On the Impact of Emotive Content on Tactile Word Perception

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ABSTRACT

An experiment on tactile speech communication systems for the deaf was carried out to test the impact of strong words with sexual content in contrast to emotional neutral words on semantic processing and psychophysiological reactions. Four wordforms were tactually presented in an identification test using (i) an articulatory coding and (ii) a non-phonetic arbitrary coding. Response behavior, skin conductance reactions (SCR), eyeblinks and response time were measured. An increase of blinking latencies indicated difficulties in the identification of the non-phonetic coding. SCRs were higher for phonetically coded stimuli, but did not increase with the emotive load of the word meanings.

1. INTRODUCTION

Research in the development of tactile speech transmission systems for the deaf has a long tradition. Whereas in early times these attempts were concentrated on the presentation of secondary communication codes to the skin, e.g. Morse code [1], later investigations have focused on designing more natural codings for tactile speech [2]. Every such task has to handle the problem that the temporal resolution capability of the skin senses is much lower than in the auditory modality. Therefore natural and easily perceivable tactile speech cannot be achieved by a simple one-to-one mapping of the acoustic signal onto the skin. But on the other hand the acoustic signal is the result of a slower activity of the human speech production apparatus.

Thus, as speech perception in general is often seen to be the perception of speech movements, it also seems promissing to ground tactile speech transmission on a coding that represents articulatory features instead [3]. From such a perspective also a recent study by the authors [4] showed that a articulation-based tactile coding of word stimuli could be better recognized than arbitrary stimuli of equal complexity coded without reference to phonetic features.

The central issue of that study was to investigate whether the articulation-based coding method applied is perceptually processed like a natural speech communication act in a sense that exceeds mere detection of phonological feature distinctions. This means that for a communicative act to be successful it is not sufficient to activate a sensory pattern comparison process. In addition, the perceptual processing must be linked to the semantic component of the human speech recognition system in order to establish the communicative transfer of word meanings. Therefore the stimuli used for presentation consisted of phonological minimal pairs one of each representing a wordform with semantic content, the other a nonword in a regular phonological form. To analyze this communicative transfer on different processing levels besides response behavior as an indicator of performance also psychophysiological parameters, i.e. eyeblinks and SCR, were recorded. Both are powerful measures to assess higher level cortical activities [5,6] also in speech perception [7].

In the literature the measurement of eyeblinks is handled as an indicator of cognitive load, since in problem-solving tasks an increase of blink rate has been found for more difficult tasks like mathematical calculation and speech-related memory activities [8]. Measuring blink latencies a blink hesitation has been reported for higher cognitive effort in an identification vs. a detection test [9]. On the other hand, SCR is a well-known indicator of emotional load. Independent of the sensory modality of stimulation an increase of emotional content of words leads to higher SCR amplitudes [10]. Thus, the measurement of SCR also provides a tool for the assessment of connotational and pragmatic communicative transfer.

The earlier study revealed that quasi-phonetic stimuli representing wordforms having a semantic content evoke higher SCRs than nonwords. This result could not be confirmed with a non-phonetic coding, thus indicating that the phonetic coding method enables natural speech perception not only on the phonological but also on the semantic processing level. The present experiment was carried out to extend the focus of investigation to the question whether such an articulation-based tactile coding method also is capable to establish the transfer of semantic connotational and pragmatic aspects of word stimuli. Therefore the perception of emotively loaded words via the tactile channel was tested.

2. METHOD

Stimuli were generated by means of the “System for Electrocutaneous Stimulation SEHR-3” of the Institute of Phonetics at Munich University. (For the description of the technical features see [11], where also the phonetic stimulus coding method is exemplified in detail.) The electrocutaneous impulse sequences on which the stimulus construction was based had a duration of 208 µs and were arranged in groups of 3 pulses following each other with a

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rate of 400 pps. For tactile stimulation the apparatus was connected to a PDP-11/83 computer and equipped with 16 pairs of circular gold-layered (5 µ) brass electrodes (9.0 mm in diameter each with a gap of 1.0 mm between the electrodes of each pair). The 16 stimulators of the device were placed equidistantly around the participants´ left forearms as shown in Fig. 1.

The psychophysiological measures (SCRs as well as eyeblinks) were registered by means of a 4-channel ZAK polygraph. Electrodes for the deviation of skin conductance reactions (Hellige biopotential electrodes, ∅8.7 mm) were placed on thenar and hypothenar of the left hand´s palm with hypotonic cream (0.06 mol NaCl) as electrolyte, and EOG-electrodes (Beckman biopotential miniature electrodes, ∅2.1 mm) were fixed above and below the right eye on the orbicularis oculi. The indifferent electrode was fixed 1 cm above the root of the nose.

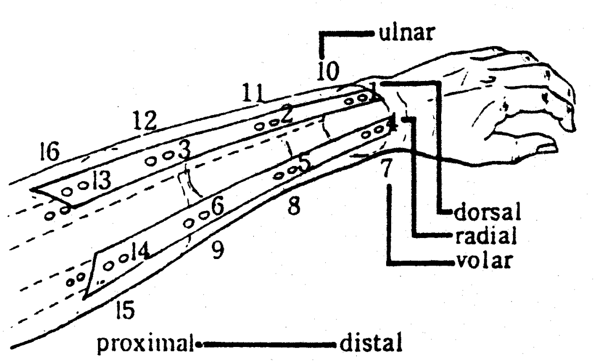

Figure 1: Electrode arrangement for tactile stimulation (Piroth and Tillmann, 1991, 335).

Four monosyllabic German wordforms (two minimal pairs) were selected for tactile coding and presentation. The words of each pair contrasted phonologically in voicing of the onset fricative only ([f/v] and [s/z]). In addition they contained a semantic differentiation in that the meaning of one word in each pair had a strong emotive connotation whereas the other was connotationally unmarked. The neutral stimuli were <fix> ([fɪks], *"quick"*) and <sechs> ([zɛks], *"six"*). Items with emotive load had a sexual content: <wichs> ([vɪks], *"masturbate" imp.*, vulgar expression) and <Sex> ([sɛks], *"sex"*, meaning of the German word restricted to sexual intercourse only).

The tactile stimulus synthesis was based on a phonetic coding method designed to transmit articulatory features as natural as possible to the skin by preserving the spatial relationship between places of articulation and the fortis-lenis contrast in obstruents. Thus, labial consonants were transformed into tactile patterns consisting of electric impulse trains that surround the forearm at the distal stimulator ring. Non-frontal places of articulation activated more proximal stimulator rings. Fortis consonants were simulated by impulse sequences with shorter inter-pulsetrain intervals (20 ms) than lenis ones (40 ms) with the effect that fortis patterns give the impression of a higher intensity. Vowels were represented by patterns moving in the distal-proximal dimension and mapping the vowel triangle into the dorsal-volar plane of the forearm [11]. An experimental control condition was defined by synthesizing tactile patterns in a non-phonetic coding with reversed articulatory-tactile feature transformation (Tab. 1).

CODE	Pattern	Articulatory Features	Tactile Features
1	"f"	+front +fortis	+front +fortis
1	"v"	+front -fortis	+front -fortis
1	"s"	-front +fortis	-front +fortis
1	"z"	-front -fortis	-front -fortis
2	"f"	+front +fortis	+front +fortis
2	"v"	+front -fortis	-front +fortis
2	"s"	-front +fortis	+front -fortis
2	"z"	-front -fortis	-front -fortis

Table 1: Tactile stimulus coding methods.
CODE 1: phonetic coding
CODE 2: non-phonetic coding

18 native speakers of German - 6 female and 12 male - in the age of 25 to 42 years ($\bar{x}$ = 32.8 years) underwent the experiment. Half of the participants had to identify stimuli in the phonetic coding, the other half in the non-phonetic one. They were informed on the details of the coding but no reference was made to the connotations of the wordmeanings. Responses were given by pressing a labeled key on a keyboard in front of their seat. The experimental design was adopted from the above-mentioned study published earlier by the authors [4]. In the experiment described there the reactions to words vs. nonwords were under test, instead of the difference in emotive load investigated in the present study. The impulse amplitude for electrotactile stimulation was adjusted to a mid value between absolute threshold and annoyance in an interactive iterative calibration procedure. Under each condition a randomized set of 40 stimuli (4 wordforms x 10 repetitions) was presented in an identification test with an interstimulus interval of 6000 ms.

The following measures were registered during the test run: the number of correct identifications (CORR) and the corresponding response times (RT). Additionally, psychophysiological measures were continuously recorded: rate (BR) and latencies of eyeblinks (BRLAT) as well as skin conductance reactions (SCR), both from stimulus onset to 4600 ms after stimulus onset.

3. RESULTS

Psychophysiological data were digitally recorded and visualized to determine SCR maxima and the number and latencies of blinks in the observed blinking behavior. Records with missing data and those corresponding to stimulus presentations on which participants reacted with rapid hand or eye movements were excluded from further statistical analysis. SCR amplitudes were transformed according to formula (1)

$$SCR_{transformed} = SCR / SCR_{maximum} \quad (1)$$

for each participant to standardize variability across subjekts [12]. Blink rate data were treated in the same way. 2x4 analyses of variance (MANOVA) were calculated [13] with CODE as between-subject factor and WORD as within-subject factor for percent correct identification (CORR), response time (RT), blink rate (BR), blink latencies (BRLAT) and transformed skin conductance reactions (SCR).

Correct Responses. Mean identification scores are above chance for all items. For the phonetic coding (CODE 1) performance is slightly better, but emotive load is not mirrored by the response behavior (Tab. 2). The MANOVA did not show any significant effects.

		CODE 1	CODE 2
E	[vɪks]	59.3	46.9
E	[sɛks]	48.0	53.8
N	[fɪks]	59.0	52.5
N	[zɛks]	53.3	42.9
∅		**54.9**	**49.0**

Table 2: CORR (correct identification) – means [%].
CODE 1: phonetic, *CODE 2:* non-phonetic
E: emotive stimuli, *N:* non-emotive stimuli

Response Time. Again, the phonetic coding evokes faster responses, although this effect is not significant (Tab. 3). On the other hand there is a significant WORD effect ($F(3,48) = 3.60$; $p = .020$).

		CODE 1	CODE 2
E	[vɪks]	1525	1635
E	[sɛks]	1661	1696
N	[fɪks]	1497	1625
N	[zɛks]	1748	1970
∅		**1608**	**1732**

Table 3: RT (response time) – means [ms].
CODE 1: phonetic, *CODE 2:* non-phonetic
E: emotive stimuli, *N:* non-emotive stimuli

Blink Rate and Blink Latency. Whereas blink rate shows no effects, for blink latency a significant CODExWORD interaction occurs ($F(3,45) = 4.06$; $p = .012$). Mean blink latencies are given in Tab. 4.

		CODE 1	CODE 2
E	[vɪks]	1487	1787
E	[sɛks]	1899	1657
N	[fɪks]	1588	1997
N	[zɛks]	1854	1881
∅		**1707**	**1831**

Table 4: BRLAT (blink latency) – means [ms].
CODE 1: phonetic, *CODE 2:* non-phonetic
E: emotive stimuli, *N:* non-emotive stimuli

Skin Conductance Reaction. SCR turns out not to be sensitive to CODE, but reveales a significant WORD effect ($F(3,48) = 3.06$; $p = .037$) and a CODExWORD interaction ($F(3,48) = 5.42$; $p = .003$).

		CODE 1	CODE 2
E	[vɪks]	.265	.264
E	[sɛks]	.325	.128
N	[fɪks]	.333	.283
N	[zɛks]	.286	.279
∅		**.298**	**.239**

Table 5: SCR (skin conductance reaction) – means.
CODE 1: phonetic, *CODE 2:* non-phonetic
E: emotive stimuli, *N:* non-emotive stimuli

4. CONCLUSIONS

The previous experiment of this series has shown the advantage of the phonetic coding method in the identification of tactile speech stimuli as well as the sensitivity of this coding to the meaningfulness of the tactile stimuli. In the present experiment the identification scores and response times confirm the superiority of the articulation-based coding, although the tendencies for both effects do not reach significance. The analysis of blink rate does not show any effect, since no differences of cognitive effort are involved in the processing of the stimuli. The latencies of first blink after stimulus presentation yield a significant interaction, which is based on the fact that latencies are shorter for stimuli with a distal place of stimulation (representing the front place of articulation), but for the phonetic coding method only. Thus, blink latencies reflect a correspondence of tactile and phonetic place features. Only skin conductance reactions show both a significant main effect of the factor WORD and an interaction. Similar to the results for the blink latencies SCRs are higher when the patterns are presented at the distal stimulators and phonetically coded. Obviously all effects differentiating between test words are induced by the spatio-temporal stimulus patterning but not by the emotive meaning component.

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Whereas the results of overt and covert behavior parameters clearly point out a greater efficency in the processing of meaningful stimuli when coded phonetically, the analyses of the data according to different emotive load of the word meanings do not provide any substantial effect. This is in contrast to the results of classical psychophysiological investigations, which have shown that acoustical or visual presentation of words with emotive load evokes significantly greater physiological reactions than the presentation of non-emotional semantic stimuli. In the present experiment this effect is missing, because the unusual tactile presentation leads to a slowed sequential processing. Most effort is spent to the identification of the phonological and semantic content of the stimuli. Reactions to other components of meaning, e.g. the emotive load, might take place in a later step in the processing not captured by the experimental procedure used. One might assume that processing will be faster after a sufficient training period and then approximate the processing duration for natural speech. When this is achieved and the perception of tactile speech analogues has become a part of the human language faculty the percipients should be able to focus their attention also on the pragmatic role of the entire communicative act. On such a level of competence reactions on the emotive component of the stimuli should be comparable to those known from spoken language processing.

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