Hand Movement Behavior with or without Speech Differs in its Kinetic Structure of Nonverbal Communication

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Introduction

In the present study we investigate the differences in hand movement behavior in the narration of everyday like scenes between a speech and a silent condition. Previous studies have shown differences between speech and silent conditions when investigating iconic hand movements [1,2]. In this study, we extend the analysis to all hand movements having occurred during the description of everyday like scenes. The analysis is performed according to the Neuropsychological Hand Movement Coding (NEUROGES)-ELAN-System, a tool for empirical hand movement research that combines a kinetic with a functional analysis of hand movement behavior [3].

Susan Goldin-Meadow proposed a model which assumes that hand movements are constrained by speech gaining the "full burden of communication" and grammatical properties without speech [2]. Studies so far, contrasting gestural output during speech and silence [1,2] could show that more hand movements are performed during silent conditions. Both of these studies have focussed on iconic hand movements not including the full manual repertoire of hand movement behavior. In this study, we look at the entire hand movement behavior of silent and verbal conditions to uncover differences of the complete manual range of nonverbal communication.

Hand movements convey meaning by different kinetic movement properties. For example, the kinetic structure of communicative hand movements is characterized by a preparation phase, a stroke phase and a retraction phase, whereas hand movements reflecting emotional states are of continuous/irregular body-focused manner without a preparation or a retraction phase [3]. Norbert Freedman has postulated that body-focused as compared to "object-focused" communicative hand movements indicates a withdrawal from communication for the purpose of self-stabilization [4]. Furthermore, hand movements that accompany speech are different in their "basic organization" [2] as the sequential nature of the information flow in speech makes the information flow in co-speech hand movements also sequential [5]. To gain insights about the kind of information transmitted by a certain kinetic property, we investigate in this study the hypothesis that the total amount of hand movements does not differ in situations with or without speech, but the kinetic hand movement structure changes in regard to mostly conceptual properties during silent conditions to a less conceptual but more self-stabilizational purposes during the speech condition. Furthermore, spontaneous hand preferences reflect the activation of the contralateral hemisphere [6]. As Kimura proposed that hand preference is determined by the lateralization of language [7], Lausberg and Kita argued that semantic aspects of the message influence the choice of hand in co-speech hand movements [1]. Because hand preference of co-speech hand movements is discussed controversially, with this study we seek to disentangle the relationship of the choice of hand and the respective neuronal correlates of hand movements by a tachistoscopic study design with a silent and a verbal condition.

Methods

Hand movement behavior of 11 healthy right-handed participants (5 female, 6 male; mean age: 41 years; mean WAIS score: 100.6; all participants living in Northern America) was videotaped for gestural analysis with the Neuropsychological Hand Movement Coding (NEUROGES)-ELAN-System [3]. The study was approved by the Ethics committee of the German Research Association, the Ethics committee of the Free University of Berlin Medical School, and the Ethics committee of the Montreal Neurological Institute. All subjects signed the Neuropsychology consent forms currently used at the Montreal Neurological Institute and Hospital. Participants sat in front of a computer and drawings of everyday life action scenes, e.g. a skipping girl, were presented unilaterally randomly in the left or right visual hemifield for 150ms. Subjects were asked on the first day of the

experiment to demonstrate with hand movements but without speaking what they had seen on the drawing. The second day of the experiment participants were asked to describe verbally what they have seen on the drawing. Each subject's performance was taped with a video camera. Two independent blind raters were trained to analyze hand movement behavior according to the Neuropsychological Hand Movement Coding (NEUROGES)-ELAN-System [3]. Kinetic hand movement structures representing different cognitive processes are coded as communicative (phasic, repetitive), emotional and self-regulating (irregular), changes in postures (shifts) and aborted movements for the right and left hand without sound. One rater coded 100% of the data for further analysis while the second rater coded 25% of the data to establish interrater agreement according to Holle & Rein (modified Cohen's kappa coefficients as measures of inter-rater agreements) [8]. Repeated measures analyses of variance (ANOVA's) were used to report significant results of the frequency per stimulus of hand movements. Multiple post hoc pairwise comparisons were corrected with Bonferroni corrections.

Results

In all, 1672 movement units were analyzed. Modified Cohen's kappa coefficients for structure values were following: irregular, 0.66; phasic 0.88; repetitive 0.90; shift 0.59; aborted 0.39. Presenting stimuli in the right visual hemifield led to greater response in hand movement behavior at all ($F(1, 9)=8.681$. $p<0.05$). Concerning the structure of hand movements the two conditions (silent (GO), verbal (VG)) showed different distributions (*structure*experiment*. $F(4, 6) = 54.480$. $p< 0.001$) but no difference in the frequency of hand movements in general. During the GO condition significant more phasic (*mean difference* [*MD*] = 0.148, $p < 0.05$) and repetitive ($MD = 0.140$, $p < 0.001$) hand movements occurred as during the VG condition significant more irregular hand movements ($MD = 0.131$, $p < 0.05$) were executed. Further, we observed a significant interaction of hand movement structure and hand preference (*structure*hand*. $F(4, 6) = 13.017$. $p < 0.01$). Whereas the left hand was preferred for irregular, shift and aborted hand movements, phasic and repetitive hand movement structures were mainly executed with the right hand.

Discussion

The present study confirmed previous findings [1] that the choice of hand depends on the semantic aspect of the message and not the hemispheric specialization of language [7]. In this data it is shown by its tachistoscopical design that communicative conceptual hand movement structures (phasic, repetitive) are executed with a right-hand-preference whereas continuous/irregular, shift and aborted hand movements, the more emotional structures of hand movements, show a left-hand-preference. This counts for the silent as for the verbal condition diminishing the influence of speech on the choice of hand. Irregular hand movements are increased in stressful situations, negative emotional experiences or the more personal the topic gets [4]. The preferred use of the left hand for this movement structure demonstrates the influence of the "emotional" right hemisphere [9]. In contrast to previous studies [2] we found that the amount of hand movements during silent and verbal conditions, considering all occurring hand movements, does not change. We observed that it is the distribution of hand movements regarding their kinetic structure that is differing between verbal and silent conditions. During the silent condition the structure of hand movements is highly conceptual observable in mainly phasic and repetitive hand movements whereas during the verbal condition continuous/irregular hand movements are executed the most. While information is transmitted without speech by the classical communicative hand movement structures, speech takes over during verbal conditions changing the kinetic organization of the hand movements. We conclude that during the verbal description of everyday like scenes the sequential information flow of speech induces a consequent sequential gestural output [1, 5] shown in less conceptual hand movements as observed in the silent condition leading to more implicit hand movement behavior during speech.

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