Emotional Preference Modulates Autonomic and Cortical Responses to Tactile Stimulation

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촉각자극에 의한 자율신경계 및 뇌파 반응과 감성

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Abstract

The purpose of the current study was comparative analysis of autonomic and electrocortical responses to passive and active touch of the textiles with different subjective emotional preference. Perspective goal of the project is development of a template for classification of tactile stimuli according to subjective comfort and associated physiological manifestations. The study was carried out on 36 female college students. Physiological signals were acquired by Grass and BIOPAC 100 systems with AcqKnowledge III software . Frontal, parietal and occipital EEG (relative power spectrum /percents/ of EEG bands - delta, theta, slow and fast alpha, low and fast beta), and autonomic variables, namely heart rate (HR), respiratory sinus arrhythmia (RSA), pulse transit time (PTT), respiration rate (RSP) and skin conductance parameters (SCL, amplitude, rise time and number of SCRs) were analyzed for rest baseline and stimulation conditions. Analysis of the overall pattern of reaction indicated that autonomic response to tactile stimulation was manifested in a form of moderate HR acceleration, RSP increase, RSA decrease (lowered vagal tone), decreased PTT and increased electrodermal activity (increased SCL, several SCRs) that reflects general sympathetic activation. Parietal EEG effects (on contra-lateral side to stimulated hand) were featured by short-term alpha-blocking, slightly reduced theta and significantly increased delta and enhanced fast beta activity with few variations across stimuli. The main finding of the study was that most and least preferred textures exhibited significant differences in autonomic (HR, RSP, PTT , SCR, and at less extent in RSA and SCL) and electrocortical responses (delta, slow and fast alpha, fast beta relative power). These differences were recorded both in passive and active stimulation modes, thus demonstrating reproducibility of distinction between most and least emotionally preferred tactile stimuli, suggesting influence of psychological factors, such as emotional property of stimulus, on physiological

outcome. Nevertheless, development of sufficiently sensitive and reliable template for classification of emotional responses to tactile stimulation based on physiological response pattern may require more extensive empirical database.

Introduction

Tactile stimulation is one of the least explored among all sensory modalities employed in psychophysiology. Most of the studies were focused on purely psychophysical aspects of tactile perception [1,2,3,5,7,8], whereas psychological processes (e.g., emotion, attention) and physiological responses associated with tactile stimulation are much less studied [2,3,9]. However, taking into account the role of tactual perception in behavioral context, existing applications of tactile modality, and potential utility of ability to predict consumers response to new textile or thin fabrics, for instance, it seems feasible to investigate physiological and subjective reactions to touch.

The purpose of the current study was comparative analysis of autonomic and electrocortical responses to passive and active touch of the textiles with different subjective emotional preference. Perspective goal of the project is development of a template for classification of tactile stimuli according to its subjective comfort and associated physiological manifestations.

Methods

The study was carried out on 36 female college students (20-24 years old). Physiological signals were acquired with Grass Neuroacquisition and BIOPAC 100W systems with AcqKnowledge III software . Frontal, parietal and occipital EEG (relative power spectrum of EEG bands), and autonomic variables, namely heart rate (HR), respiratory sinus arrhythmia (RSA), pulse transit time (PTT), respiration rate (RSP) and skin conductance (SCL and SCR) were analyzed for rest and stimulation conditions. Tactile stimulation in passive mode was delivered by specially constructed computer system controlling rotating revolver with attached textile, while active stimulation mode was performed by haptic touch of the same textures. Tactile stimulation trials and rest periods were 30 s long. Each session was followed by 1 min of subjective rating of tried textiles and evaluation of its scores on pleasantness scale. Totally 6 textures (thin polyester and cotton fabric materials for underwear cloth) were used in the experiment . Three most preferred textiles and 3 least preferred textiles were pre-selected from samples provided by Korean Research Institute for Science and Standardization. Textures were evaluated by Kawabata method [6].

Results

Analysis of the overall pattern of reaction indicated that autonomic response to tactile stimulation was manifested in a form of moderate HR acceleration, respiration rate increase, RSA decrease (e.g., lowered vagal tonus), decreased pulse transit time (index of increased beta-adrenergic sympathetic activity) and increased electrodermal activity that reflects general sympathetic activation. Parietal EEG effects (on contra-lateral side) were featured by short-term desynchronization, alpha-blocking, slightly reduced theta and increased delta and beta activity with few variations across stimuli.

Comparison of passive vs. active touch mode ANS and EEG effects of the same textures did not show significant differences in HR and RSP responses, but differentiate by RSA, PTT , number and amplitude of SCRs (electrodermal activity was higher in passive touch mode), as well as magnitude of EEG responses (more increase of delta and decreased alpha during active touch).

The main finding of the study was that comparison of most and least preferred textures exhibited significant differences in autonomic (HR, RSP, PTT, SCR, and at less extent in RSA and SCL) and electrocortical responses (delta, slow and fast alpha, fast beta power). These differences were recorded both in passive and active stimulation mode, thus demonstrating reproducibility of distinction between most and least emotionally

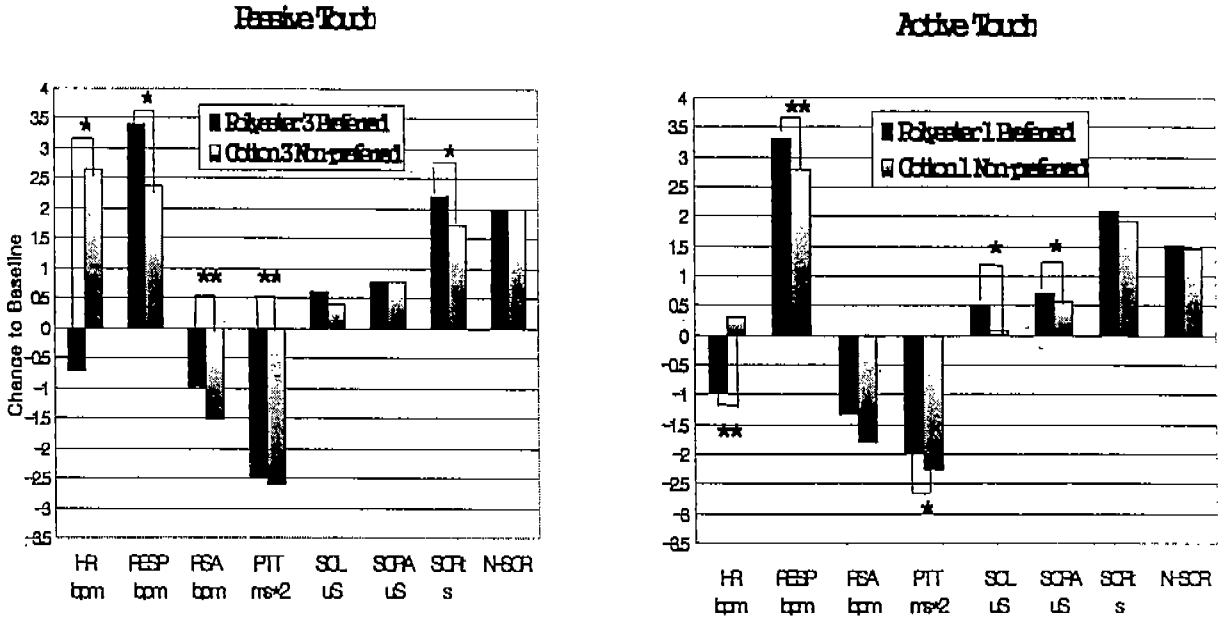

Figure 1. Comparison of autonomic responses to most and least preferred tactile stimulation (N=36) in passive (left) and active (right) touch mode. Significant differences to emotionall preferred and non-preferred textures were manifested in HR, RESP, RSA, PTT, SCL and amplitude
* -p < 0.05 ** -p < 0.01

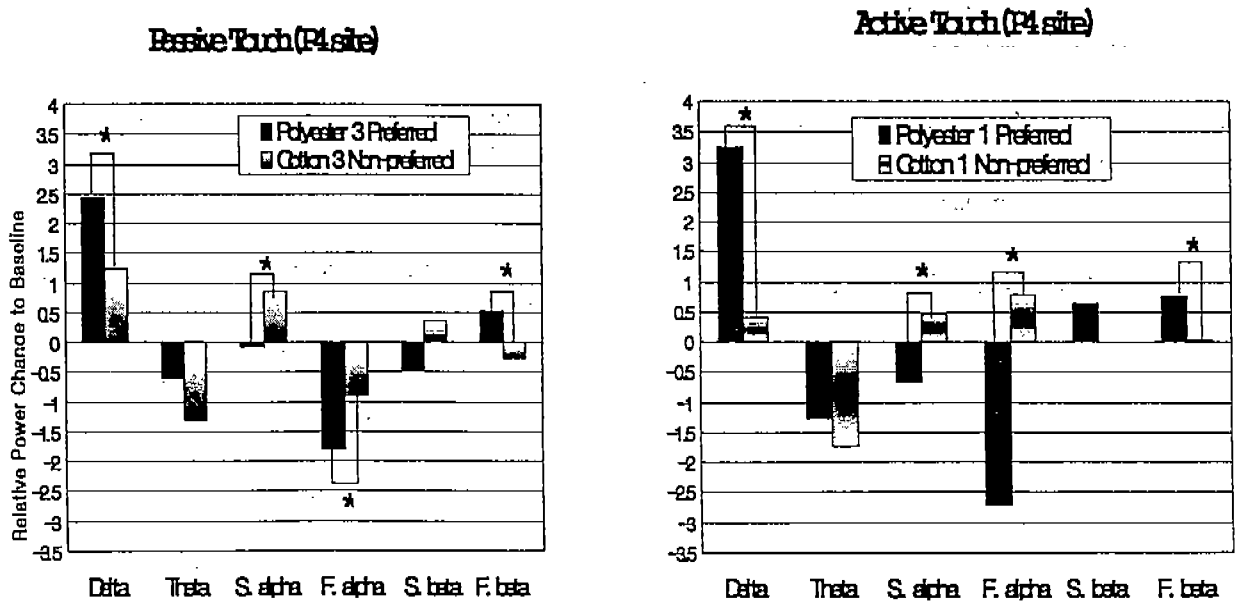

Figure 2. Comparison of EEG responses to most and least preferred textures (N=36) in passive and active touch mode EEG responses to emotionally preferred and non-preferred stimulation show differences significant for delta, slow and fast alpha and fast beta sub-bands. * -p < 0.05

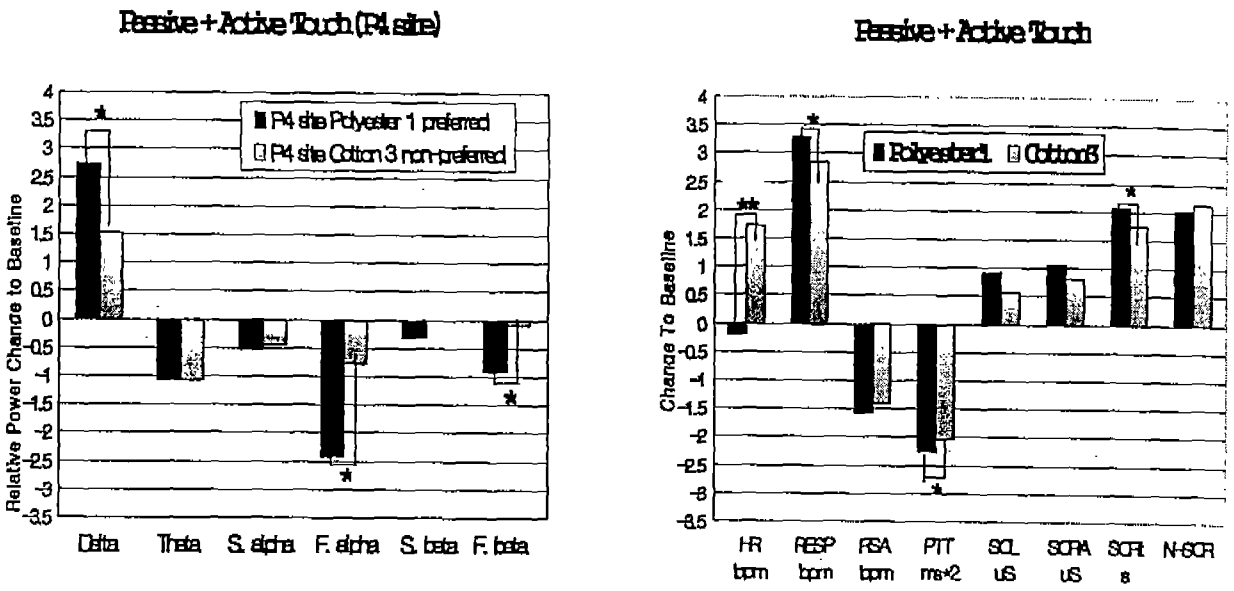

Figure 3. Comparison of autonomic nervous system (ANS) and CNS responses to most and least preferred textures (N=36, mean for both active and passive touch modes). ANS indices differentiate emotionally preferred textures by HR, RF, PTT and SCR amplitude, while EEG by relative power of delta, fast alpha and beta bands.. * - $p< 0.05$; ** - $p< 0.01$.

preferred tactile stimuli.

Analysis of responses within least and most preferred texture group revealed only some minor differences, mostly in HR and SCR response magnitudes and moderate EEG variability across similar textiles (three in each group). All results of the experiment are summarize in Figures 1,2 and 3.

Discussion and conclusions

Obtained results are in accord to our previous data [3,9], however, in current study we used textiles in similar conditions (e.g., did not have wet vs. dry pairs) and significantly extended number of monitored physiological variables. Data are substantially more informative when applied along with standardized psychological rating scales for textile evaluation by hand [6].

Differentiation of responses observed within same textures in passive and active touch mode are easier to understand in term of differences in metabolic demands efforts in active touch case, where even small motor demand may lead to elevated cardiovascular and respiratory activity, but to lower electrodermal responses, since physical activity interfere sensory intake. On other hand, reproducibility of differences between most and least preferred textures in both stimulation modes says for influence of other factors, such as emotional property of stimulus, on physiological outcome.

Matching of physiological responses profiles with overall response pattern is rather important for interpretation of results and understanding significance of emotional modulation of reaction. Detailed analysis of response profiles in group of textures with similar subjective rating and their comparison with those typical for alternative affect valence group may provide more insight on the problem. Nevertheless, development of sufficiently sensitive and reliable template for classification of emotional responses to tactile stimulation based on physiological response pattern may require more extensive empirical data. Further experiments in this direction deem quite rationale due to numerous potential application of the approach in applied psychophysiology and ergonomics.

Acknowledgements

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