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Passive and Active Touch of Fabrics: Psychophysiological Responses Modulation by the Emotional Preference of Touched Textures

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Abstract The sense of touch has both objective and subjective characteristics. During hand evaluation of the fabrics, psychophysiological processes such as emotion and attention to touched textiles are able to influence physiological responses to tactile stimulation. On other site, the mode of touch (passive vs. active) is also capable to modulate somatosensory responses, i.e., suppress somatocensory perception during active grasp. 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. 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 and parietal EEG (relative power of EEG bands) 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 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, 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.

Keywords: tactile stimulation, autonomic and cortical responses, emotional preference

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Introduction

Touch is an unique among other sensory systems. The sense of touch has both objective and subjective facets. Tactual sensory system is able to perceive material features of touched objects, i.e., their textutes qualities, geometrical properties, shape, elasticity, temperature etc. (Evans, Craig, 1991; Heller, 1989; Jeka, Lackner, 1995; Lederman, Klatzky, 1987, 1990). On other hand, sensations evoked from tactile stimulus may reflect as well subjective aspects of touch, such as pleasantness of texture and other emotionally charged responses (Im et al., 1997). These emotional reactions may exert influences on somatosensory perception and physiological responses associated with touch. Whatever form of modulation emotional or attentional processes can exert on tactual information processing, the fact is that they are potentially able to modulate somatosensory responses and concomitant cortical and autonomic reactions (Sohn et al., 1997; Evans, Craig, 1991).

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 (Darian-Smith et al., 1982; Jeka, Lackner, 1995; Lamb, 1983; Loomis et al., 1993; Post et al., 1994), whereas psychological processes (e.g., emotion, attention, cognition) and physiological responses associated with tactile stimulation are much less studied (Evans, Craig, 1991; Im et al., 1997; Sohn et al., 1997). There was reported (Chapin, Woodward, 1982; Lederman, Klatzky, 1987; Post et al., 1994; Schmidt et al., 1990) that somatosensory response suppression during movement ("sensory gating"), as well as modulation of somasthesis based on behavior (attending, affective reactions etc.). Besides that it was shown that some cognitive influences may selectively enhance somatosensory perception during tactual tasks (Jeka, Lackner, 1995; Lamb, 1983; Evans, Craig, 1991; Kruger, 1996). Nevertheless, there are not available any data about comparative selectivity between active and passive modes of tactile stimulation and related issues. 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 100WS systems with AcqKnowledge III software. Frontal and parietal EEG (relative power spectrum of EEG bands), and autonomic variables, namely heart rate (HR), respiratory sinus arrhythmia (RSA, defined as HR difference between minimal and maximal peaks in each respiration cycle), pulse transit time (PTT, or RPI-interval, calculated as time between R-wave of ECG and peak of peripheral pulse wave detected by photoplethysmogram), respiration rate (RSP), skin conductance level (SCL) and skin conductance response (SCR) characteristics such as SCR amplitude, rise time and number of SCRs were analyzed for rest and stimulation conditions.

Tactile stimulation in passive mode was delivered by specially constructed computer system 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 (hereafter referred to as preferred texture) and 3 least preferred textiles (non-preferred) were pre-selected from samples provided by Korea Research Institute for Science and Standardization. Textures were evaluated by hand using also method of Kawabata (1990).

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 (later reflect attending to stimuli and cortical arousal) 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 (more decrease in passive touch), PTT (less decrease in active touch), number and amplitude of SCRs (total electrodermal activity was higher in passive touch mode), as well as magnitude of EEG responses, namely, more increase of delta and more consistent decrease of alpha power 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 preferred tactile stimuli.

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

Discussion

Obtained results are in accord to our previous data (Im et al., 1997; Sohn et al., 1997), however, in current study we used textiles in similar physical conditions (e.g., we did not have wet vs. dry pairs compared) and significantly extended number of monitored physiological variables which gives more clues to understanding of mediating neurophysiological mechanisms (e.g., increase of beta-adrenergic sympathetic influences, general sympathetic activation and withdraw of vagal activity, electrocortical arousal at parietal sites). Data are substantially more informative when applied along with standardized psychological rating scales for textile evaluation by hand (Kawabata, 1990) and subjective prefrence reports.

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 subtle motor activity (or even preparation to motor act) may lead to elevated cardiovascular and respiratory activation, but to lower electrodermal responses, since physical activity interfere sensory intake. As it was mentioned above, motor activity, such as haptic movement, is able to interfere with tactual information processing and may lead to inhibition of physiological somatosensory responses through so called "sensory gating" mechanisms (Schmidt et al., 1990; Chapin, Woodward, 1982). On other hand, reproducibility of differences between most and least preferred textures in both stimulation modes says not only for role of pure somatic activity, but also 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 to tactile stimulation. Preliminary drawn template is presented on Table 1. Detailed analysis of response profiles in group of textures with similar subjective rating and their comparison with those typical for alternative preference group of textures

Table 1. Template of autonomic responses to tactile stimulation

Physiological variables		*Preferred texture*		*Non-preferred textures*	
		Passive touch mode	*Active*	*Passive*	*Active*
PNS/b-SNS balance indices					
Cardio-respiratory variables	Mean				
HR bpm	0.55	-	-	=	+
change to baseline					
RSP br/min	3.11	+	-	+	-
change to baseline					
RSA bpm	- 1.45	=	-	-	+
change to baseline					
PTT ms	- 4.20	+	-	-	+
change to baseline					
Comparison of profile with overall response pattern (matching)		H	L	L	H
SNS activation indices					
Skin conductance variables					
SCL uS	0.61	+	-	+	-
SCR (amplitude) uS	0.83	+	-	+	-
SCR rise time ms	2.05	+	-	=	-
SCR magnitude uS	1.68	+	-	+	=
SCR number	2.02	+	-	+	-
Comparison of SCR profile and matching with overall pattern		H	L	H	L
Summary of ANS profile matching.		H H	L L	L H	H L
Final decision criterion		H	L	mixed L/H	mixed H/L

Abbreviations: HR - heart rate. RSP- respiration rate. RSA - respiratory sinus arrhythmia (PNS index). PTT - pulse transit time (b-SNS index). SCL - skin conductance level (tonic). SCR - skin conductance response (phasic). SCR amplitude and rise time - parameters of first SCR. SCR magnitude - sum of all SCRs during stimulation. SCR No number of SCRs. ANS - autonomic nervous system. b-SNS - beta-adrenergic sympathetic nervous system. PNS - parasympathetic nervous system..

Note : = - matching of response with mean for all stimulation conditions

+ - response higher than mean

- - response lower than mean

H : (higher) profile of responses matches or exceeds overall response pattern

L : (lower) profile of responses is lower than overall response pattern. less matching.

Table 2. EEG bands relative power responses to tactile stimulation in active and passive mode. P1, P2 ,P3 - group of preferred texrures (polyester), C1, C2, C3 - group of non-preferred textures (cotton)

		Changes as compared to baseline											
		Passive Touch						Active Touch					
		Preferred			Non-preferred			Preferred			Non-preferred		
site	EEG	P1	P2	P3	C1	C2	C3	P1	P2	P3	C1	C2	C3
F3	Delta	2.19	2.26	2.97	1.98	1.89	1.08	2.52	1.10	0.94	0.58	0.52	2.24
	Theta	-0.68	-0.95	-1.73	-0.41	-0.66	-2.29	-3.00	-0.11	-0.50	-1.74	-1.70	-1.45
	S. alpha	-1.02	-1.26	-0.62	-1.40	-1.54	0.73	-1.14	-0.85	0.09	0.33	-2.40	0.21
	F. alpha	-0.81	-0.32	-0.44	0.24	0.17	0.87	-0.42	-0.08	-0.05	0.46	0.27	-0.14
	S. beta	-0.43	-0.28	-0.62	-0.79	-0.52	-0.57	0.28	-0.36	-0.73	-0.04	0.03	-0.68
	F. beta	0.75	0.55	0.43	0.40	0.67	0.18	1.05	0.30	0.25	0.40	1.28	-0.19
F4	Delta	2.64	1.97	2.82	2.15	2.21	1.67	3.34	1.53	1.53	0.73	0.24	3.18
	Theta	-0.90	-1.26	-1.27	-0.21	-1.41	-2.37	-2.35	0.33	-0.67	-1.88	-1.90	-0.28
	S. alpha	-1.05	-0.52	-1.03	-1.71	-1.43	1.73	-0.95	-0.90	-0.42	0.04	-2.03	0.90
	F. alpha	-0.93	-0.11	-0.36	0.14	0.51	0.03	-0.41	-0.09	-0.14	0.69	0.55	0.43
	S. beta	-0.56	-0.47	-1.03	-0.69	-0.57	-0.77	-0.27	-0.45	-0.79	0.11	-0.04	-0.03
	F. beta	0.80	0.39	0.03	0.32	0.69	-0.29	0.65	-0.43	0.48	0.31	1.09	0.37
P3	Delta	2.48	2.65	2.62	2.05	2.18	0.19	2.57	0.30	1.05	0.58	0.24	2.36
	Theta	-0.59	-0.26	-0.53	-1.39	-0.72	-1.19	-1.63	-0.44	-0.63	-1.50	-1.87	-1.07
	S. alpha	-0.32	-1.76	-0.32	-1.84	-1.39	0.49	-0.48	0.68	-0.18	0.48	-2.36	0.04
	F. alpha	-2.03	-1.99	-1.50	-0.16	-1.00	0.03	-2.06	0.21	-0.87	0.26	-0.47	-0.83
	S. beta	-0.79	0.45	-0.74	0.11	-0.02	0.35	0.66	-0.65	-0.19	-0.26	0.56	-0.36
	F. beta	1.26	0.90	0.47	1.40	0.95	0.12	0.94	-0.10	0.82	0.43	1.70	-1.15
P4	Delta	2.25	1.80	2.45	2.41	1.94	1.24	3.25	1.04	1.79	0.40	0.20	1.80
	Theta	-0.89	-0.03	-0.61	-1.39	-0.71	-1.32	-1.27	0.21	-0.64	-1.72	-2.04	-0.82
	S. alpha	-0.39	-0.82	-0.09	-1.48	-1.62	0.86	-0.66	-0.09	-0.67	0.48	-2.36	0.02
	F. alpha	-2.09	-1.35	-1.61	-0.16	-0.46	-0.89	-2.73	-1.00	-1.13	0.80	0.34	-0.68
	S. beta	0.04	-0.13	-0.47	-0.21	0.02	0.36	0.64	0.08	0.09	0.01	0.48	-0.39
	F. beta	1.08	0.53	0.53	1.12	0.54	-0.26	0.77	-0.24	0.57	0.03	1.38	0.07

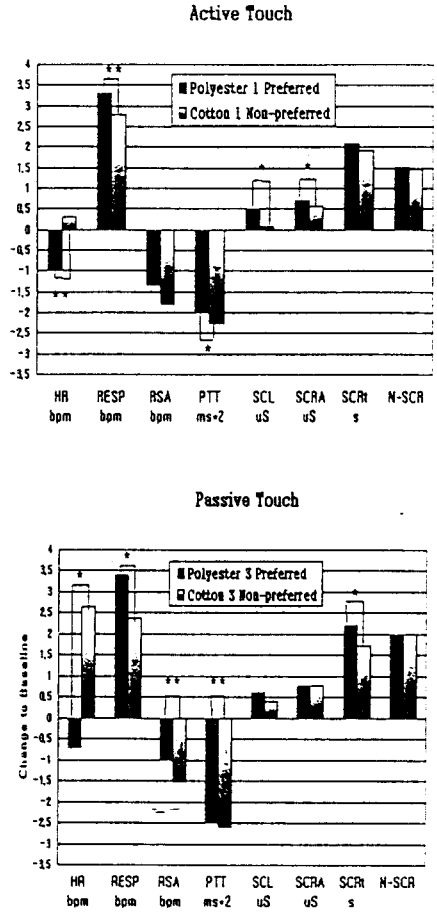

Figure 1. Comparison of autonomic responses to most and least preferred tactile stimulation (N=36) in passive (left) and active (right) touch mode. Significant differences to emotionall preferred and non-preferred textures were manifested in HR. RESP. RSA. PTT. SCL and amplitude * -p ⟨ 0.05 ** -p ⟨ 0.01

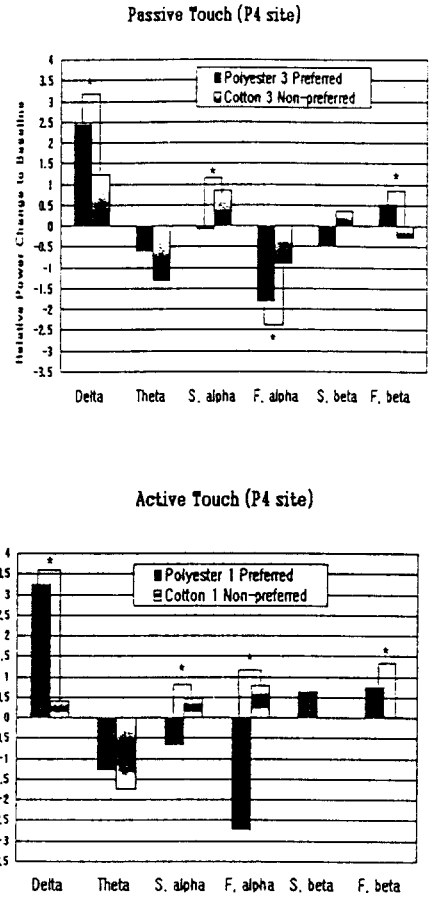

Figure 2. Comparison of EEG responses to most and least preferred textures (N=36) in passive and active touch mode EEG responses to emotionally preferred and non-preferred stimulation show differences significant for delta. slow and fast alpha and fast beta sub-bands. * -p ⟨ 0.05

(preferred and non-preferred pairs) may provide more insight on the problem.

exploration of texture and interference o somatic activity and tactual perception.

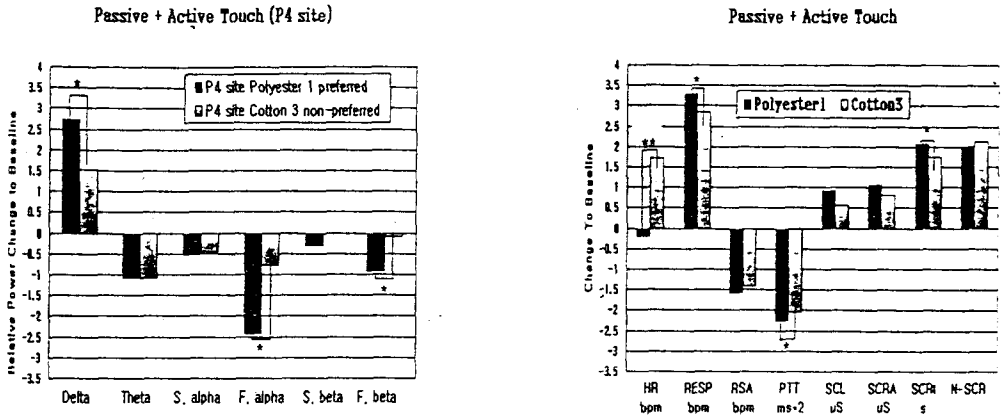

Figure 3. Comparison of autonomic nervous system (ANS) and CNS responses to most and least preferred textures (N=36, mean for both active and passive touch modes). ANS indices differentiate emotionally preferred textures by HR, RF, PTT and SCR amplitude, while EEG by relative power of delta, fast alpha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

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 and comprehensive analysis of collected databases. Further experiments in this direction deem quite rationale due to numerous potential application of the approach in applied psychophysiology and ergonomics.

Conclusions

Emotional responses evoked by touch of fabrics modulated physiological responses to tactile stimulation. Autonomic and cortical parameters differentiate responses to prefered and non-preferred textures.

Passive touch mode elicits more consistent physiological responses to tactual stimuli than active touch, probably due to cardiovascular and respiratory adjustment to metabolic demands during motor act of manual

More extensive experimental database seem to be necessary to develop sensitive templat for reliable distinction of emotional preferenc of touched textiles according to physiologica responses evoked by tactile stimulation.

Acknowledgement

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