Neuronal interaction of gesture and language comprehension: Preliminary results

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Background

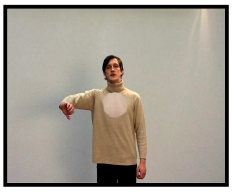
Gestures are a significant component of non-verbal interpersonal communication. Up to now there have been no attempts to gain further insight into the neural foundations of the recognition and allocation of gestical symbol formation and its interaction with language. There are neuropsychiatric disorders such as schizophrenia in which comprehension of gestures is impaired (Berndl et al 1986). Genetic predispositions are possibly related to the deficits in speech and gesture comprehension in patients with schizophrenia. This study shows the preliminary results of language and gesture integration in healthy subjects. Further investigations with patients with schizophrenia are intended.

Study aims

- **To examine cerebral correlates of speech and gesture comprehension in healthy subjects**
- **To investigate the integration of both modalities**
- **To develop a paradigm to investigate dysfunctional integration processes for language and gesture comprehension in patients with schizophrenia**

Material

The stimuli for experiment consist of short video clips. The clips are designed in advance by the investigators for both language and gesture, and then performed by a bilingual actor. The same spoken phrases are used for the metaphoric, free and no gesture condition.



All video clips have the same length of 5 seconds with at least 0.5 seconds before and after each sentence, where the actor neither speaks nor moves. The stimuli were rated by 20 subjects who did not participate in the main study. Rating includes questions according to comprehensibility, emotional content and naturalness. Other parameters such as movement characteristics, pantomimic content, transitivity or movement of the right hand were also considered.

Fig 1: Example video: The actor speaks a sentence and performs an unrelated gesture. The lighter spot on his shirt belongs to the control task. The participants have to press the left button, for the lighter spot and the right button if the spot is darker.

Design

Our Experiment will contrast meaningful, with meaningless and no gestures in a 3x3 factorial design of gesture by language (beside the No-Gesture/No-Speech condition).

	metaphoric gestures = meaningful gestures	**free gestures** = meaningless gestures	**without gestures**
German = meaningful language	 „Die Mannschaft steigt in die 1. Liga auf."	 „Die Mannschaft steigt in die 1. Liga auf."	„ Die Mannschaft steigt in die 1. Liga auf."
Russian = meaningless language	 „Места находятся на трибуне."	 „ Места находятся на трибуне."	„Места находятся на трибуне."
without language			

Fig 2: Experimental design: Three language and three gesture conditions and there combinations were examined in one experiment. To avoid repetitions of sentences or gestures four complementary video sets were constructed.

Task

Subjects were presented with short video clips and were required to choose between two response alternatives (lighter vs. darker spot) displayed on the actors pullover.

FMRI

Functional images were measured by use of echo-planar-imaging (3 Tesla, EPI, 31 slices, ST= 4mm, IG=0,3, TE=30ms, TR=2000ms, MS 64×64, FOV=240mm, α=90°). All results are based on an event related random effect model, and a threshold of p<.001 (uncorrected) has been applied to all calculations.

Results

The results are based on the investigation of 6 healthy subjects who participate on the fMRT-Experiment.

Gesture Processing

The comparison between German conditions with co-verbal metaphoric gestures vs. isolated German speech condition leads to a bilateral activation in the middle and superior occipital lobe.

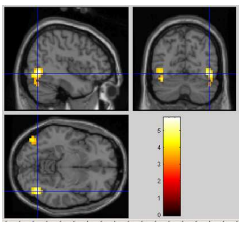
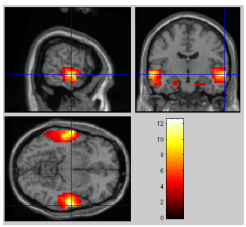


Fig 3: Difference contrast: The contrast of meaningful speech and gesture condition versus an isolated speech condition revealed bilateral activation of the occipital lobe (p=.001; uncorrected; MT area).

Results

Language processing

The comparison between German conditions with co-verbal metaphoric gestures vs. isolated movements from the metaphoric condition leads to extended bilateral activations in the temporal lobes (Fig. 4).



The comparison between German conditions with co-verbal metaphoric gestures vs. the equivalent Russian condition leads to a focal activation in the left middle temporal gyrus.

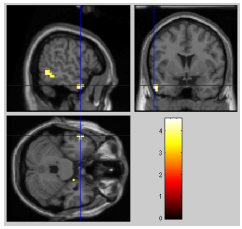


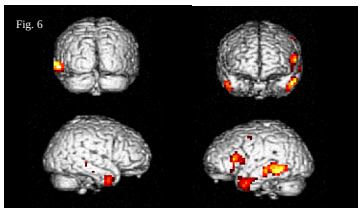
Fig 4: The presentation of speech and gesture in comparison to isolated gestures leads to a bilateral temporal activation (p<.001, uncorrected).

Fig 5: The specific increase in activation due to the semantic content of speech is located in the left middle temporal gyrus (p<.001, uncorrected).

Interaction of language and speech comprehension

To investigate the interaction of language and gesture comprehension, we conducted a weighted interaction model. We assume that the increased activation observed with increased integration difficulty of the auditory and visual input, occurs in the areas responsible for the integration of both modalities.

For the German condition we suggest the lowest activation for the sentence without any hand and arm movement. The integration difficulty increases for the metaphoric videos, were the gesture fits to the content of speech and the highest effort for the integration of both modalities appears, if the Gesture is independent of the content of speech, in the free gesture condition. For the Russian conditions we assume the reverse effect to incorporate an appropriate control condition.



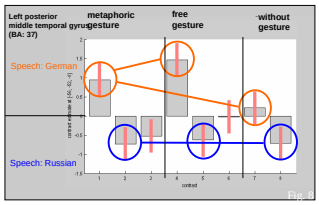


Fig 6: Interaction results: The calculation of the weighted interaction leads to left hemispheric activation in the anterior and posterior middle temporal gyrus and the inferior frontal lobe (p< .001, uncorrected). Fig. 7 shows the contrast estimates over all conditions for the left posterior middle temporal gyrus.

Behavioral data

Approximately 30min. after scanning, participants perform a memory task for the videos of the German conditions. 50% old videos were presented with 50% new videos and the participants had to decide, if it is a new (press left) or an old (press right) video.

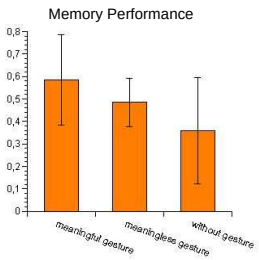


Fig. 8: Memory performance for seen vs. unseen video clips. Co verbal gestures enhances the memory performance. Meaningful gestures induce higher memory performances than meaningless gestures. Due to the small sample size these results are not sig., but data of pretest show sig. differences between the conditions.

Conclusion

Language and gesture processing in comparison to isolated gesture processing activates the left and right temporal lobe. However, the different contrast between German and Russian metaphoric gesture conditions leads to activation in the left middle temporal gyrus. Thus the semantic processing of bimodal language perception seems to be clearly located in the left temporal lobe. The brain activation pattern during language and gesture integration is mainly left lateralized and includes the anterior and posterior middle temporal gyrus and the inferior frontal cortex. For the German sentences, these areas show a clear activation increase over the no-gesture, metaphoric gesture and free gesture condition. There is also a relationship between integration difficulty and activation level in these regions.

Patients with schizophrenia produce less coverbal gestures (Troisi et al., 1998) and have far more difficulties in recognizing their meanings (Berndl et al., 1986). Indeed, schizophrenic patients who show impaired semantic processing also show a dysfunction of the left posterior temporal regions (Kircher et al., 2001). Therefore we assume for patients with schizophrenia that there is a dysfunctional integration of both speech and gesture processing.

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