EXPRESSION OF PHYSIOLOGICAL SENSATION OF ANATOMICAL PATTERNS IN WOOD: AN EVENT-RELATED BRAIN POTENTIAL STUDY

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The emotional and psychological activities associated with the visual perception of macroscopic and microscopic structure patterns of wood were investigated. The macroscopic and microscopic structure patterns of 18 different timber tree species of northeast China were selected as the research objects, and these were divided into eight categories for event-related potential analysis. The 30 effective subjects' tasks were to watch the wood structure stimuli patterns and evaluate them on a 7-point bipolar scale. The results showed that the emotional valence of the wood structure stimuli patterns of the eight categories evoked P2 and late positive potential (LPP) composition in a specific area of the brain. P2 refers to an early perception analysis processing for visual perception of the wood stimuli patterns, while LPP refers to late processing and reflects evaluations when people face different wood stimuli patterns. The results also indicated that people prefer to connect the understanding of macroscopic and microscopic patterns of wood with their own mood. Evaluation processing for macroscopic and microscopic structure patterns of wood were based on visual perception analyses, which were judged by personal feelings and decisions. People made active emotional assessments of the macroscopic and microscopic structure patterns of wood.

Keywords: Wood structure patterns; Macrocosmic; Microcosmic; Emotion experience; Event-related potentials

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INTRODUCTION

Wood expresses its external features and internal properties with its own silent language. People can use their senses to communicate with it, understand it, and they can also find its beautiful patterns of cell permutations visually appealing. The macro- and micro-structure patterns of wood are composed of cell-piled textures and patterns that form a protean artistic pattern with unique beauty, and the original patterns can give a person a sense of infinite charm and a feeling of vitality. Many experts and scholars have conducted research on the macro-surface texture of wood, but most of the studies have been about the physical stimulation and psychological perception features caused by the appearance of wood (Nakamura *et al.* 1993, 1994, 1996; Rice *et al.* 2006; Jonsson *et al.* 2008). There have been few research studies that focus on the exterior and interior structure of wood and utilize a psychological index and neural function index in order to evaluate people's emotional response to the macro- and micro-structure patterns of wood.

Event-Related Potentials (ERPs) is a method for measuring brain activity during cognitive processing. It enables the reflection and assessment of the topographic distribution of brain activity and the neural responses to the perception of emotional stimuli with millisecond temporal resolution (Pollatos *et al.* 2005). Most brain electrical responses and affective ERPs produced have frequently been triggered by complex picture stimuli (Carretie *et al.* 2001, Spangler *et al.* 2001; Sylvain *et al.* 2004; Florian *et al.* 2010). ERPs reflect emotional activities with various aspects of cognitive processes in the brain, which is a "window" to understand the brain cognitive function.

In perceptual processing, vision can provide the most important information (Solso *et al.* 2008). Visual cognitive processing entails a process of explanation within the brain after extracting outside information (Friedenberg and Silverman 2006). In the study about vision, cognition, the classic P2 component of ERPs, belongs to exogenous (physiological) factors and is influenced by the physical characteristics of the stimulus. The P2 component is related to attention and plays a role in the facilitation of the early sensory process of what was noticed (O'Donnell *et al.* 2004). The present study uses the visual target stimulation in the experiment through the different reaction conditions (for example: passive, press-response, *e.g.*) to test the influence of reaction and task dependency in the frontal area P2 (P2a), and showed that P2 stimuli are associated with the task, which reveals an index of stimuli appraisal but not the production of a reaction (Potts 2004).

Early in the study of emotion and visual ERPs, Lifshitz (1966) first used the visual stimulation of emotions as materials for EEG recording. After that, researchers used emotional stimuli pictures to evaluate the ERPs' effects on emotion (Radilova 1982; Kayser *et al.* 1997; Flaisch *et al.* 2008). They pointed out that the visual cognitive processing depends on the nature of the stimulus and the influence of the content by emotional stimuli, and emotions affect temporal dynamics of visual attention. At the same time, effective visual attention resources have also influenced emotional processing (Srivastava and Srinivasan 2010). Isen (2000) found that moderate intensity on positive emotion promotes thinking consciousness, problem solving, *etc*., and negative emotion inhibits cognitive behavior. With the development of research, people have begun to realize that an emotional reaction constitutes positive information input with individual judgment. In many cases, the response of emotion can improve the performance of behavior for evaluation and decision.

Emotion plays an important role in people's lives. It is more complex than the general cognitive behavior, and it relates to social, cultural, and environmental factors. Experts in the fields of psychology and neuroscience have conducted studies on ERPs with emotional stimuli and processing in recent years. Many numerical experiments have shown that although there are no clear ERP components associated with emotional processing itself, some of the components reflect emotional processes from another perspective, such as N2, P3, LPP, EPN *etc*. (Zhao 2010). So far, most studies dealing with cognition and understanding of emotional stimuli have shown that, in general, people's emotional states affect cognitive processing in an efficient manner. They produce multiple effects in terms of cognitive processing and embodiment of emotional processing, which also tends to increase the emotional intensity of emotional experience (Philippot *et al.* 2006). Many studies demonstrate that there are complicated interactions between human emotions and cognitive processes (Pessoa *et al.* 2002; Shafritz *et al.* 2006; Mitchell and Phillips 2007; Goldstein *et al.* 2007).

Researchers have shown that emotional valence mainly is a reflection of the P1 component in an early ERP component, which may indicate that aroused attention directs resources of the relevant brain area in the early primary processing (Delplanque *et al.* 2004). The frontal P2 component, which is related to distribution of attention, is also influenced by emotional valence, and research shows that the amplitude of negative emotion stimuli conditions is significantly greater than that of positive emotion (Cacioppo and Gardner 1999; Huang *et al.* 2006), which may reflect the evaluation process of emotional tasks. In the late stage of processing and reaction of emotional evaluation, negative emotional stimuli evoke the LPP (late-positive potential) components, in which the amplitude is significantly greater than under the corresponding positive conditions (Cacioppo *et al.* 1996; Huang *et al.* 2009; Schupp *et al.* 2000). Research generally supports a concept that an affective picture will induce a larger late-positive component LPP (late-positive potential) than a non-affective picture (Zhao 2010). The research of Huang and Luo (2005) and Yuan *et al.* (2007) proved that human emotional activities have a reaction-priming effect in emotionally negative stimuli and in the intensity of emotional valence reflected in P2, N2 components, and late P3 component.

The subjective sensory and emotional experience is a process in which one’s attitude toward things change, and it directly affects the way of looking at things. In this paper, we study the emotional psychological reactions and visual cognitive processing of macroscopic and microscopic structure patterns of wood. The possible neural mechanism by comparing the ERPs component was evoked with the visual processing and evaluation of macroscopic and microscopic structure stimuli patterns of different kinds of wood. That is, through the brain, electrical measurements collect evidence of electrical physiology, which is related to emotional changes in response to wood’s macroscopic and microscopic structure patterns. These measurements have been able to provide an objective basis for the application and creation of wood’s macroscopic and microscopic structure patterns in real life, as well as research concerning the visual aesthetics of wood structures.

EXPERIMENTAL

Subjects

The sample consisted of 30 volunteer students (15 male, 15 female) from different majors, backgrounds, and colleges. The mean age was 23.6 years, and ages ranged from 20 to 30 years of age. All the participating students were right-handed (Oldfield 1971). Informed consent was obtained from all the participating students. They were all native speakers of Chinese and had normal or corrected-to-normal vision, normal hearing, and were without other nerve psychiatric diseases.

Stimulus Materials

Eprim2.0 was used to present stimulus programs. The stimulus material consisted of 400 pictures chosen from 18 species of trees in Northeast China, which were divided into eight kinds of wood macro- and micro-structure patterns: macro-tangential section of softwood (type1), macro-tangential section of hardwood (type2), micro-transverse section of softwood (type3), micro-transverse section of hardwood (type4), micro-radial section of softwood (type5), micro-radial section of hardwood (type6), micro-tangential section of softwood (type7), and micro-tangential section of hardwood (type8).

In order to minimize the influence of color on wood's Kansi images, the selected images of wood, with equal size, were grey-processed. The picture size was 300 × 300 pixels, and resolution was 300 dpi. Slides of wood structure patterns were projected at a distance of approximately 1.0 m from the subjects' eyes.

Experimental Environment and Apparatus

The experiment took place in the visual arts and brain cognition laboratory. The experimental apparatus used was a ESI-64 Leads EEg recording analysis system of the Neuroscan (Fig. 1). The psychological experiment used the following professional software: E-prime (E-prime is a suite of applications which provides computerized experiment design, data collection, analysis, and millisecond precision timing) for programming and presenting stimulus, the Scan data analysis software, SynAmps2, Quick-Cap, and electrode according to the international 10-20 system (Pollatos *et al.* 2005). A 17-inch display was used to present visual stimulation.

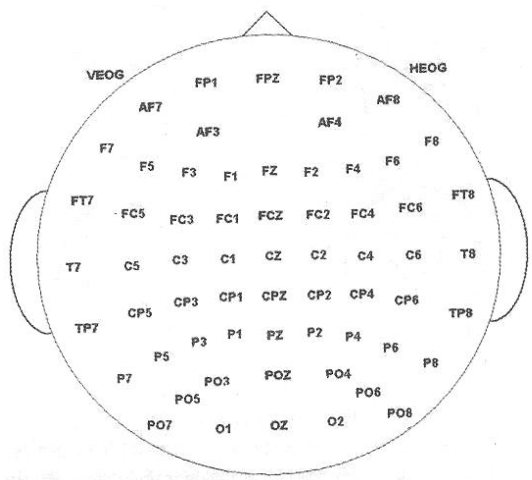

Fig. 1. NeuroscanQuik - Cap 64 records electrodes arrangement schematic diagram

Procedure

Subjects provided personal information. Next, they were seated in a comfortable chair in a noiseless and half-dark chamber. In the training procedure, there were instructions on the central screen. Subjects initiated the trial by pressing any key after having read the instructions carefully. Then, the subjects were presented with a fixation point of a black plus sign (+) at the center of the screen (Fig. 2). The plus sign (+) provided the subject with a clue as to where the picture would appear in each trial, and the stimulating pictures (wood structure patterns) appeared in the same position after the (+) sign disappeared, which presents time of the stimulus pictures for 1000 ms. After each stimulating picture had randomly appeared, subjects made a key reaction to the picture based on three-pair Kansei bipolar vocabulary on the screen in order to emotionally evaluate the wood structure patterns (on a 7-point bipolar scale, -3 to +3, corresponding to the keyboard of Z-M, and on the keyboard identification). Perceptual terms were each presented for a period of 500 ms, and the reaction time allowed for key press action was 1000 ms (Fig. 2). EEG and behavioral records were carried out simultaneously.

A questionnaire survey and statistics were used to analyze selected representative Kansi evaluation words for eight types of wood structures (Song 2011). With respect to the orientation of the wood samples, type1 and type2 corresponded to the macroscopic tangential section, type3 and type4 belonged to the microscopic transverse section, type5 and type6 belonged to the microscopic radial section, and type7 and type8 were associated with the microscopic tangential section. Therefore, the eight types of wood structures were divided into four groups. And there were three pairs of Kansi words for each group, respectively. So, “pleased-dislike”, “natural-artificial”, “practical-decorate” were selected as the representative Kansi evaluation vocabulary for type1 and type2. The representative Kansi evaluation vocabulary of type3 and type4 were “pleased-dislike”, “natural-artificial”, “fine-loose”; type5 and type6 were “pleased-dislike”, “soft-hard”, “exquisite-inelegance”; and type7 and type8 were “beauty-unsightly”, “free-sedulously”, “practical-decorate”. Three pairs of Kansi words after stimulus pictures were presented randomly. Therefore, each participant underwent a total of nine blocks, and all the trials were presented 432 times. The orders of trials were randomized, and the stimulus intervals were 500 ms.

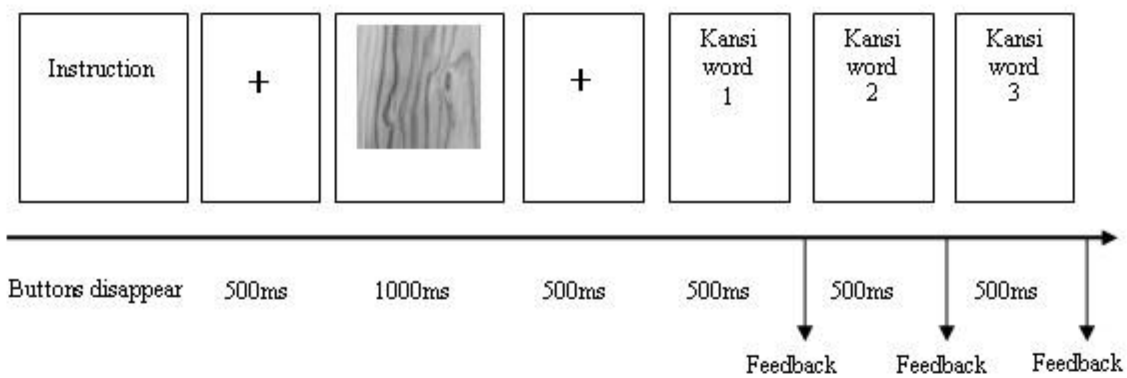

Fig. 2. The flow of a trial

ERP Recording

The experimental apparatus was the Neuroscan Synamps 2 system (Neuroscan Inc., USA). The Select 64 scalp position with Ag/AgC1 electrodes was used for EEG registration and ERP processing according to the international 10-20 system. Reference electrodes were placed on the nose tip, and the forehead was used for electrical grounding. Both horizontal and vertical electrooculograms (EOG) were recorded. The horizontal electrooculogram electrodes were placed lateral to the outer canthus of each eye (HEOG), and vertical electrooculogram electrodes were set above and below the left eye (VEOG). The linked bilateral mastoid was used as a reference electrode. NeuroScan EEG amplifier band-pass filter was set at 0.05 to 100 Hz, the sampling rate was set at 500 Hz, and electrode resistance was maintained below 5 kΩ throughout the experiment.

Data Analysis

Data record and off-line analysis were acquired with Scan 4.3. For EOG artifacts, rejection was based on a correlation method. The averaging program analyzed length of each epoch from pre-stimulus 100 ms to post-stimulus 1000 ms, using the average voltage of the pre-stimulus 100 ms for baseline leveling. Volatility greater than ±100 μV was deemed as an artifact in superposition and was eliminated automatically. Superposition of the average respectively yields eight types of stimulation picture ERPs. To convert bilateral mastoid for reference, and off-line data were analyzed with a 20 Hz (24 dB/oct) low-pass filter.

According to the general average figure (Fig. 3 to Fig. 6), which shows cognitive processing and evaluation of different types of wood macro- and micro-patterns, this study mainly shows that analysis of induced composition of P2 and LPP were related to brain regions of the brain cortex. The mean amplitudes and latency of P2 were submitted to 8 (types of wood) ×5 (electrode position: FZ, FCZ, CZ, CPZ, PZ) two-way repeated-measures ANOVAs. The mean amplitudes and latency of LPP were submitted to 8 (types of wood) ×3 (electrode position: FZ, CZ, PZ) two-way repeated-measures ANOVAs. The prominent ERPs components were identified by visual inspection of individual sweeps, as well as grand mean ERPs in the following time windows: P2(150-280 ms). The FZ and CZ average amplitude was measured for LPP within the range of 500 to 700 ms, and the PZ average amplitude was measured within the range of 400 to 600 ms. The Greenhouse–Geisser correction was applied wherever necessary. For post-hoc multiple comparisons, when the degree of freedom was larger than 1, the Greenhouse–Geisser method was used to correct the p value and was used with a significance level of 0.05.

RESULTS AND DISCUSSION

Behavioral Data

In the brain-electrical signal acquisition and ERP processing, data related to the subjects' behavioral responses having to do with emotional valence corresponding to the wood macro and microstructure patterns were recorded and analyzed statistically.

Event-Related Potentials Data

P2 (150 -280ms)

As shown in Figs. 3 to 6, all the wood pictures exhibited an obvious P2 component, which is the central-top area distribution, and this occurred in the time period of 150 to 280 ms after stimulus presentation. According to repeated measures analyses of variances (ANOVA), P2 had significant electrode position main effects (F (4,116) = 12, p<0.01), wood types main effects (F (7,203) = 9.58, p<0.001), and content × region interaction (F (28,812) = 5.41, p<0.001). The results showed larger amplitudes at the midline (PZ) for eight types of wood structure patterns, and micro-radial section of hardwood (type6) reached maximum amplitude (9.92±4.74μV).

As found in P2 latency repeated measures analyses of variances (ANOVA), there were only electrode position main effects (F (4,116) = 58.16, p<0.001) from the front electrode position to back and a delay in P2 latency. The larger latency at the midline (PZ) for eight types of wood structure patterns and microscopic radial section of softwood (type5) reached maximum latency (239.27 ± 38.72 ms). Statistical results showed a wood types × electrode position interaction.

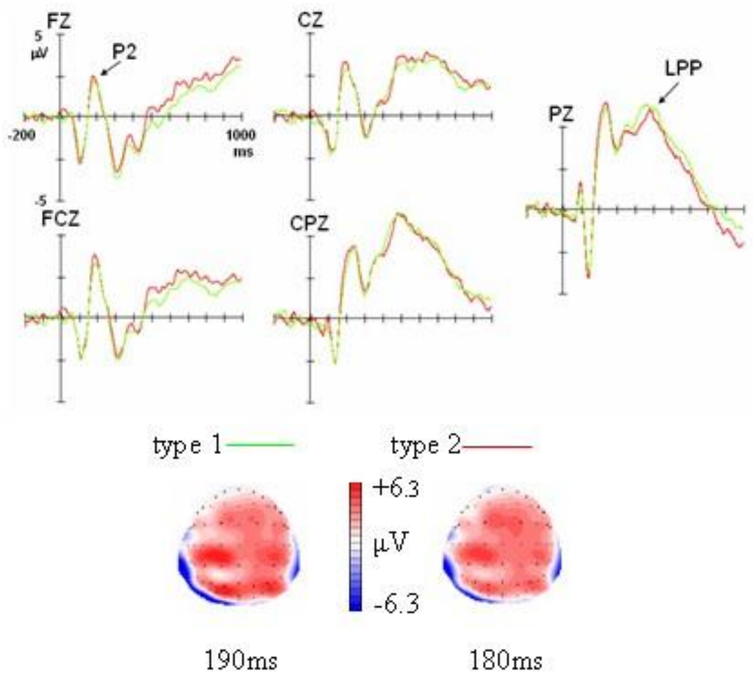

Fig. 3. Grand mean ERPs of P200, LPP, and brain topography peak distribution for macroscopic tangential sections of wood stimuli pictures

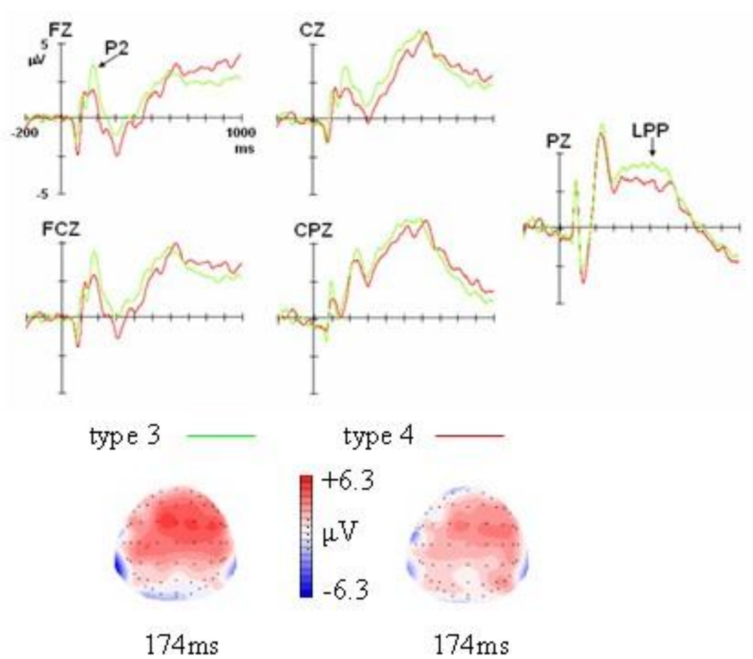

Fig. 4. Grand mean ERPs of P200, LPP, and brain topography peak distribution for microscopic transverse sections of wood stimuli pictures

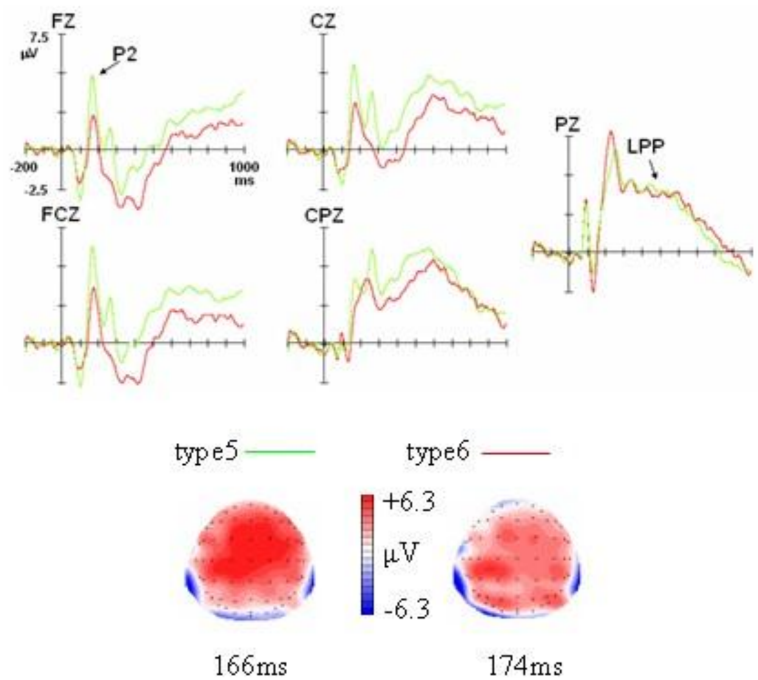

Fig. 5. Grand mean ERPs of P200, LPP, and brain topography peak distribution for microscopic radial sections of wood stimuli pictures

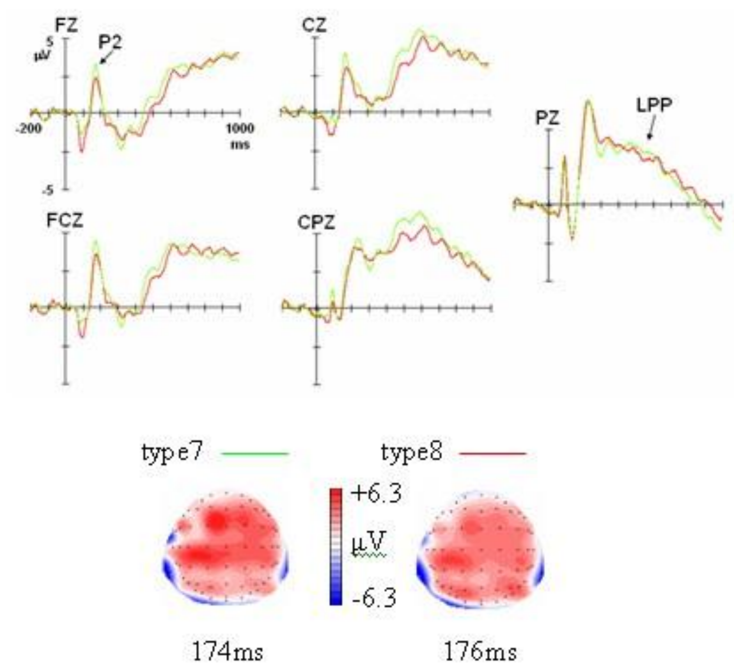

Fig. 6. Grand mean ERPs of P200, LPP, and brain topography peak distribution for microscopic radial sections of wood stimuli pictures

The P2 amplitudes of the species of wood for type1-type2, type3-type4, type5-type6, type7-type8 at each electrode position were executed with the matched T test. The results showed CZ (p<0.10) and CPZ (p<0.10) differences on type1 and type2 of P2 amplitudes at the central-top area had marginal significance; in other electrode positions, the differences were not significant. There were significant differences at the electrode position (p<0.05) for P2 amplitudes of type3 and type4, except in the case of CPZ. Differences of P2 amplitudes of type5 and type6 at other electrode positions were significant except at PZ (p<0.01). P2 amplitudes of type7 and type8 were the only CZ differences that were significant (p<0.05). To summarize the above findings, different processing mechanisms were produced in brains when the different types of wood structure patterns were presented for about 150 to 280 ms in emotional experience.

In the brain topographical peak distribution maps of P2 (Fig. 3 to Fig. 6), the red axis corresponds to positive voltage, and rulers indicate a positive wave; the blue axis corresponds to negative voltage and rulers indicate a negative wave. The topographical maps of P2 were mainly distributed in the central-top, and type3, type5, and type7 all in the central-top area evoked larger P2 (red deeper) than type1. So, brain areas with a positive activated range and sensitivity to micro three-section softwood were larger than hardwood, and brain areas with an activated range and sensitivity to macro-tangential section of softwood were smaller than hardwood.

LPP (400-700ms)

As illustrated in Figs. 3 to 6, all the wood pictures evoked LPP, which was pronounced at the central-top area. The minimum amplitude for FZ occurred within a time window from 400 to 700 ms after stimulus presentation, and the latency of LPP occurred at the central and frontal electrodes posterior to top electrode. LPP exhibited significant electrode position main effects ($F(2,58) = 8.57$, $p< 0.01$) and content × region interaction ($F(14,406) = 6.93$, ($p< 0.01$). All the types of wood were analyzed by the matched T test. The results showed that LPP amplitudes of type1 and type2 at FZ were significant ($p = 0.05$), and at CZ and PZ, the difference was not significant. LPP amplitudes of type3 and type4 at FZ difference were significant ($p = 0.05$), and at CZ and PZ the difference was not significant. LPP amplitudes of type5 and type6 at CZ and FZ difference were significant (p<0.05) and was not significant at PZ. LPP amplitudes of type7 and type8 at CZ difference were marginally significant (p<0.10), and at FZ and PZ the differences were not significant.

DISCUSSION

This experiment evaluated visual cognitive processing of eight types of wood structures presented as stimulation pattern slides and concluded that emotional experience was related to different kinds of wood structure patterns. The ERP results showed that the wood structure stimuli patterns of the eight categories evoked P2 and LPP composition in the specific area of the brain. P2 refers to visual perception of the wood structure stimuli patterns, while LPP reflects evaluations when people face different wood structure stimuli patterns, and it belongs to late processing.

Behavior Data Analysis

The sensory evaluation of macroscopic tangential sections of wood structure pattern had a main effect difference, and there were no significant differences associated with "practical-decorate", possibly because wood's macroscopic structure pattern in life is relatively common, and therefore people's discrimination has become relatively stable for them. The sensory evaluations of microscopic tangential sections of wood structure pattern had no significant main effect difference. The sensory evaluation of microscopic radial sections and tangential sections of wood structure pattern had a main effect difference, because no microscopic structure pattern can be seen at all in the course of everyday living; thus, some cell-piled structures in three sections could have prompted a different emotional response. Although some differences did not reach statistical significance in an analysis, there were still differences in other cases.

In addition, although the stimuli patterns of wood structure were presented for only a short time, according to the experimental conditions, the average amplitude of the resulting electroencephalogram (EEG) was able to distinguish differences for eight kinds of wood structures patterns. Because the brain is very smart in its ability to accept stimuli patterns in a very short time and to respond accordingly, as people evaluate stimuli patterns they inevitably go on to make inferences that are influenced by other factors such as thinking and the environment. At the same time, wood structure patterns have a correspondence with the rhythms of the body; thus wood will tend to provide a good feeling, and it may sometimes have a direct impact on subjects' emotional responses so that there is an effect on perceptual evaluation.

P2 and Emotional Experience of Macroscopic and Microscopic Structure Patterns of Wood

P2 was found to be a significantly positive component that was produced at the central forehead, in general, and it has been connected with early identification of visual target stimuli, at a latency period at about 200 ms. Other studies suggest that the response is related with the task of processing (Potts *et al.* 1996; Potts and Tucker 2001; Potts 2004).

Based on our research work, the waveform of wood patterns of softwood and hardwood began to exhibit differences at about 200 ms when viewing different structure sections, and in the case of eight kinds of wood structure patterns, the waveform reached a peak (P2 component). This shows that the stimulation patterns of wood structure evoked a P2 component of reflective visual cognitive processing. In this work, the measured P2 component occurred within the time period of 150 to 280 ms. Studies indicate that the brain is only able to engage in preliminary perceptual processing 150 ms after visual stimuli have been presented (Hillyard and Anllo-Vento 1998). So, in this study, the waveform separation appeared on different kinds of wood macroscopic and microscopic structure for the measurement of P2 at about 200 ms, which may indicate the embodiment of cognitive processing of wood structure pattern characteristics. In "type1 & type2", P2 amplitudes of macroscopic tangential section of hardwood structure patterns were a little larger than softwood. This shows that P2 amplitudes of most of the microscopic three sections of softwood structure patterns were a little larger than hardwood in "type3 & type4", "type5 & type6", and "type7 & type8". That said, the visual cognitive processing was more strongly affected by these wood structure patterns. There were smaller P2 amplitudes for the macroscopic tangential sections of softwood and most of the microscopic sections of hardwood (all three orientations), which shows that vision cognitive processing appears to be a little bit weak regarding these conditions. This may be because the piled structure of wood cells formed different patterns and texture characteristics, for which visual cognition was not sensitive and had weak processing strength.

Schachter and Singer proposed the attribution theory of emotion, from which thinking and emotions are derived from the individual cognition evaluation for the stimuli and cognition of physiological self-reaction (Kong 2007). The research confirmed that sentiments and emotion were produced with cognitive processing, and therefore it can be considered that the subjects were in a certain emotional state with visual cognitive processing, and the emotional processing of wood structure patterns also plays a part. So, this study on the emotional experience of wood structure patterns evoked obvious P2 effects at the beginning when subjects observed the stimulation patterns of wood structure. Some researchers have suggested that cognitive processing dramatically changes the emotional experience of an individual towards the same thing (Ellis 1991). These studies illustrate the fact that people can more easily understand meaning and feelings that match their own mood and emotions with stimulation patterns of wood structure in the cognition process.

LPP and Emotional Experience of Macroscopic and Microscopic Structure Patterns of Wood

The visually evoked potential of picture stimuli depends on brain activity associated with emotions and affective factors related to performance (Pollatos *et al.* 2005; Bradley and Lang 1994; Codispoti *et al.* 2007). For visual cognitive processing, the wood structure patterns evoked a pronounced LPP composition at the electrode positions FZ, CZ, and PZ, which occurred within a time window from 400 to 700 ms after the P2 composition. The results support the study of Cuthbert *et al.* (2000) and show that LPP composition might continue for hundreds of milliseconds and is dependent on continuous emotional stimuli.

In the sense of psychology, the amplitude variation of LPP was determined by distribution of psychological resources (Olofsson *et al.* 2008). It also reflected the degree of processing with the stimulation. In the study of emotions, LPP composition is representative of the indexes of stimulus evaluation processes (Donchin 1981, 1988; Hajcak *et al.* 2006; Hajcak and Nieuwenhuis 2006; Ito *et al.* 1998). Other studies have found that not only is the early primary sensory process affected by emotional impact, the electrical activity of the brain associated with factors such as the distribution of attention and evaluation is also affected by emotion valence impact (Delplanque *et al.* 2004; Huang and Luo 2006).

Schupp *et al.* (2000) suggested that the data of LPP composition represented the process of emotional pictures, which was through the meaning of their intrinsic motivation and evaluation of the pictures stimulus presentation. Our research showed that LPP amplitudes of macroscopic tangential section of hardwood structure patterns were a little larger than those of softwood at FZ, CZ in “type1 & type2”, and the microscopic sections of softwood structure patterns (all three orientations) were a little larger than hardwood in “type3 & type4”, “type5 & type6”, and “type7 & type8”. It is shown that the degree of processing in response to stimulation was larger in the case of the macroscopic tangential section of hardwood and microscopic three sections of softwood structure patterns, and positive evaluation for the patterns. But LPP amplitudes of macroscopic tangential section of softwood and most of the microscopic three sections of hardwood were smaller. The results show that the process of stimulation associated with “like” is a little bit weak under this condition, and it might be because the wood cells piled structure formed varied patterns and texture characteristics, and subjects might have a distribution of psychological resources and emotional experience for such pictures. Therefore, the interpretation of emotional evaluation of wood structure patterns was based on the visual cognitive processing through a degree of wood picture stimulation processing. This indicated that the normal behavioral cognition included an interaction between emotion valance and cognitive regulation (Delplanque *et al.* 2004).

In addition, research shows that people are more likely to have an emotional dependence effect in which processing involves the need to recall materials rather than engage in simple memory activities (Eich and Metcalfe 1989). The previous ERPs studies indicate that LPP reflects the unconscious and the orientation receives attention for emotional visual stimulation (Hajcak *et al.* 2009). At the same time, it is shown that LPP reflects psychological processing in a complex and advanced manner. According to the research results, LPP stands for evaluation processing of wood stimulation patterns, which included judgment evaluation of personal emotion, and decision coloring was based on the perception analysis.

Physical Sensation of Emotional Experience of Wood Macroscopic Structure Patterns

In this study, the macrostructure patterns of hardwood and softwood evoked obvious P2 composition at five electrode positions of FZ, CZ, FCZ, CPZ, and PZ. There were significant differences in the central parietal region at the CZ and CPZ electrodes for “type1 & type2”, and P2 amplitudes of type2 were greater than type1 at the CZ and CPZ electrodes. The macrostructure patterns of hardwood and softwood evoked an obvious LPP composition, and there was a significant difference at the FZ electrode in the frontal area.

According to relevant research (Conroy and Polich 2007; Rozenkrants and Polich 2008), the perceptual evaluation of wood structure patterns should occur during the ERPs experiment, so the design and results of experiments were judged to be useful. As seen from the perceptual evaluation results, macroscopic tangential section patterns of hardwood and softwood tend to evoke a perceptual evaluation of “pleasing” and “natural”; hardwood has a practical advantage, while softwood has a decorative advantage. One possibility is that people experience the application of more wood sections with macrostructure patterns and texture of hardwood and softwood, which is more common in real life. Taken in comparison, emotional evaluation of macroscopic tangential section of softwood structure patterns tend to be categorized as “nature” and “decoration”, and hardwood structure patterns tend to be associated with practical applications. Previous research for P2 and LPP composition has shown that visual processing is more sensitive to the macroscopic tangential section of hardwood structure patterns, which made a positive evaluation. This may be because the larger change of order and roughness of the macroscopic tangential section of hardwood structure patterns which displayed practical features have helped to integrate information about perception and caused some impact on a person emotionally, and it has activated related emotion processing, so people carried a positive evaluation. The macroscopic tangential section of softwood structure patterns were due to the smaller change of roughness and order, and evaluation tended to be described as “natural” and “decorate”, so the visual processing and evaluation was weaker than hardwood.

Physical Sensation of Emotional Experience of Wood Microscopic Structure Patterns

The microstructure patterns of hardwood and softwood at five electrode positions for FZ, CZ, FCZ, CPZ, and PZ also evoked obvious P2 composition, in which the amplitude of microstructure of three sections of softwood was greater than those of hardwood. The brain topographic map also showed that softwood’s voltage was higher than that of hardwood. The FZ, CZ, and PZ evoked obvious LPP composition in which the microstructure amplitude of three sections of softwood was greater than the hardwood. The ERP study on emotion valence confirmed that no facial emotion pictures in the central frontal area or more extensive electrode area evoked the LPP composition in which positive valence will produce larger LPP amplitude compared to negative valence (Cuthbert *et al.* 2000; Delplanque *et al.* 2006).

The microstructure section patterns of hardwood and softwood, with three orientations, are familiar in life. According to relevant studies (Bradley *et al.* 2007; Codispoti *et al.* 2007), the physical characteristics of visual stimuli (*e.g.,* wood cells structure like vessels, wood fibers, and wood parenchyma) are likely to have an effect on people’s emotion perception. Research also argues that an increase in LPP amplitude reflects the increase of input attention resources for emotional stimuli (Dillon *et al.* 2006). According to the perceptual evaluation result, microstructure transverse section patterns of softwood and hardwood tended to be “pleasing”, “nature,” and “fine”, and when compared, people still preferred softwood. Microstructure radial section patterns of softwood tended to be “pleasing”, “soft,” and “exquisite” compared with hardwood, and people still preferred softwood. Microstructure tangential section of softwood was slightly exquisite and soft compared with hardwood.

Studies found that the adverse results, pleasure stimulation evoked greater LPP composition than non-pleasure stimulation for a time window of 300 to 700 ms. (Cuthbert *et al.* 2000). Combining the research, taken together with the ERPs waveform and perceptual evaluation, microstructure three-section patterns of softwood evoked obvious P2 and LPP composition compared with hardwood, and subjective perceptual evaluation also tended to prefer softwood. That may be because people have had little contact with microstructure patterns; transverse structure patterns of softwood look more fine and natural than hardwood, and radial structure patterns of softwood were superior to hardwood with respect to the descriptors, soft and exquisite. Tangential structure patterns of softwood compared with hardwood gave people the feeling of being slightly free and beautiful. So, microstructure patterns of softwood receive visual attention processing and result in positive emotional evaluation. By contrast, hardwood’s patterns of high complexity and irregular textural variation gave people the feeling of loose, hard, and slightly sedulous, and subjective evaluation with modesty, so they resulted in weak attention processing. The emotional changes might have been caused by imagining other things during the evaluation, which resulted in the allocation of psychological perception, for which the evaluation is weaker than softwood. The results show that the differences of wood stimulation patterns influence emotional ERPs waveforms, which is proof that when people observe positive emotional pictures, larger LPP composition is evoked more than when people observe neutral pictures (Flaisch *et al.* 2008; Van Strien *et al.* 2010). Combined with the research, emotional dependence memory of wood structure patterns is a kind of internal sense produced in the cognitive processing, but it does not appear as a simple intake extrinsic evaluation vocabulary, and it was also confirmed that psychological complexity determines the interaction between emotion and cognitive processing (Ellis 1991; Delplanque *et al.* 2004; Gross *et al.* 2006).

Although the emotional reaction to the wood microstructure patterns might be different, the brain also does not easily eliminate characteristics of the impression produced by the initial observations about wood stimulation patterns, because the emotional response can influence the cognition. At the same time, cognitive evaluation dramatically changes emotional feeling of individual reactions to specific information (Gross 2007). Overall, the emotional stimulus can enhance the cognitive process of psychological activity intensity. So, there was positive emotional evaluation for wood's microstructure patterns. This was because wood cells structure patterns and texture has a spectrum relationship with human physiological rhythm (Zhao 1997).

Therefore, from the results of this analysis, the subjects were given emotional evaluation for characteristics of wood stimulation patterns based on visual processing. And the different wood stimulation patterns showed different characteristics of processing evaluation. It finally made response judgment and emotional valence according to the perceptual vocabulary-matching characteristics. There is already a cognitive processing mechanism in the brain during the first sight of the wood stimulation patterns, which suggests high-level processing in the brain when seeing and the perceptual evaluation vocabulary to do the evaluating, such that the brain began to evaluate different kinds of wood structure patterns on the thinking level consciously. Thus it is expected that this research has a specific outcome, which indicates that the benefits for human living environment about such as wood applications, furniture design, manufacture, clothing design, and graphic design could be obtained through the results from this study.

CONCLUSIONS

1 Emotional responses to wood macro-microstructure patterns were obtained through P2 and LPP. P2 reflects visual cognitive processing of wood stimulation patterns, while LPP reflects late evaluations when people are exposed to different wood structure stimulation patterns.

2 Different wood stimulation patterns have an impact on emotional ERPs waveforms. Macroscopic tangential section of hardwood structure patterns evoked larger P2 and LPP amplitude compared to softwood patterns. This result reflects the fact that hardwood structure patterns and texture are more complex and diverse, causing visual cognitive processing sensitivity. Uncommon microscopic three-section (radial, tangential, and transverse) structure patterns of wood of softwood caused larger amplitude in the brain regions and brain topography compared to hardwood. That said, softwood structure patterns were perceived as soft, beautiful, and loveable, which aroused visual stimulation reactions to become more sensitive.

3 There were positive emotional experiences and evaluation for the wood macroscopic and microscopic structure patterns, and it was found that people can more easily understand meaning and feelings that match their own mood and emotions with wood macro and microstructure patterns. It was found that evaluation and judgment, involving personal feelings and decisions of the wood macroscopic and microscopic stimulation patterns, was based on visual cognitive processing.

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