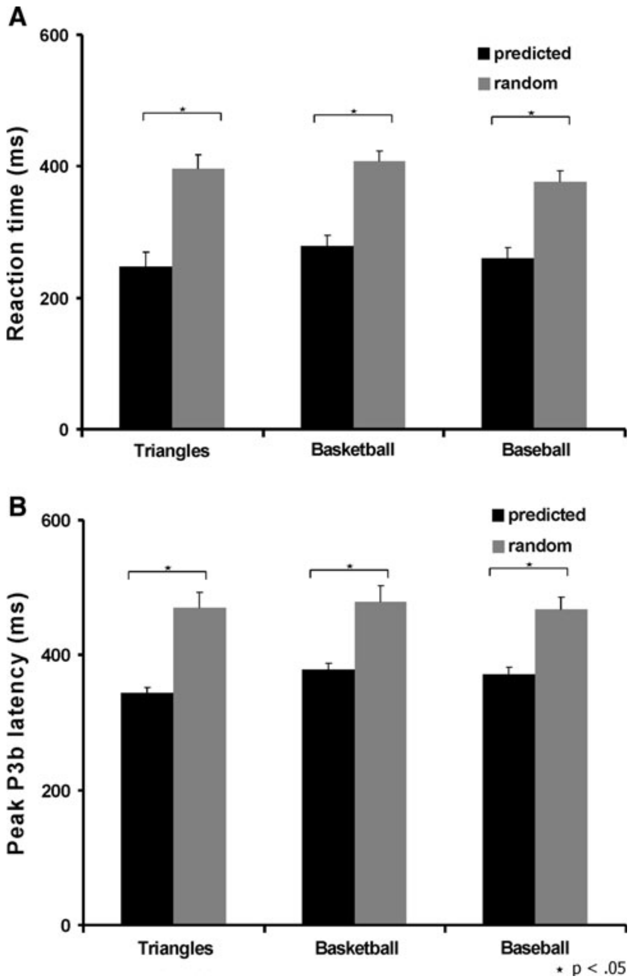

Fig. 2 Reaction times (**a**) and P3b peak latency at CPz (**b**) for predicted and random targets in the three sessions displaying triangles (*Triangles*), images from basketball (*Basketball*) or images from baseball (*Baseball*), across the two groups ($n = 19$). *Bars* SEM

stimuli. All three sessions showed maximal and minimal P3b amplitudes at electrode sites CPz and AFz, respectively. In addition, peak P3b amplitude was significantly larger in basketball players (overall mean P3b amplitude = 16.88 ± 1.21 μV) compared with individual sport athletes (overall mean P3b amplitude = 11.98 ± 1.27 μV) across sessions, conditions, and electrodes.

P3b latency

Since peak P3b amplitudes were largest at CPz, we used this electrode in the comparison of peak P3b latencies. We performed an ANOVA with group (basketball players, individual sport athletes) as the between-subject factor and with condition (predicted, random targets) and session (triangle, basketball, baseball) as the repeated measures factors. There was a main effect for condition ($F(1,17) = 51.58$, $p < .0001$). However, there was no main effect for session ($F(2,34) = .90$, $p = .415$). There were no significant group interactions or an overall group effect. Post hoc t tests showed that peak P3b latency was shorter for predicted targets (mean P3b latency = 363 ± 8 ms) compared with the peak P3b latency for random targets (mean P3b latency = 472 ± 14 ms) across the three sessions and 19 subjects. P3b latency comparisons are displayed in Fig. 2b.

N2

To compare peak N2 amplitudes, we performed an ANOVA with group (basketball players, individual sport athletes) as the between-subject factor and with condition (predicted, random targets), electrode site (AFz, Fz, FCz, Cz, CPz, and Pz), and session (triangle, basketball, baseball) as the repeated measures factors. There was a main effect for condition ($F(1,17) = 26.78$, $p < .0001$), but no main effect for electrode ($F(5,85) = 0.88$, $p = .418$) or session ($F(2,34) = 1.13$, $p = .329$). There were no significant interactions. However, there was an overall group effect ($p = .005$). Post hoc tests corrected for multiple comparisons showed that the peak N2 amplitude was larger for random targets (mean peak N2 amplitude = 5.84 ± .47 μV) compared with predicted targets (mean peak N2 amplitude = 3.64 ± .37 μV) across the three sessions ($p < .0001$). In addition, peak N2 amplitude was significantly larger in basketball players (overall mean N2 amplitude = 5.90 ± .50 μV) compared with individual sport athletes (overall mean N2 amplitude = 3.58 ± .52 μV) across sessions, conditions and electrodes. N2 comparisons are displayed in Fig. 4.

Discussion

This study demonstrated that neural correlates of local contextual processing were similar for stimuli consisting of triangles and of real-life images from basketball and baseball. Second, we found that peak P3b and N2 amplitudes were larger in professional basketball players compared with professional athletes of individual sports.

Modality independent effects of local contextual processing

We found comparable effects of local contextual information across the different types of visual stimuli that were presented. Neural correlates associated with local contextual processing (Fogelson et al. 2009b, 2010; Fogelson and Fernandez-del-Olmo 2011) were similar across the three sessions, in which visual stimuli consisted of either abstract stimuli (triangles) or meaningful real-life images from the field of basketball or baseball. First, in all three sessions

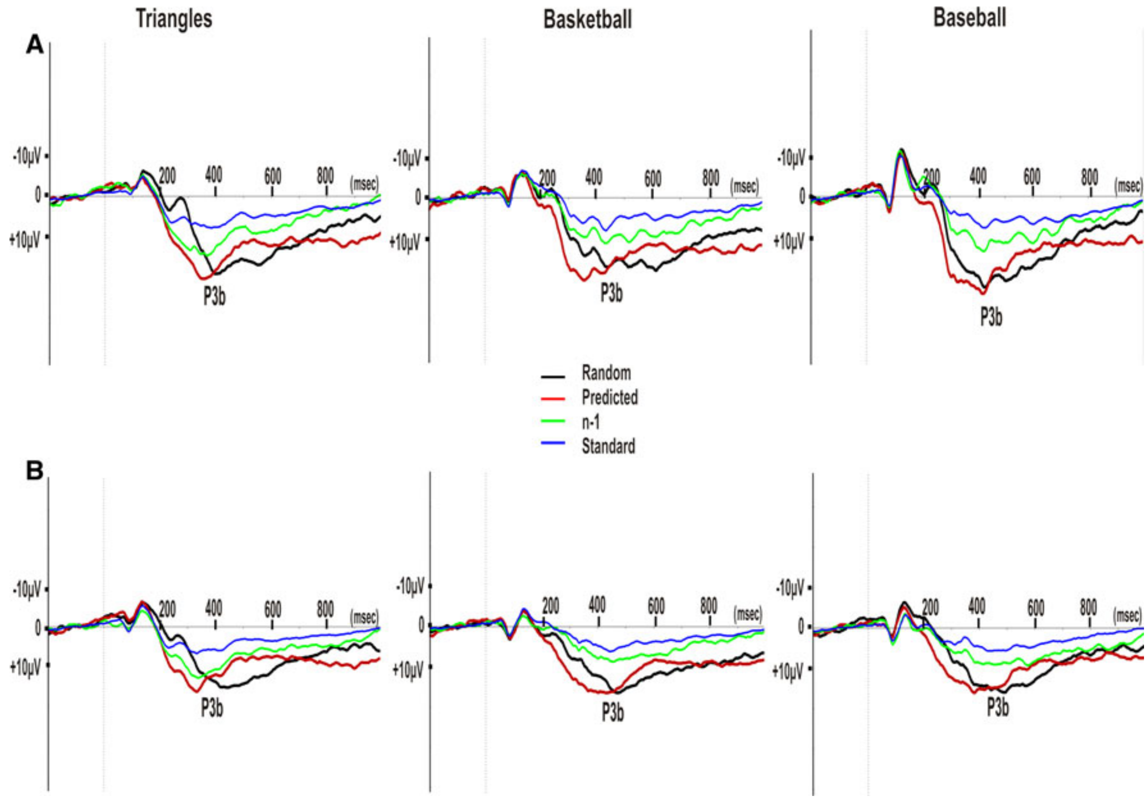

Fig. 3 Grand average at CPz for the 4 conditions: targets after random non-predictive (*Random*) and predictive sequences (*Predicted*), the last most informative standard comprising the predicting sequence (n−1) and random preceding standards (*Standard*) for basketball players (**a**) and individual sports athletes (**b**), in the three sessions displaying triangles (*Triangles*), images from basketball (*Basketball*) or images from baseball (*Baseball*). *Vertical dotted lines* indicate time of stimulus presentation onset

P3b amplitude increased with task-informative stimuli, so that a significant P3b is generated by the last and most informative stimulus of the predicting sequence, and P3b amplitude then reaches a maximum for predicted and random targets. Thus, n−1 became a secondary target for the subjects and thus an indicator for successful local contextual processing. There were no significant differences in P3b amplitude between predicted and random targets, suggesting that task relevance was manipulated with the build up of contextual information (during the detection of the predictive sequence) and reached its maximum in both the predicted and random targets (replicating Fogelson et al. 2009b, 2010; Fogelson and Fernandez-del-Olmo 2011).

Second, P3b latency was shorter for sequence predicted targets than for targets after non-predictive sequences, suggesting that predictive local context affects target detection by reducing the duration of stimulus evaluation (Kutas et al. 1977; Duncan-Johnson 1981; McCarthy and Donchin 1981; Duncan-Johnson and Donchin 1982; Hillyard and Kutas 1983; Fogelson et al. 2009b). The P3b latency shift observed may have been due to the fact that 100 % predictable targets merely required stimulus detection, while random targets had to be identified first. Similar P3b latency shifts were observed across the three sessions, suggesting that subjects utilized the local predictive contextual information provided by the predictive sequence in a similar way for both abstract and real-life images, in order to speed cognitive processing. These results were associated with parallel behavioral findings, which revealed a comparable shortening in response times for predicted targets compared with random targets, across the three sessions.

In addition, peak N2 amplitudes attenuation was observed for predicted targets compared with random targets, in all three sessions. N2 is known to be sensitive to the difficulty of target-standard discrimination (Fitzgerald and Picton 1984), increasing for difficult targets. It is thought to reflect sensory classification of attended stimuli (Ritter et al. 1979) and the degree of attention required to process stimuli in visual cortex (Suwazono et al. 2000; Folstein and Van Petten 2008). In the present study, the detection of a predictive sequence attenuated N2 amplitude relative to the random condition, suggesting that less attentional resources were required for the processing and sensory classification of predicted targets compared with that of random targets.

In summary, we found comparable local context effects for abstract and real-life images. These findings suggest that local contextual effects are independent of the type of

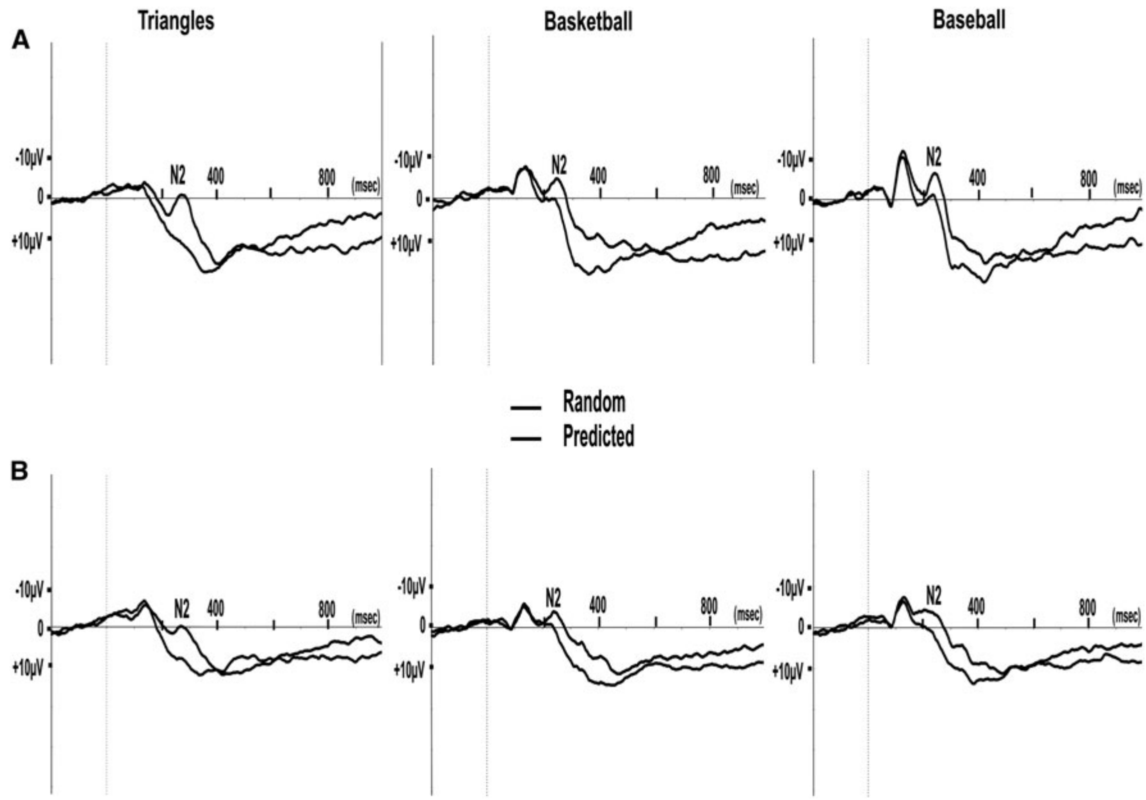

Fig. 4 Grand average for predicted and random targets at electrode site FCz, where maximal amplitudes were displayed, in basketball players (**a**) and individual sports athletes (**b**), in the three sessions displaying triangles (*Triangles*), images from basketball (*Basketball*) or images from baseball (*Baseball*). *Vertical dotted lines* indicate time of stimulus presentation onset

stimulus presented and are not altered when a logical sequence of meaningful images from a real-life situation is utilized instead of a series of abstract stimuli. Modality independent effects of local contextual processing have been demonstrated in an earlier study (Fogelson et al. 2009b) showing comparable effects of the predictive sequence on P3b amplitude and latency for both auditory and visual stimuli. Together, these findings give further support for local contextual processing to be a top-down function, related to prefrontal control networks (Cohen and Servan-Schreiber 1992; MacDonald et al. 2000; Barch et al. 2001; Miller and Cohen 2001; MacDonald et al. 2005; Huettel et al. 2005; Barceló and Knight 2007; Fogelson et al. 2009a).

Differences between basketball players and individual sports athletes

Our findings suggest that basketball players and individual sport athletes process local contextual information similarly. We found no significant differences in the neural correlates of local context between the two groups of athletes. Both groups displayed similar magnitudes of a P3b latency shift between predicted and random targets and an attenuation of N2 for predicted targets compared with random targets. In addition, both groups displayed a gradual increase in P3b amplitude with task-informative stimuli, so that a significant P3b was generated by the last and most informative stimulus of the predicting sequence, while P3b amplitude was maximal for predicted and random targets.

However, we found that basketball players had larger peak P3b and N2 amplitudes compared with athletes of individual sports. This increase was not specific to the type of visual stimuli that were presented (triangles versus images from basketball or baseball) nor to a particular condition (targets, predictive sequence or standards), within each session. P3b has been shown to be influenced by allocation of attention to a stimulus (Johnson 1986) and has been proposed to reflect resources invested in identification of a stimulus, Kok 2001), while N2 is thought to reflect sensory classification of attended stimuli (Ritter et al. 1979) and the degree of attention required to process stimuli in visual cortex (Suwazono et al. 2000; Folstein and Van Petten 2008). Thus, our findings suggest that the basketball players may have focused or allocated greater attentional resources when processing and discriminating the visual stimuli that were displayed compared to the group of athletes from individual sports. Other studies have shown increased P3b (Iwadate et al. 2005; Di Russo et al. 2006) and N2 amplitudes (Di Russo et al. 2006) in athletes compared with non-athletes. In the present study, however, both groups were skilled athletes who had comparable years of experience and hours of daily practice, thus excluding possible confounds of differences in P3b amplitudes due to fitness level (Polich and Lardon 1997). The main difference between the two groups of athletes was the type of sport that was practiced: basketball versus individual sports. Extracting information from a rapidly changing environment is crucial for basketball players in order to guide their behavior successfully while playing. In comparison, the other group of athletes practice sports such as swimming, rowing, triathlon, and exhibition wushu (non-combative individual martial art). In these sports, performance does not depend on the ability of the athletes to make constant time-constrained decisions as a function of a dynamic sporting environment, as it does in basketball. Thus, it is likely that the basketball players exhibited higher level of attention while processing dynamic sequences of both abstract and complex real-life images. However, it is important to note that the lack of differences in the utilization of local contextual information between the two groups may have been due to the task not being sensitive or representative enough of the dynamic sporting environment of the basketball players, since in the present study due to methodological limitations, static images were presented at relatively slow presentation rates. The task may have also been too easy, as reflected by high accuracy rates, and thus, the behavioral and electrophysiological measures of local context may have reached ceiling effects in both groups.

In conclusion, the findings of the current study suggest that predictive contextual information is processed similarly for abstract and for meaningful images, as indicated by behavioral and neural correlates of local contextual processing, and that professional basketball players seem to allocate more attentional resources in the processing of these visual stimuli.

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