The first conference in linguistics within the Birgit Rausing Language Program

Brain Talk: Discourse with and in the Brain

The impact of context on language processing

Program and Abstracts

LUND UNIVERSITY

Center for Languages and Literature, June 2–3, 2008

Organizing committee

Lund University: Merle Horne, Magnus Lindgren, Mikael Roll
Newcastle University: Kai Alter
University of Oslo: Janne von Koss Torkildsen

Program

June 2

9:00–10:15	Coffee
10:15–10:30	Opening: **Birgit Rausing**

Session 1: Magnus Lindgren (Chair)

10:30–11:00	Speaker: **Kenneth Hugdahl**, University of Bergen *Speech perception and brain function: Experimental and clinical studies*
11:00–11:30	Speaker: **Yury Shtyrov**, Medical Research Council, Cambridge *Rapid, automatic and parallel language processing: Neurophysiological data*
11:30–12:00	Speaker: **Mireille Besson**, CNRS, Marseille *Electrophysiological studies of prosody*
12:00–14:00	Lunch

Session 2: Janne von Koss Torkildsen (Chair)

14:00–14:30	Speaker: **Inger Moen**, University of Oslo *Production and perception of word tones in Norwegian patients with brain damage*
14:30–15:00	Speaker: **Ina Bornkessel-Schlesewsky**, Max Planck Institute, Leipzig *The role of prominence in the neurocognition of language comprehension: A new perspective on the syntax-semantics interface*
15:00–15:30	Coffee break

Session 3: Mikael Roll (Chair)

15:30–16:00	Speaker: **Matthias Schlesewsky**, University of Marburg *Demystifying semantic P600 effects: Theoretical arguments and cross-linguistic observations*
16:00–16:30	Speaker: **Kerry Ledoux**, Johns Hopkins University, Baltimore *On-line studies of repeated name and pronominal coreference*
16:30–16:50	Poster Pitch: Mikael Roll (Chair)
16:50–18:30	Poster Session*
19:30	Conference Dinner (for invited participants)

June 3

9:00–10:00 Coffee

Session 4: Kai Alter (Chair)

10:00–10:30 Speaker: **Ann Pannekamp**, Humboldt University of Berlin, and **Ulrike Toepel**, University and University Hospital Lausanne
Fishing for information: How children learn to interpret focus

10:30–11:00 Speaker: **Leticia Pablos**, University of Reading
NPI licensing in languages with a rich agreement system

11:00–11:30 Speaker: **Francisco Lacerda**, Stockholm University
A biological and interactional perspective on the emergence of early linguistic functions

11:30–12:00 Speaker: **Janne von Koss Torkildsen**, University of Oslo
ERP correlates of word learning in infants: Effects of productive vocabulary size

12:00–14:00 Lunch

Session 5: Merle Horne (Chair)

14:00–14:30 Speaker: **Stefan Heim**, Research Center Juelich
Neurocognitive profiles of developmental dyslexia

14:30–15:00 Speaker: **Mikael Roll**, Lund University
The role of left-edge intonation in Swedish language processing

15:00–15:30 Coffee break

Session 6: Merle Horne (Chair)

15:30–16:00 Speaker: **Martin Meyer**, University Hospital of Zurich
The laughing brain: Comparative evidence from behavioral and neuroimaging studies in human and monkey

16:00–16:30 Speaker: **Kai Alter**, Newcastle University
The processing of emotional utterances

16:30–17:00 Discussion and Concluding Remarks: Kai Alter (Chair)

*Poster Presentations

Giorgos P. Argyropoulos, University of Edinburgh: *Neocerebellar emulation of language processing*

Zoltán Bánréti, Hungarian Academy of Sciences: *Restricted discrimination between local economy and global economy in agrammatic aphasia*

Elisabeth Bay, Marion Grande, Katja Hussmann, Swetlana Christoph, Klaus Willmes, Martina Piefke, and **Walter Huber**, University Hospital Aachen: *Basic parameters of spontaneous language: Do they differentiate between unimpaired and aphasic speakers?*

S. M. E. Bihler, D. Saur, S. Abel, D. Kümmerer, W. Huber, J. Dittmann, and **C. Weiller**, University Hospital Freiburg, University of Freiburg, and University Hospital Aachen: *Auditory repetition of words and pseudowords: An fMRI study*

Angèle Brunellière and Ulrich Hans Frauenfelder, University of Geneva: *Morpho-syntactic context effects in spoken language processing: An ERP study*

F. Citron, K.A.M. Klingebiel, B.S. Weekes, and **E.C. Ferstl**, University of Sussex: *Evaluation of lexical and semantic features for English emotion words*

T. Ibertsson, L. Ásker-Arnason, K. Hansson, and **B. Sahlén**, Lund University: *Phonological processing, speech intelligibility and reading in Swedish children with cochlear implants*

Armina Janyan, Ivo Popivanov, and **Elena Andonova**, New Bulgarian University and University of Bremen: *Evoked gamma-band oscillations in single-word translation*

H. Kreiner, S. Mohr, K. Kessler, and **S. Garrod**, University of Glasgow: *Can context affect gender processing? Evidence from ERP about the differences between lexical and stereotypical gender*

Francisco Lacerda, Ulla Sundberg, Iris-Corinna Schwarz, Ulla Bjursäter, Ellen Marklund, Eeva Klintfors, Göran Söderlund, and **Lisa Gustavsson**, Stockholm University: *Development of lateralised speech perception*

Frida Mårtensson, **Merle Horne**, **Mikael Roll**, and **Pia Apt**, Lund University and Malmö University Hospital: *Implications of aphasia on abstract and concrete noun processing*

Kathrin Pusch, **Jessica Rosenberg** and **Rainer Dietrich**, Humboldt University: *Circadian rhythm in phonetic speech perception*

Stefanie Regel, Thomas C. Gunter, and **Seana Coulson**, Max Planck Institute Leipzig: *The impact of pragmatic knowledge on the comprehension of irony: An ERP study*

Bengt Sigurd and **Bengt Nilsson**, Lund University: *Modelling brain activity understanding self-embedded sentences*

Sverker Sikström and **Petter Kallioinen**, Lund University: *Exploring the high dimensional semantic space in the brain*

Jaana Simola, Kenneth Holmqvist, and **Magnus Lindgren**, Lund University: *Hemispheric differences in parafoveal processing: Evidence from eye-fixation related potentials*

Speaker Abstracts

The processing of emotional utterances

Kai Alter[1], Carly Metcalfe[1], Damien Gabriel[1,2], Manon Grube[1], Herman Ackermann[3], Susanne Dietrich[3]

Newcastle Auditory Group[1]; Université de Génève[2]; University of Tübingen[3]

The expression of emotions is one of the most important parts in everyday communication. Communicational situations require immediate feedback between speaker and listener demanding effort in recognising both speaker's and listener's attitude to a specific topic. This task often results in an interaction that necessitates specific knowledge about encoding and decoding of emotional information. Emotional lexical information and emotional prosody interact in speech processing on various levels: Lexical information itself can express emotions such as in utterances like 'I am happy' or 'This is disgusting' containing words like 'happy' or 'disgust'. However, sentence like statements can be easily replaced by small vocalisations called *interjections*. Interjections are short, verbal items expressing speaker's emotional state, and that are used to convey emotion such as 'yipee' for happiness, or 'yuk' for disgust. However, in actual brain research, it is still a challenge to disentangle lexical and emotional information. It remains an open issue how affective/emotional information is encoded in the speech signal, and how the Human brain processes this information. We therefore conducted three studies on the processing of interjections in two languages, and one study across languages in order to find out if there are differences in between and across languages. In two behavioural studies on German (Dietrich, Szameitat, Ackermann & Alter, 2006) and English (unpublished data) interjections, it has been found that listeners classify interjections into two categories with respect to lexical and prosodic information. Performance data on discrimination and classification indicate that interjections can be classified into two major categories: interjections with low or high lexical information. Lexical items such as 'yuk' facilitate recognition because of the redundancy of the two information levels in prosody and lexicality. An interjection such as 'yuk' can only be classified as disgust. On the other hand, low lexical items containing ambiguous information such as related to

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a single vowel like /a/ bears more ambiguity because it can be used as an expression for happy surprise or anger. The correct interpretation depends solely on its prosodic realisation. This ambiguity leads to higher reaction times in both German and English. Moreover, in a follow-up study, low lexical stimuli have been investigated in an EEG study in order to find out communalities across languages such as English and German. EEG data reveal a N400 for the processing of the German interjection /i:/ in English volunteers. In German, this vowel corresponds solely o the expression of 'igitt' related to disgust whereas in English it doesn't. A comparison to other vowels with less lexical load such as the above mentioned German happy and angry /a/, however, revealed a smaller or no N400. In this presentation, the present data will be discussed with respect to how the brain disentangles prosodic and lexical information.

Recommended literature

Dietrich, S., Szameitat, D., Ackermann, H., & Alter, K. (2006). How to disentangle lexical and prosodic information? Psychoacoustic studies on the processing of vocal interjections. *Progress in Brain Research* 156, 295–302.

Dietrich, S., Hertrich, I., Alter, K., Ischebeck, A., & Ackermann, H. (2007). Semiotic aspects of human nonverbal vocalizations: a functional imaging study. *NeuroReport* 18, 1891–4.

Electrophysiological studies of prosody

Mireille Besson

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CNRS-Marseille Universités, Marseille, France

In this presentation, I will review a series of experiments that aimed at investigating the role of prosody in speech comprehension. These studies addressed different aspects of linguistic prosody in relation with the semantic and pragmatic levels of language processing. In all the experiments, we analyzed behavioural and electrophysiological measures (Event-Related brain Potentials, ERPs).

In the first experiment (Astésano et al, 2004), we used spoken sen-

tences ended by semantically and/or prosodically congruous and incongruous words. The prosodic mismatch was produced by cross-splicing the beginning of statements with the end of questions, and vice-versa and the semantic mismatch was produced by presenting words unexpected within the sentence contexts. Results argue in favour of interactive prosodic and semantic processing.

In the second experiment (Magne et al, 2005), we used short dialogues, composed of a question and an answer that was congruous or incongruous with regard to the pragmatic context introduced by the question. Results showed that prosodic patterns are processed on-line by listeners in order to understand the informational structure of the message and revealed interactive effects of the pragmatic and prosodic aspects of language. Maybe most importantly, they demonstrate the psychobiological validity of the pragmatic concept of focus, expressed via prosodic cues.

In the third experiment (Magne et al, 2007), we used short sentences ending in semantically and/or metrically congruous or incongruous trisyllabic words. Results demonstrated the online processing of the metric structure of words. Moreover, they show that violations of a word's metric structure may hinder lexical access and word comprehension. Results were also taken to argue in favour of the automaticity of both semantic and metric processing.

Finally, I will quickly describe the results of experiments aimed at testing the influence of musical expertise on the perception of linguistic pitch patterns. These results show that musicians are more sensitive to pitch variations in speech than non musicians in their own language (Schön et al, 2004) as well as in a foreign language (Marquez et al, 2007).

These results will be discussed in relation with models of spoken language comprehension and in the context of the specific or general nature of the processes involved in language processing.

References

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Magne, C., Astésano, C., Aramaki, M., Ystad, S., Kronland-Martinet, R & Besson, M. (2007). Influence of syllabic lengthening on semantic processing in spoken French: Behavioural and electrophysiological evidence. *Cerebral Cortex*, Advance access, published January 30, 2007.

Magne, C., Astésano, C., Lacheret-Dujour, A., Morel, M., Alter, K., & Besson, M. (2005). On-line processing of "pop-out" words in spoken French dialogues. *Journal of Cognitive Neuroscience* 17, 740–756.

Marques, C., Moreno, S., Castro, S.L. & Besson, M. (2007). Musicians detect pitch violation in a foreign language better than non-musicians: Behavioural and electrophysiological evidence. *Journal of Cognitive Neuroscience* 19, 1453–1463.

Schön, D., Magne, C. & Besson, M. (2004). The music of speech: Music training facilitates pitch perception in both music and language. *Psychophysiology* 41, 341–349.

The role of prominence in the neurocognition of language comprehension: A new perspective on the syntax–semantics interface

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Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig

Models of language comprehension typically assume a relatively strict separation between syntax and semantics. More specifically, virtually all existing models in this domain subscribe to the perspective that sentence meaning is determined by the syntactic structure (i.e. sentence-level meaning is essentially "read off" the syntax). While different classes of models (interactive vs. two-stage) differ with respect to the time-course with which non-syntactic features can influence the comprehension process (i.e. whether they influence initial structure building or are only drawn upon in a post-initial stage of comprehension), they all agree that these features impact upon interpretation by serving to mediate *structural choices* rather than the establishment of meaning itself.

In this talk, we will present evidence for a different characterisation of the syntax–semantics interface in language comprehension. On the basis of neurophysiological findings from a wide range of languages (e.g. Chinese, German, Hindi, Japanese, Tamil and Turkish), we will argue that the form-to-meaning mapping at the sentence level

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is best characterised with reference to a range of hierarchically ordered information types termed "prominence scales" (e.g. animacy, definiteness/specificity, person, case marking, linear order). These scales, which cut across the traditional syntax–seman-tics boundary, act in concert to determine argument interpretation across languages. Specifically, they serve to establish an interpretive hierarchy between the arguments (in terms of the generalised semantic roles Actor and Undergoer) and further indicate the arguments' role prototypicality. Crucially, prominence information only encompasses a restricted set of information types motivated by insights from language typology (e.g. Aissen, 2003; Comrie, 1989; Croft, 2003). Thus, under this view, it is not the case that all available information types influence the from-to-meaning mapping.

Prominence-based processing is driven by a principle termed "Distinctness", which specifies that co-arguments should be as distinct as possible from one another in terms of the different prominence scales. Whereas the application of prominence hierarchies according to the Distinctness principle is deemed to be universal, we propose that languages differ with respect to the relative weighting of the different information types. An important consequence of the prominence-based approach is that it allows for relatively rich interpretive processing of the arguments independently of the verb, thus explaining incremental interpretation in verb-final structures. We will show that, akin to the predictions that a verb generates with respect to upcoming arguments, the prominence features of arguments can lead the processing system to expect particular types of verbs.

In addition to presenting empirical evidence for the importance of prominence information during sentence comprehension, the talk will outline the consequences of the prominence-based approach for both psycholinguistic modelling and for the neurocognition of language comprehension.

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Neurocognitive profiles of developmental dyslexia

Stefan Heim, Elisabeth Bay, Helen Schreiber,
Julia Tschierse, Klaus Willmes-von-Hinckeldey,
Walter Huber, and Marion Grande

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Different theories conceptualise developmental dyslexia as either a phonological, attentional, auditory, magnocellular, or automatisation deficit. Such heterogeneity of theories and supporting empirical evidence suggests the existence of yet unrecognised subtypes of dyslexics suffering from distinguishable deficits. Moreover, it is yet an open issue whether possibly distinct cognitive deficits underlying developmental dyslexia are associated with shared or distinct neurofunctional mechanisms in the brain.

The purpose of Study #1 was to identify possible cognitive subtypes of dyslexia. Out of 642 children screened for reading ability, 49 dyslexics (mean age 9.3 years) and 48 controls (9.2 years) were tested for phonological awareness, auditory discrimination, motion detection (magnocellular), visual attention, and rhythm imitation (automatisation). A combined cluster and discriminant analysis approach revealed three clusters of dyslexics with different cognitive deficits. Compared to reading-unimpaired children, cluster #1 had worse phonological awareness; cluster #2 had higher attentional costs; cluster #3 performed worse in the phonological, auditory, and magnocellular tasks. These results indicate that reading deficits associated with developmental dyslexia may result from distinct cognitive impairments. For future remediation programmes this finding implies the need for a multivariate diagnostics including neuropsychological tests, and individualised trainings based on the particular deficits of each child.

In Study #2 we investigated differences in brain activation in reading, picture naming, visuo-magnocellular processing, auditory processing, phonological processing, attention, and automatisation in 20 dyslexic children (mean age 9.6 years) and 20 controls (mean age 9.4 years). Such procedure allows the simultaneous analysis of cognitive functions crucial for reading in the same group of subjects. The data are currently being analysed and will be presented in the talk.

ERP correlates of word learning in infants: Effects of productive vocabulary size

Janne von Koss Torkildsen

University of Oslo

During the second half of the second year most children experience a steep increase in the rate of productive vocabulary acquisition, often called the vocabulary spurt. At present we know little about the cognitive underpinnings of this development. For example, it is unclear whether the observed productive spurt is accompanied by equally significant advances in receptive word processing. The present event-related potential (ERP) study aimed to investigate the neural correlates of receptive word learning in two groups of 20-month-olds: those who appeared to have reached the productive vocabulary spurt (high production group) and those who had not (low production group).

The study consisted of a training phase and a test phase. In the training phase, links between novel words and novel pictures were built up through repeated co-presentations. Subsequently, in the test phase, the trained associations were violated by presenting the words together with other, but equally familiar, pictures. Real words and pictures of real objects were also included in the experiment as a control condition. In order to investigate both the dynamics and outcome of learning, results from both phases of the study were analyzed.

Results from the training phase revealed distinct patterns of repetition effects for children with large and small productive vocabularies. High producers showed evidence of recognizing the novel word forms already after three presentations, while the low producers needed five presentations to display a recognition effect. The familiarization process was manifested in the modulations of two components, the N200-400 and a fronto-central component (Nc), which appeared to increase in amplitude until a certain level of encoding was reached and then decrease with further repetition. In the test phase, 20-month-olds with high productive vocabularies, but not 20-month-olds with low productive vocabularies, displayed an N400-like incongruity effect to violations of the trained associations between novel words and pictures. The absence of the N400 in the low production group could not be due to missing N400 mechanisms, as low producers displayed a robust N400 effect to semantic violations involving real words.

In sum, our results indicate differences between high and low vo-

cabulary infants both in the rate of word form familiarization and in the ability to establish associations between words and referents. These findings suggest that the productive vocabulary spurt late in the second year may be associated with marked improvements in receptive word processing.

Speech perception and brain function: Experimental and clinical studies

Kenneth Hugdahl

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University of Bergen, Norway

In my talk I will review research on asymmetry of language processing in the left and right cerebral hemispheres, focusing on dichotic presentations of consonant-syllable pairs, and the application of this approach to clinical groups. We have over the years gathered a large data base consisting of data from more than 1500 individuals, ranging from 5 to 89 years, and including males, females, right- and left-handers. A key objective in our research has been how speech processing is organized in the brain, and how this is impaired in clinical groups. We have been particularly interested in how higher cognitive processes, like attention and executive function, modulates the right ear advantage typically seen in the dichotic listening paradigm, thus looking for bottom-up and top-down information processing interactions. We have also validated the behavioral results through simultaneous recordings of BOLD fMRI and ERP signals from the brain. We have applied these approaches to a variety of clinical groups, including children and adults with dyslexia and with specific language impairment (SLI), and in patients with localized brain lesions. A particularly challenging application is the understanding of auditory hallucinations in schizophrenia. A more recent interest is studies of auditory hallucinations in schizophrenia, with the hypothesis that auditory hallucinations are internally generated speech mis-attributions that may originate in the speech perception areas in the upper posterior part of the left temporal lobe.

A biological and interactional perspective on the emergence of early linguistic functions

Francisco Lacerda

Stockholm University

Within their second half of their first year of life, human infants typically utter their first words and about one year later they tend to take their first steps towards the full exploration of their ambient language's linguistic combinatorial power. Although overwhelmingly exposed to continuous speech utterances produced by other speakers, the infant is obviously able to derive the underlying linguistic structure contained in the heard utterances and to focus on elements embedded in such utterances, in spite of the unavoidable disparity between the acoustic characteristics of the infant's and the adult's speech sounds.

This presentation is intended as a critical assessment of experimental evidence shading some light on how general perceptual, production and interaction mechanisms might account for the typical language development process. Results from behavioural experiments, using both eye-tracking and EEG techniques, to determine which factors influence the infants ability to establish sound-meaning correspondences under naturalistic settings, will be discussed.

On-line studies of repeated name and pronominal coreference

Kerry Ledoux

Johns Hopkins University, Baltimore

Coreference (the process by which anaphors and their referents are understood to refer to the same entities in the world) is a ubiquitous and essential feature of natural language processing. Much attention has been paid to processing differences in the establishment of coreference using different referential forms, such as pronouns and repeated names. In a series of experiments, using both eye-tracking and event-related potentials (ERPs), we have further explored this question by

manipulating the discourse context in which different referential forms are used to establish coreference.

In the first set of experiments, we compared the processing of coreferential repeated names to that of names that introduced a new discourse entity at the same sentence position. As repeated words, the processing of the repeated names should benefit (relative to the new names) from repetition priming. Using eye-tracking and ERPs, we found evidence of such a priming benefit for repeated names relative to new names, but only within a specific discourse context (in which the antecedent of the repeated name was of low discourse prominence) that licensed the establishment of coreference using repeated names. In another discourse context, with a prominent antecedent, the establishment of coreference using a repeated name was more difficult; in this case, we observed no evidence of a repetition priming benefit for the repeated names. In two follow-up studies, we found similar results under more natural ERP presentation conditions (using auditory stimuli and using a faster RSVP presentation rate). These results suggest that processes of coreference, which take advantage of information available in discourse organization, can sometimes interact with or perhaps override the recognition and memorial mechanisms for processing individual words.

In a second set of experiments, we have examined the interaction of the discourse factor of antecedent prominence with another factor, implicit causality, that is generally believed to be related to lexical-semantics. We are interested in the extent to which implicit causality acts as a focusing mechanism in reading, and whether that mechanism would override the focusing mechanism of discourse prominence. We examined the eye movement and ERP responses to coreferential pronouns and repeated names in sentences in which the implicit causality bias of a verb was maintained or was violated. The manifestation of the ERP effect of violating the implicit causality bias of the verb differed for repeated names (but nor for pronouns), depending on the prominence of the antecedent in the discourse context. These results suggest an on-line interaction of semantic and structural factors during discourse processing.

In summary, the structure of the discourse context has direct effects on the processes engaged during the establishment of coreference. These effects can, in some cases, override effects that would be expected based on lexical or lexical-semantic processing alone.

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The laughing brain: Comparative evidence from behavioral and neuroimaging studies in human and monkey

Martin Meyer

University Hospital of Zurich

In the context of research on discourse and non-linguistic aspects of communication, comparative studies in human and monkey have revealed immensely interesting insights during the last decade, e.g. the role of articulatory gestures and nonspeech vocalization in social interaction.

Laughter could also be considered an affective nonspeech vocalization that is not reserved to humans, but can also be observed in other mammalians, in particular monkeys and great apes. This observation makes laughter an interesting subject for brain research as it allows us to learn more about parallels and differences of human and animal communication by studying the neural underpinnings of expressive and perceptive laughter. In the first part of the presentation, I will briefly sketch the acoustic structure of a bout of laughter and relate this to the differential anatomy of the larynx and the vocal tract in human and monkey. The subsequent part of the talk introduces the present knowledge on behavioral and brain mechanisms of "laughter-like responses" and other affective vocalizations in monkeys and apes, before we describe the scant evidence on the cerebral organization of laughter provided by neuroimaging studies.

Essentially, this contribution indicates that a densely intertwined network of auditory and (pre-)motor functions subserves perceptive and expressive aspects of human laughter. Even though there is a tendency in the present literature to suggest a rightward asymmetry of the cortical representation of laughter, there is no doubt that left cortical areas are also involved. In addition, subcortical areas related to emotional mechanisms, namely the amygdala, have also been identified as part of this network. Furthermore, I conclude that research on the brain mechanisms of affective vocalizations in monkeys and great apes report the recruitment of similar cortical and subcortical areas similar to those attributed to laughter in humans. Therefore, I propose the existence of equivalent brain representations of emotional tone in human and great apes. This reasoning receives support from neuroethological models that describe laughter as a primal behavioral

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tool in social discussion used by individuals—be they human or ape—to prompt other individuals of a peer group and to create a mirthful context for communication.

Production and perception of word tones in Norwegian patients with brain damage

Inger Moen

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University of Oslo

The interest of aphasiologists and clinical linguists in the prosodic aspects of language is a long-standing one. It goes back to Broca's observation (1861) that lesions in the third frontal convolution of the left hemisphere were accompanied by speech dysfluency. The auditory correlates of prosody are variations in pitch, loudness, tempo, and rhythm. These auditory features of sound have a primary relationship with the physical dimensions of fundamental frequency, intensity, and time.

Pitch variation is a property of all natural languages. No language is spoken on a monotone. But pitch differences function differently in different languages. One taxonomy of this type has two categories: (1) intonation languages, languages where differences in pitch are associated with phrases or sentences, like English; (2) tone languages, languages which use differences in pitch for lexical purposes, like Thai, Chinese, and Norwegian. Tone languages also have sentence intonation, but with fewer possibilities in pitch variation than intonation languages.

Studies of speech production and speech perception in the brain damaged population have been used to investigate the role of the left and right hemispheres in the control of word tones in tone languages. Several hypotheses have been put forward with regard to hemispheric specialization of prosody. One of these hypotheses (Van Lancker 1980, 1988) proposes a scale of pitch contrasts from the most linguistically structured pitch contrasts (e.g. Chinese and Norwegian word tones) associated with left-hemisphere specialization to least linguistically structured pitch contrasts (e.g. emotional tone, voice quality) associated with right hemisphere specialization. A similar hypothesis (Packard

1986) assumes that the important factor is not whether the pitch contrasts are included in the linguistic system or not, but which part of the system they are included in.

Another view is that prosody is a multifaseted phenomenon consisting of a set of features some of which are processed by the right hemisphere and some by the left. Fundamental frequency is assumed to be processed by the right hemisphere, whereas the other prosodic features, like timing and intensity, are produced by the left (e.g. Van Lancker & Sidtis 1992). It has also been suggested (Gandour 1987) that hemisphetic spesialization depends on the relationship between the control of fundamental frequency and timing.

The presentation will report studies of the production and perception of word tones in Norwegian patients with brain damage with a view to see to what extent these studies support current theories of the functional lateralisation of speech prosody.

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NPI licensing in languages with a rich agreement system

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The processing of negative polarity items (NPI) raises interesting questions for the human sentence processor since they require syntactic as well as semantic/pragmatic information to be licensed. Therefore, it is one of the few scenarios that allow us to further examine the interplay of these two components of grammar in real-time processing.

Previous work on NPI licensing in German (Drenhaus et al. 2005, Vasishht et al 2005, 2006) and English (Xiang et al. 2006) has shown that the parser does not always respect the licensing of structural conditions of NPIs and that, surprisingly, speakers take constructions where the licensor is structurally inaccessible for the NPI as acceptable. Drenhaus et al. 2005 and Vasishht et al. 2005 found a spurious licensing effect for the condition with an inaccessible licensor in German ERP studies which showed a N400 and a P600 effect, ERP components that reflect semantic and syntactic incongruencies respectively. Recent results, though, (Xiang et al 2006, Vasishht et al. 2006) seem to point at a contrast between off-line versus on-line tests with respect to the spurious licensing effect found in these constructions. These results raise the issue of whether the observed intrusive negation effects can be solely explained as a processing strategy, and not as a side-effect of the structural conditions for the licensing of the polarity item not being met. Moreover, they also bring up the question of what kind of information the parser uses when processing constructions that require more semantic composition than pure syntactic dependencies. Besides the specific syntactic conditions required to form the structural dependency consisted of the licensor (negation) and the licensee (NPI), NPI licensing imposes certain semantic constraints on the parser that are in principle harder to disentangle in languages such as German and English because of their internal grammatical configuration.

In order to decode the meaning of previous results and to disentangle the interplay between syntax and semantics in sentence processing, in this talk we turn to languages that provide a richer ground for NPI licensing. Specifically, our aim is to examine how this is reflected in on-line comprehension of sentences containing negative polarity items in

both Spanish and Basque (languages with a rich agreement system), by analyzing reading time behavioural results and by testing which specific event-related components are generated when the licensing conditions for these polarity items are not met.

Our research aims at differentiating processing strategies and structural sensitivity by exploiting an agreement requirement present in embedded structures that involve NPIs in Basque and Spanish. This agreement requirement in NPI constructions in these languages is reflected in the appearance of a partitive complementizer in Basque and a subjunctive mood at the verb in Spanish. The licensing conditions for NPIs in these two languages are not met either when the semantics of the main verb scoping over the NPI are not appropriate, or, importantly, when the agreement in an embedded clause is not licensed by the NPI. Once the semantics of the main clause is of an appropriate kind (e.g. contains negation or not), the agreement phenomena acts as a final check on the licensing of these structures. Therefore, whether or not the parser is affected by a wrong agreement can provide more information about how NPI licensing is done and the extent to which structural dependence is considered. In addition, by manipulating the linear position of the NPI in the sentence with respect to agreement in these two languages, more things could be learnt about the specific timing in the licensing of NPI constructions and about how early in parsing are NPI constructions licensed. In order to test these questions, we manipulated the following factors in our data: the semantics of the main verb (=no negation); the position of the NPI within the sentence (pre-verbal/ post-verbal) and the absence of NPI within the sentence (NPI vs. NP in embedded subject position).

Results from two behavioural experiments in Spanish and Basque show that the parser is sensitive to both semantic and syntactic information of the sentence when licensing NPIs; and that reading time differences surface when there is the wrong agreement at the auxiliaries and when the NPI cannot be licensed by the preceding context. Besides, we found differences in results with respect to how early the ungrammaticality could be detected. When the NPI preceded the agreement information at the auxiliaries in Basque, the ungrammaticality did not seem to be so immediately recognized as when the NPI followed the agreement information in Spanish. We consider this difference to be related to ungrammaticality detection issues rather than related to differences in NPI licensing among languages.

Our results so far suggest that the NPI results from German and English must be an effect of processing strategies and not of NPI licensing, since Spanish and Basque speakers seem to be sensitive to the agreement processes involved in NPI licensing. Furthermore, fu-

ture ERP results from Basque and Spanish NPI constructions could shed further insight into the kind of components generated in NPI licensing and could make further distinctions with respect to what particular semantic/syntactic process is involved in these dependencies.

Experimental items

1. *Spanish NPI conditions*

   *Pedro asegura que en breve **(a) *vaya/**   **(b) *va**   a
   Pedro assures that in short (a) aux-subj/ (b) aux-ind prep
   venir nadie a la cena.
   come nobody to the dinner

   'Pedro assures that nobody will come shortly to the dinner party'

2. *Spanish NP conditions*

   Pedro asegura que en breve **(a) *vaya/**   **(b) ✔va**   a   venir
   Pedro assures that in short (a) aux-subj/ (b) aux-ind prep come
   Inés a la cena.
   Ines to the dinner

   'Pedro assures that Ines will come shortly to the dinner party'

3. *Basque NPI conditions*

   *Peruk onartu du festara **inor**   berandu etorri **(a)**
   Peru   assures aux party-to nobody late   come (a)
   ***denik/**   **(b) *dela**   gaur gauean.
   aux-Comp-ptt/ (b) aux-Comp-decl today night

   'Peru assures that nobody will come late to the party'

4. *Basque NP conditions*

   *Peruk onartu du festara **Itxasne** berandu etorri **(a)**
   Peru   assures aux party-to Itxasne late   come (a)
   ***denik/**   **(b) ✔dela**   gaur gauean.
   aux-Comp-ptt/ (b) aux-Comp-decl today night

   'Peru assures that Itxasne will come late to the party'

Fishing for information: How children learn to interpret focus

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Learning how to distinguish old from new and contrasted information (i.e. focus) is a complex task during spoken language acquisition which extends into late childhood. So far, only little is known about the cues that children use for focus interpretation throughout language development. We will present preliminary data from a longer-term project which is concerned with the developmental brain markers for discourse interpretation in children aged 5, 8 and 12 years, and compare them with adults.

In adults, the interplay of pragmatics and prosody was found to prompt the differentiation of focused from non-focused information in dialogs. Yet, electrophysiological data suggest a strong prevalence of pragmatic (i.e. context) information for focus interpretation. In contrast, first language learning is known to strongly rely on the acquisition and recognition of prosodic regularities of the mother tongue. So far, developmental aspects of discourse interpretation are still largely understudied.

The project to be presented involves recordings and analyses of electrophysiological data during the auditory presentation of simple question–answer dialogs in four age groups. The dialogs were designed so that the answers incorporated a context-driven (pragmatic) focus position which either expressed a novelty or corrected a fact relative to the preceding question. As the dialogs were produced by two speakers mimicking a dialog situation, the prosodic patterns (i.e. accentuation) of the answers are appropriate with respect to the pragmatic content. However, the study design also consists of dialogs which incorporate contextually induced pragmatic focus positions which are unaccented and thus prosodically inappropriate.

We hypothesize that pre-school children strongly rely on the presence of a focus accent to identify the positions of novel or corrected information in dialogs. For older children we expect electrophysiological results indicating a development towards the adult perception pattern. That is, adults interpret focus predominantly by means of pragmatics

or contextual requirements, respectively.

Preliminary data on the spatio-temporal dynamics of focus interpretation in children and adults will be presented. In addition to classical event-related potential (ERP) analyses we will put forward reference- and observer-independent measures of the global electrical field power (GFP) and electric map topographies. That is, GFP modulations would designate changes in the neural response strengths between prosodically appropriate and inappropriate dialogs. On the other hand, modulations of the electric field topographies between dialog conditions would indicate changes in the intracranial generators due to the prosodic markedness of a pragmatic focus. Distributed neural source estimations will be conducted during the course of the project to explore on this aspect.

Overall, comparisons of the spatio-temporal brain dynamics to pragmatically and/or prosodically focused information between age groups will enable the visualization of learning-related neural changes during discourse comprehension.

The role of left-edge intonation in Swedish language processing

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Intonational phrase boundaries are always associated with major syntactic boundaries. Thus, intonational cues associated with the right edge of prosodic boundaries have been shown to be important for the processing of syntactic boundaries in various languages. In recent years, it has been shown that left edges of intonational boundaries also correlate with major syntactic boundaries in a number of languages. In an earlier study, we found that speakers produce a high tone at the left edge of Swedish embedded main clauses, possibly to indicate their relative syntactic independence as compared to ordinary subordinate clauses.

Using acceptability judgments and Event Related Potentials (ERP), we tested whether the Swedish left-edge boundary tone is a relevant cue for determining syntactic structure in the on-line processing of Swedish. Embedded main clauses were rated as more acceptable when

associated with a high left-edge boundary tone. In the ERPs, we found a P600 effect for mismatch between left-edge intonation and syntactic structure, showing syntactic reprocessing at the syntactically disambiguating word. Further, a posterior positivity following left-edge boundary tones in contexts where embedded main clause structure was unexpected was interpreted as a correlate to immediate intonation-syntax interaction. Taken together, the results clearly indicate the relevance of left-edge intonation in the syntactic processing of Swedish.

Demystifying semantic P600 effects: Theoretical arguments and cross-linguistic observations

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The literature on the electrophysiology of language comprehension has recently seen a very prominent discussion of "semantic P600" effects, which have been observed, for example, in sentences involving an implausible thematic role assignment to an argument that would be a highly plausible filler for a different thematic role of the same verb. These findings have sparked a discussion about underlying properties of the language comprehension architecture, as they have generally been viewed as a challenge to established models of language processing and specifically to the notion that syntax precedes semantics in the comprehension process.

This talk will argue that, in contrast to these widely held assumptions, semantic P600 effects *are* in principle compatible with a syntax-first comprehension architecture. More specifically, we show how these effects can be derived within an independently motivated, hierarchically organised neurocognitive model of language comprehension in which syntactic structuring precedes argument interpretation (the extended Argument Dependency Model, eADM; Bornkessel & Schlesewsky, 2006). The eADM posits that syntactic representations only encode categorial relations between the different constituents of a sentence, but do not serve to constrain sentence-level interpretation. This claim, which was motivated by cross-linguistic considerations with respect to the nature of the sentence comprehension architecture, is

the key to resolving the apparent contradiction between a syntax-first model and the observation of semantic P600 effects. In addition to straightforwardly deriving the phenomenon of a semantic P600, the basic architectural properties of the eADM account for apparent empirical inconsistencies within the semantic P600 literature that cannot be addressed within previous approaches.

To complement these theoretical arguments, we will demonstrate that semantic P600 effects should be considered from a broader empirical perspective. Thus, cross-linguistic examinations reveal that these effects are, in fact, language specific in that they appear to be restricted to languages with a relatively strict word order (e.g. English and Dutch). By contrast, similar manipulations in languages of other types have revealed N400 rather than P600 effects. We will illustrate this in detail with respect to an ERP study on German, but will also briefly mention converging evidence from Chinese and Turkish.

On the basis of these findings, we propose that semantic P600 effects reflect a mismatch in a mapping process that occurs *after* the core linking of argument and verb representations and that serves to integrate these linking-based representations with further information types (such as world knowledge, plausibility). Whether a particular language shows a P600 or an N400 for typical "semantic P600 manipulations" is crucially determined by the language-specific properties of the linking step.

Rapid, automatic and parallel language processing: Neurophysiological data

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Do all aspects of language and related cognitive processes need our active attention on the subject? Or can some of them take place irrespective of whether or not we focus on incoming speech and can they be, in this sense, automatic? Recent studies investigating the cognitive processes underlying spoken language processing found that even under attentional withdrawal, size and topography of early brain responses reflect the activation of memory traces for language elements in the human brain. Familiar sounds of one's native language may elicit a larger

brain activation than unfamiliar sounds, and at the level of meaningful language units, words elicit a larger response than meaningless word-like sound combinations. This suggests that using modern neuroimaging tools, we can trace the activation of memory networks for language sounds and spoken words even when no attention is paid to them. Unattended word stimuli elicit an activation sequence starting with superior-temporal cortex and rapidly progressing to left-inferior-frontal lobe within the first 200 milliseconds. The spatio-temporal patterns of these cortical activations depend on lexical and semantic properties of word stems and affixes, thus providing clues about lexico-semantic information processing. At the syntactic level, we can see reflections of grammatical regularities in word strings in the similarly early time range. This growing body of results suggests that lexical, semantic and syntactic information can be rapidly processed by the central nervous system outside the focus of attention in a largely automatic and near-parallel manner. Analysis of spatio-temporal patterns of generator activations underlying such responses to speech may be an important tool for investigating the brain dynamics of spoken language processing and the distributed cortical networks it involves.

Poster Abstracts

Neocerebellar emulation of language processing

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The cytoarchitectural homogeneity of the cerebellum (Bloedel, 1992), its reciprocal expansion with frontal cortical areas, and the delineable projections of the dentate nucleus to Broca's area (Leiner et al., 1991) encourage the formulation of a cerebellar neurolinguistic model based on unitary cerebellar computations, as proposed in the literature (e.g., Wolpert et al., 1998), a fortiori given the neuropathological evidence for a "*lateralized linguistic cerebellum*" (Mariën et al., 2001). Given the identification of the cerebellum with the neural analog of a dynamic state estimator (Paulin, 1989), Pickering and Garrod's (2007) psycholinguistic Kalman filter processor is ideally instantiated in the neocerebellum: Automatization of multi-level linguistic perception is thus granted a plausible neurolinguistic basis: Cerebellar predictions transmitted by the dentate nucleus to Broca's area are trained by the error signals induced by the sensory discrepancies between the cerebellar predictions and the cortically processed input, transmitted via the climbing fibers. Cerebellar error signaling involved in the reanalysis of ambiguous sentences has already been shown in Stowe et al. (2004), while lack of practice- induced facilitation in linguistic tasks is characteristic in cerebellar patients (Fiez et al., 1992). Processing of over-learned input (e.g., words, constructions) may thus rely maximally on the linguistic internal model stored in the neocerebellum, and minimally on the language-related cortical loci (Ito, 2000), reflected in the psycholinguistic trade-offs between an "*associative pseudosyntax*" and a "*categorical syntax*" in Townsend and Bever's (2001) model.

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Restricted discrimination between local economy and global economy in agrammatic aphasia

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1. The problem

The economy constraints of the grammar are somehow restricted in

the performance of agrammatic aphasic subjects (Vasić, Avrutin, and Ruigendijk 2006). Grodzinsky *et al.*'s results suggest that their agrammatic aphasics showed limitations in tasks concerning the binding of personal pronouns (*limited Principle B*) as opposed to the binding of reflexive pronouns (non-impaired *Principle A*).

2.

We conducted sentence-picture matching tests by Hungarian speaking Broca's aphasics. The results showed that *Principle A* was limited (*not Principle B*) in some complex syntactic structures.

We suggest a characterisation of the limited binding principles in agrammatic aphasia data in terms of **global economy** and **local economy.** On the basis of the local economy, decision concerning the applicability of an operation depends on what pieces of information are available **within** the sentence representation at hand, irrespective of other sentence representations. Global economy constraints require comparison of several sentence representations in order for a decision to be made concerning the applicability of some operation.

3. The test

Five syntactic structures of diverse complexity were selected. The pronouns occurring in the sentences were either reflexive or personal pronouns. For each pair of sentences, two pictures were drawn, suggesting the meanings of the respective sentences. The test material included 200 sentences and 200 pictures. The subjects saw a picture and heard a sentence and were asked to decide if what they heard corresponded to what they saw. Each sentence was heard twice once paired up with one of the relevant pictures, and once with the "wrong" picture. The sentences were presented randomly. The two subjects were agrammatic Broca's aphasics.

4. Results

STRUCTURES	PICTURE MATCHING	
Judgements:	**Correct**	**Incorrect**
Type I: The pronoun is a direct object of a Verb		
Reflexive pronoun	40 (100%)	–

Personal pronoun   32 (80%)   8 (20%)

Type II: The pronoun occurs in the possessor position of a possessive construction
Reflexive pronoun   36 (90%)   4 (10%)
Personal pronoun   36 (90%)   4 (10%)

Type III: The pronoun is a constituent of a possessed NP (a modifier of the possessed N) in possessive construction
Reflexive pronoun   8 (20%)   32 (80%)
Personal pronoun   28 (70%)   12 (30%)

Type IV: The pronoun is a constituent of an infinitival construction has no overt lexical subject
Reflexive pronoun   32 (80%)   8 (20%)
Personal pronoun   28 (70%)   12 (30%)

Type V: The pronoun is a constituent of an infinitival construction has its "own" lexical subject
Reflexive pronoun   12 (30%)   28 (70%)
Personal pronoun   24 (60%)   16 (40%)

5. Discussion

In the case of the simplest, type I structures, the subject made correct discriminations between reflexive and personal pronouns. As the structural complexity of the sentences grew, the number of correct decisions with respect to personal pronouns decreased somewhat. Incorrect decisions were mainly made in the context of the non-matching picture.
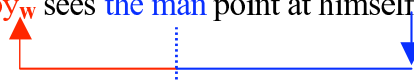
An especially interesting result is what we got in the case of types III and V, for reflexive pronouns (*Principle A)*. The subject wrongly took the sentence initial NP to be the antecedent of the pronoun in 32 and 28 cases, respectively, as opposed to the actual, local antecedent that immediately preceded the pronoun. Structures III and V are syntactically complex. We have to assume that the structural complexity of sentences elicits alternative structural analyses and their assessment. And the net result is that the subject wrongly assumed bindings for reflexive pronouns that would have been grammatical non-local bindings for personal pronouns.

Examples for **incorrect** decisions (showed by red lines) for reflexives in the context of the non-matching picture (type III and V):

*A férfi$_m$ örül a fiú önmagáról$_m$ készített fényképének.
'The man$_m$ is glad about the boy's photograph of himself$_m$.'

*A kisfiú$_w$ látja a férfit mutogatni önmagára$_w$.
'The little boy$_w$ sees the man point at himself$_w$.'

As witnessed by the simpler structures (type I and II), the subjects did possess the ability to distinguish binding relations of reflexive from those of personal pronouns. They did **not** react to increasing complexity by trying to resort to some structure that was simpler or shorter. On the contrary: in their **incorrect decisions** they used a **more costly mechanism**, incorrectly. The distinction between local economy and global economy was not properly accessible for them. Instead of assessing the operations to be employed in a less costly manner, restricting their attention to local structural relations and ignoring other, non-local structural representations, they tried to do the opposite: they attempted to make a decision on the applicability of some structural operation by comparing alternative structural relations to one another. We suggest that such distribution of performance can be attributed to the subject's limited ability to tell local and global economy from each other.

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Basic parameters of spontaneous language: Do they differentiate between unimpaired and aphasic speakers?

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When assessing a patient's language output, speech and language therapists face the problem of rating the performance as deviant or adequate. This is relatively easily achieved as long as there are normative data. However, for spontaneous language, normative data are lacking (Prins & Bastiaanse, 2004). This is partially due to methodological problems, as most analyses rely on the identification of linguistic deviations like aphasic symptoms, thus not allowing the assessment of unimpaired spontaneous language. In contrast, the computer-assisted instrument Aachener Sprachanalyse (ASPA, Huber et al., 2005) uses linguistic basic parameters for a quantitative analysis of German spontaneous language. These parameters are essential units of language (e.g. word categories; syntactic completeness). They can be identified in both impaired and unimpaired adult and child language (Grande et al., 2007) and allow for the derivation of normative data of spontaneous language. The question remains whether the language output of unimpaired and aphasic speakers can be differentiated by means of basic parameters, irrespective of aphasic symptoms.

Spontaneous language was elicited from 60 German speakers (17–79 years; mean 47.9) by means of the semi-standardised interview from the Aachen Aphasia Test (AAT, Huber et al., 1983). The first 30 clause-like units of each language sample were transcribed using ASPA. The following basic parameters were analysed:

1. percentage words

2. percentage open class words

3. type token ratio

4. syntactic completeness

5. syntactic complexity

6. mean length of utterances in words

Data were compared to data from a sample of 28 aphasic speakers (22–74 years; mean 47.4; 14 fluent, 14 non-fluent) who had undergone the same procedure (Grande et al., 2007). Step-wise discriminant analyses were conducted to assess the discriminative power of basic parameters. Three groups (fluent aphasia, non-fluent aphasia, unimpaired speakers) were differentiated.

The parameter differentiating best was syntactic completeness. 88% of the cases were correctly reassigned (60/60 unimpaired speakers, 12/14 non-fluent aphasias, 8/14 fluent aphasias). In order to further improve the predictive power, a 90% threshold for the probability of correct reassignment was introduced. Yet, two cases of fluent aphasia were still erroneously reassigned to the group of unimpaired speakers.

For most cases, basic parameters allow for differentiating between aphasic and unimpaired language. However, some participants with fluent aphasia were erroneously reassigned as unimpaired speakers, probably because their linguistic deviances were not well captured by the chosen lexical and syntactic parameters. Instead, their deviances were detected by additional qualitative analyses. Consequently, when conducting quantitative analyses of spontaneous language in fluent aphasia using basic parameters, the diagnostics might be further improved by

1. applying phonological and semantic basic parameters

2. combining quantitative with qualitative analyses.

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Auditory repetition of words and pseudowords: An fMRI study

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Introduction

There is no psycholinguistic model of word repetition. Processes that are necessary for repeating aloud auditorily presented words and pseudowords can be eliminated by the extended speech production model of Levelt et al. (1999; see Indefrey & Levelt 2004): phonetic and phonological de-and encoding. It's outstanding whether word repetition also involves semantic processing of lexical concepts or not and which routes are used.

The purpose of this study was to examine the neural regions that are specific for pseudoword repetition in contrast to word repetition and vice versa. Pseudowords unlike words have no semantic content, remain phonetically in the target language, but have an unfamiliar word form. We wanted to investigate, how the new word form impact cognitive processing, and to eliminate processes that are specific for repetition of words.

Methods

Subjects were 34 native German speakers (18m/16f) with a median age of 27.5 without any neurological deficit. During scanning in a Siemens 3 Tesla MR scanner subjects were presented acoustically with 60 words and 60 pseudowords to repeat overtly. An event-related design with two sessions was used with a trial duration of 8 s. T1-

weighted 3D volumes were acquired using MP-RAGE with 160 sagittal slices, 1 mm thickness, TR/TE of 2200 ms/2.15 ms. Echoplanar images were acquired with 30 axial slices, 3 mm thickness, TR/TE of 1600 ms/30 ms. Using SPM5 (http://www.fil.ion.ucl .ac.uk/spm/) one-sample t-tests were performed for the main effects (words > rest, pseudowords > rest) and flexible-factorial ANOVAs for the effects of interaction (words > pseudowords, pseudowords > words).

Results

Repetition of both words and pseudowords contrasted with rest activated bilateral primary and secondary auditory areas, the left inferior frontal gyrus (BA 44), bilateral motor areas, SMA, the mid cingulate gyrus and subcortical regions. See Fig. 1a.

Pseudowords contrasted with words activated the left inferior frontal gyrus (BA 44) and ventral premotor cortex, the left inferior frontal gyrus (BA 45) and ant. insula as well as the left post. sup. temporal sulcus, the left ant. sup. temporal gyrus and the left SMA. See Fig. 1b.

Contrasting words with pseudowords the parietal-temporal cortex was bilaterally activated (see Fig. 1c), the bilateral mesial cortex (see Fig. 1d), the rostral and dorsolateral prefrontal cortex, the left cerebellum as well as bilateral ant. temporal areas, post. insula and thalamus. A good portion of the activation shown for words is due to deactivation for pseudowords.

Discussion

Repetition of words and pseudowords comes along with bilateral auditory and motor processing. Contrasting pseudowords with words shows a clear left lateralized activation for phonetic and phonological processing. This corroborates the assumption that an explicit phonological processing of the new word form is necessary for repeating pseudowords (Castro-Caldas et al. 1998). Activations in SMA, inferior premotor regions and the ant. insula refer to articulatory planning and imply that phonetic processing is not only driven by phonemes but also by the word form, which interferes with the phonetic processing level. Contrasting words with pseudowords reveals hardly interpretable results by reason of deactivation. It is shown that there occurs no reference to lexical concepts in word or pseudoword repetition for want of clear semantic activation. This corroborates the involvement of a nonlexical route in repetition (Hanley et al. 2004).
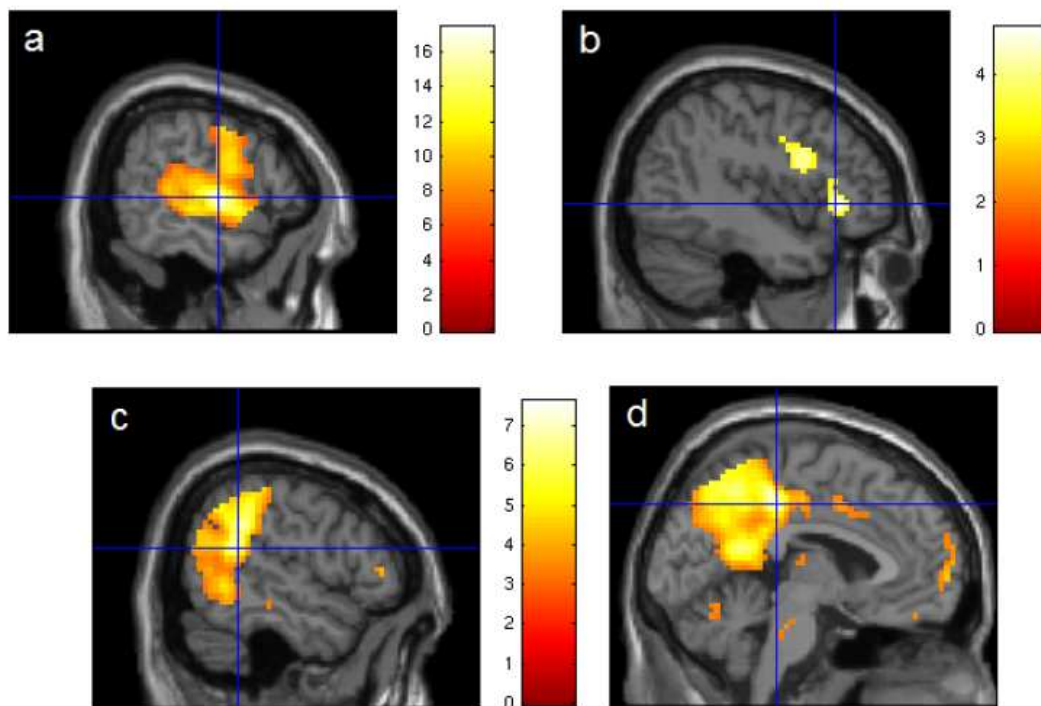
Figure 1: Functional activation maps overlaid on average MP-RAGE: (a) Word repetition vs. Rest ($p < .005$, FWE-corrected), (b) Pseudoword repetition vs. Word repetition ($p < .001$, uncorrected), (c)-(d) Word repetition vs. Pseudoword repetition ($p < .001$, uncorrected).

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Morpho-syntactic context effects in spoken language processing: An ERP study

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Behavioural and electrophysiological studies suggest that sentential context can be used by the human brain to predict upcoming words. For example, an ERP study (Delong, Urbach, Kutas, 2005) showed that the N400 amplitude to a word was inversely correlated with the probability that it was given as a continuation to a sentence fragment in an offline task, suggesting that the activation level of words is determined by context. It has further been shown that context can lead the reader to anticipate phonological and grammatical properties of articles that are dependent upon a following predictable noun (Delong et al., 2005; Wicha, Moreno, Kutas, 2003, 2004). The aim of this study is to determine whether a unit smaller than the word (i.e., an inflectional morpheme on a verb) can be predicted by morpho-syntactic context like that provided by an immediately preceding pronoun. More specifically, in this study, participants heard pairs of primes (congruent pronoun, incongruent pronoun and non-predictive pseudo-pronoun) and targets (verb vs. pseudo-verb) that were grammatically congruent (*nous chantons*), incongruent (**vous chantons*) or neutral (*zous chantons*). They

were instructed to make a lexical decision on the target item, that is, to decide as rapidly as possible whether it is a French word or not. The results showed an effect of congruency, that is, the pronoun facilitates or inhibits the lexical decision on the verb depending on the relation (congruent or incongruent) between the pronoun and the verb. In addition, a congruency effect in the opposite direction was observed with pseudo-verb targets. Here, faster reaction times (RTs) with respect to the non-predictive context were found in the incongruent context and slower RTs were observed in the congruent context. In line with these behavioral data, electrophysiological priming effects were also observed after the onset of the verbal inflections. In particular, for words, at 70–130 ms after the onset of verbal inflection, a central negativity wave was found that was more negative at frontal and central recordings sites in the incongruent context than in the two others contexts. In the same time window, this negativity at centro-parietal recordings sites was greater in the non-predictive context than in the congruent context. This greater negativity for the incongruent context with respect to the two others contexts is attributed to the incongruency between the expected and actual verbal inflectional. Similarly, the observed electrophysiological differences between the non-predictive and the congruent contexts also showed that the pronoun primes the verbal inflectional. Taken together, these behavioural and electrophysiological results suggest that anticipatory processes are involved in the processing of the agreement relation between pronouns and verbs.

Evaluation of lexical and semantic features for English emotion words

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One issue in discourse comprehension research is situation model building. For concrete scenarios, the situation model might consist of a visual image of the text context. More generally, it encodes text dimensions such as causal structure, temporal sequences, or the emotional status of the protagonist (for a review: Zwaan and Rapp, 2006).

Emotional aspects have been shown to be important during text comprehension (Gernsbacher et al., 1992) and violations of the emo-

tional status of the protagonist of a story were investigated using a consistency paradigm (Ferstl et al., 2005; Ferstl et al., 2007). Texts containing emotional information were shown to be processed in a qualitatively different way compared to texts containing chronological or spatial information, with the emotionally inconsistent texts eliciting repair and integration processes. In addition, emotional stories elicited activation in the limbic system (Ferstl et al., 2005; Ferstl et al., 2007).

In these studies the consistency was manipulated by using a single emotional word within a context. It is therefore necessary to disentangle the lexical effect of the word itself from the effect of the text context.

Processing of emotional words has been shown to be influenced by different features, such as emotional valence, arousal, imageability, age of acquisition and familiarity. These factors influence cognitive processing (as revealed by ERPs and eye-tracking measures and behavioural responses) during naming tasks, lexical decision tasks (Kuchinke et al., 2007; Kanske et al., 2007) and memory tasks (Maratos et al., 2000), employing written words or pictures (Weekes et al., 2007; Dolcos et al., 2002).

The aim of the present study is to generate a corpus of English words of different emotional valence, evaluated for various lexical and semantic features. The corpus will be useful for experiments employing ERPs and eye-tracking techniques, to allow a better control of the effects of these features. Furthermore, the corpus could allow a well balanced selection of words employed for discourse processing research, so that the effect of text context can be separated from word level effects.

300 words were rated by 50 English native speakers. Emotional variables were valence and arousal. Lexical variables were age of acquisition and familiarity. Moreover, the words were rated with respect to imageability.

The results of these ratings were then used to create three sets of words: positive, negative and neutral. These sets are matched for frequency of use, word length in letters, syllables and phonemes and for concreteness.

This corpus goes beyond similar works (e.g., Võ et al., 2006; Siegle, 1994), in which only a subset of these variables was considered.

Possible uses of the corpus in studies of discourse comprehension are outlined. In particular, features such as arousal, imageability and age of acquisition should play a great role during situation model building and updating.

Phonological processing, speech intelligibility and reading in Swedish children with cochlear implants

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Deaf children tend to have difficulty developing literacy skills despite normal levels of intelligence. This means that deaf persons risk being counted out at school, at work and in other social settings. The combined empirical picture from studies of deaf children with cochlear implants deafened before three years of age is that they reach higher levels of reading skills than children with severe to profound hearing impairment without CI, and that they often perform within the average range for hearing children. Twenty-nine Swedish children with CI (ages 6–18 years), divided in two goups; 16 younger children 6–13 years and 13 older children 13–18 years were studied. Reading comprehension was related to phonological processing, speech intelligibility and working memory measures. In the younger group, 10 out of 16 children performed within 1 SD compared to hearing peers on a reading comprehension test. In the group of older children, relatively fewer children performed as hearing children, a result that is in accordance with recent longitudinal studies on children with CI. Reading comprehension was significantly asssociated with intelligibility and phonological processing, even when demographic facors (age and age at implant) were controlled for. Few children with poor phonology performed well on reading tests. The complex influence of demographic factors will be discussed.

Evoked gamma-band oscillations in single-word translation

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To address the issue of bilingual language representation, psycholinguistic studies compare processing of cognates and non-cognates in bilinguals. Cognates are words that have similar form and meaning across languages and non-cognates are words that have different word forms with a similar meaning. The general finding is that cognates are produced, recognized and translated faster than non-cognates (e.g., Dijkstra et al., 1999; Costa et al., 2000). The faster production, recognition and translation of cognates are usually attributed to a common set of form-based representations that are used to process them in both languages. However, cognates also share semantic representations across languages (see Kroll & Tokowicz, 2005). The present study aims to investigate the extent of the involvement of semantics (concreteness) in cognate vs. non-cognate processing. We examine brain activation during the processing of concrete and abstract words coupled with words' cognate status by means of EEG measurements. In this study, we use evoked gamma-band oscillations since gamma activity was shown to be relevant to higher-order cognitive processes and in particular, to language processes (e.g., Palva et al., 2002). The study aims to determine at what point the concreteness effect emerges during word recognition in a translation task, and how the cognate status influences the concreteness effect.

22 right-handed Bulgarian-English bilinguals were presented with single English words for 300 ms and were asked to translate them orally into Bulgarian as fast and as accurately, as possible. The EEG was recorded by means of 17Ag/AgCl ring electrodes that covered frontal, temporal, parietal and occipital areas.

For the analyses of gamma activity, a wavelet transform based on Morlet wavelets was employed on 35 to 40 gamma-band frequency. Mean amplitudes were analyzed using a Cognate status (cognate, non-cognate) x Concreteness (concrete, abstract) x Time Window (100–200, 200–300, 300–400, 400–500, 500–600, 600–700 ms after stimulus onset) x Topography (frontal, central, parietal) x Region (left hemisphere, midline, right hemisphere) repeated measures ANOVA. The analysis re-

vealed main effects of cognate status and concreteness: higher gamma activity was found for cognate words than non-cognates, and for abstract words than concrete words. An interaction between concreteness, region and topography indicated that concrete words elicited similar amounts of gamma activity across regions and topographic areas while abstract words elicited higher gamma activity in the central area in the left hemisphere than in the right hemisphere. An interaction between cognate status, concreteness and topography showed that concreteness effect for cognates emerged in the frontal areas, and for non-cognates —in the central areas which may suggest qualitatively different functional processes. Finally, an interaction between time window, concreteness and cognate status showed a late concreteness effect in cognates (600–700 ms after stimulus onset) and an early and prolonged concreteness effect in non-cognate processing (starting from the 100 ms after stimulus onset till the 400 ms).

To summarize, the results showed that evoked gamma-band oscillation was sensitive to experimental manipulation and suggested that cognates activate semantics much later than non-cognates which, on their hand, have access to the semantics practically immediately after their presentation.

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Can context affect gender processing? Evidence from ERP about the differences between lexical and stereotypical gender

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Readers experience processing difficulty when an anaphor (herself) refers to an antecedent (minister) that mismatches in gender (e.g., a, b). This difficulty has been shown in both eye-tracking (Kreiner et al., in press) and ERP studies (Osterhout et al., 1997) and has been attributed to a gender clash between the pronoun and the antecedent. In this paper we ask whether, and in which conditions, discourse context can modulate this clash and how this is reflected in EEG parameters.

Previous studies have argued that whereas definitional-gender (king) can be recovered directly from the lexicon, stereotypical-gender (minister) requires an elaborative inference based on world-knowledge or discourse representation (Carreiras et al., 1996). Hence, stereotypical-gender is expected to be more sensitive to context effects (McKoon & Ratcliff, 1992) than the lexically-accessed definitional gender. This view was supported by eye-tracking studies (Kreiner et al., in press) that contrasted stereotypical-and definitional-gender nouns. They demonstrated that in anaphora sentences such as (a), where the role noun precedes the gender-marked reflexive, stereotypical- and definitional-gender nouns lead to a similar mismatch-effect. However, in cataphora sentences such as (b), where the reflexive precedes the role-noun, a mismatch-effect is exhibited only for definitional-gender nouns. This indicates that stereotypical-gender can be overridden when gender is specified by prior discourse, unlike definitional-gender. This conclusion seems inconsistent with previous ERP findings indicating that lexical features can indeed be overridden by context (Nieuwland & van Berkum, 2006). Furthermore, they are incompatible with findings of P600-like mismatching-effects for both stereotypical-and definitional-gender implying no qualitative difference in the processing of the two noun types (Osterhout et al., 1997). The present paper aims at investigating the apparent divergence of eye-movements findings from those of previous ERP studies.

In two experiments participants' EEG responses were recorded while they read sentences presented word by word on a computer screen. Experiment 1 used anaphora sentences (a) and compared EEG responses

for reflexives (himself/herself) preceded by matching or mismatching co-indexed role-nouns. Experiment 2 used cataphora sentences (b) and compared the responses for role-nouns preceded by matching or mismatching reflexives. Both experiments included definitional- and stereotypical-gender nouns. Critically, however, in Experiment 1 the gender noun was not preceded by discourse information that could bias its interpretation, whereas in Experiment 2 the preceding gender-marked reflexive could bias the gender interpretation of the role noun. P600-like mismatching-effects were shown for both noun types, indicating no qualitative differences in terms of ERP components. However, the findings show different patterns in terms of amplitude: In anaphora sentences the mismatching effect elicits an equally strong P600 component for the two different noun types; cataphora sentences, by contrast, show a more interactive pattern with different P600 amplitudes for definitional-and stereotypical-gender nouns. Taken together the results are consistent with the proposal that discourse context can modulate the processing of gender agreement when the gender is stereotypically biased but not when it is lexically defined. Interestingly, this seemingly pragmatic effect is reflected by P600 component (and not N400 as might have been expected (Nieuwland & van Berkum, 2006)). This puzzle will be discussed in view of recent models of language related ERP components and the underlying processes associated with them.

Examples:

(a) Yesterday the king/minister left London after reminding himself/ herself about the letter.

(b) After reminding himself/herself about the letter, the king/minister immediately went to the meeting.

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Development of lateralised speech perception

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Previous fMRI and PET studies indicated left hemispheric activation for the processing of speech and phonetic features, and right hemispheric activation for the processing of emotions and melody. EEG measures are not commonly employed in lateralisation research, neither has lateralisation been extensively investigated in a developmental perspective. This study aims to fill this gap. Although ERP measures cannot precisely localize task-activated cortical regions, differences in voltage reflect scalp electricity in response to the activation of a distinct neural network (Giard et al., 1995). With EEG, we study the lateralisation of speech processing in 4- and 9-month-olds and adults in two conditions, spoken sentences and their spectrally rotated version. Rotating is a technique to render speech intelligible while preserving language-specific characteristics such as rhythm. A previous EEG study showed no lateralisation in 4-month-olds for the processing of speech versus nonspeech sounds as measured with 65 electrodes (Dehaene-Lambertz, 2000). For refined measurement, we employ 128 electrodes and use infant-directed speech stimuli for both conditions. It has been established that language comprehension tasks elicit bilateral hemispheric activation (Awad, Warren, Scott, Turkheimer, & Wise, 2007; Davis et al., 2007), showing intrahemispheric localisation differences within the left hemisphere for phonetic features and comprehension in speech processing tasks (Obleser, Zimmermann, Van

Meter, & Rauschecker, 2007; Scott, Blank, Rosen, & Wise, 2000). As sentence comprehension increases with age, we predict an increase of activation in the left hemisphere when comparing 4- to 9-month-olds and 9-month-olds to adults. The melodic and emotional components of the infant-directed speech stimuli should elicit right-hemispheric activation which is predicted to decrease with age. Therefore, the measured differences between left- and right-hemispheric activation are predicted to increase with age. Left-hemispheric activation is also expected for the rotated speech condition due to the speech-likeness of the stimuli, however to a lesser degree than in the natural sentence condition (Ischebeck, Friederici, & Alter, 2007). This activation difference between the speech and rotated speech conditions should also increase with age as comprehension increases. The results are presented in regard to these hypotheses and discussed in the light of recent research.

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Implications of aphasia on abstract and concrete noun processing

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Concrete nouns are generally processed faster and more accurately than abstract nouns in cognitive tests, including word recognition, recall, lexical decision and sentence comprehension. This phenomenon is known as the 'concreteness effect', and there are different explanations of what its neurophysiological basis might be. The dual coding theory (Paivio, 1986) suggests that whereas abstract word processing is mainly dependent on verbal representation forms in the language-dominant left hemisphere, concrete words also have non-verbal, sensory-motor, e.g. visual, representations in both hemispheres. This suggestion is also consistent with a Hebbian view, according to which concrete words can be assumed to activate cell assemblies representing the actions or sensory experiences they are associated with (Pulvermüller, 1999). Other theories attribute the concreteness effect to concrete nouns being associated with a larger amount of contextual information (Schwanenflugel et al., 1988) or having a greater number of stable semantic features (Plaut & Shallice, 1993).

The present study examined abstract and concrete noun processing in four Swedish subjects with aphasia; two with left hemisphere frontoparietal lesions, one with left hemisphere temporoparietal lesions and one with left hemisphere occipital lesions. It was hypothesised that aphasia due to left hemisphere frontoparietal/temporoparietal lesions may implicate an enhanced concreteness effect. Both the fact that the sensory-motor features associated with concrete nouns have meaning

representations in posterior association cortices and the fact that many of these representations are bilateral would be likely to contribute to a relatively better preservation of concrete nouns in aphasia.

The accuracy and speed with which concrete and abstract nouns were processed was investigated with a multiple-choice test and a free word association test. In the multiple-choice test, the task was to choose definitions for abstract/concrete nouns from four (three incorrect and one correct) alternatives consisting of other nouns. In the word association test, the task was to say the first word that came to mind when presented with an abstract/concrete test noun. The aphasic participants' multiple-choice test scores and word association access times were compared with those of twelve healthy controls.

A significant concreteness effect was present in the frontoparietal/temporoparietal aphasics' multiple-choice test scores. In addition, signs of a reverse concreteness effect were observed in the participant with the occipital lesions. As regards access times, no significant interaction between participant group and the concreteness of the nouns was found. Some qualitative analysis of the word associations was also performed. Taken together, the results indicate an enhanced concreteness effect in the participants with frontoparietal and temporoparietal lesions. These findings are discussed with respect to the different theories and the localization of the lesions, and some suggestions for further studies are made.

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Circadian rhythm in phonetic speech perception

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Some studies found time-dependent variation of cognitive performance which was separate from lapses in attention and psychomotor slowing (see Schmidt et al. 2007). This could suggest circadian rhythm in cognitive functions. Our study investigated a daily structure in speech processing, in particular auditory speech perception, during the circadian cycle. Based on the theory of Borbély (1982, see Schmidt et. al 2007) we predicted a circadian modulation in auditory phonetic speech perception which can not be explained for solely by variations of alertness and vigilance. 11 subjects performed a behavioural discrimination task in a forced choice paradigm every 3h during 40h of sustained wakefulness under controlled conditions (Constant Routine protocol). Acoustic and phonetic stimuli were presented binaural via headphones. To determine variations of alertness, we tested subjective sleepiness hourly and psychomotoric vigilance every three hours. Circadian phase was estimated from salivary melatonin at 1-hr intervals and body temperature as continue measure. A significant circadian modulation of speech performance indicates circadian oscillation which cannot be accounted for solely by effects of vigilance. Best speech performance was found in the evening which was positive correlated with body temperature. Nadir of speech performance was found in the early morning. Speech performance increased again after nadir. We interpret this fact as indicator for circadian drive and discuss it with regard to a possible modulation by the suprachiasmatic nucleus (SCN) as the main circadian peacemaker of sleep-wake-cycle and to possible influence of masking effects.

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The impact of pragmatic knowledge on the comprehension of irony: An ERP study

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Contextual and pragmatic knowledge has been shown to influence the interpretation of sentences within a discourse (Coulson & Kutas, 2001, Otten and Van Berkum, 2007, St. George et al. 1994). Specifically, this information gains in importance when sentences have a non-literal, e.g. ironic, meaning which has to be derived by means of contextual knowledge. The knowledge about speakers, for example, indirectly adds extra-linguistic information that probably facilitate the interpretation of a sentence having a non-literal meaning. In an ERP experiment we investigated when and how the access and integration of such pragmatic knowledge relate to the meaning construction of a sentence. The experiment was carried out in two sessions between which the speakers use of irony was manipulated. One of these speakers was characterized as being highly ironic and making very frequently ironic statements, whereas the other speaker appeared to be a low-ironic person saying mainly literal sentences. In Session 1 a clear difference between the high and low ironic speaker's use of irony was present, while this difference was balanced in Session 2. Participants were presented with discourses ending in an ironic or non-ironic sentence expressed either by the high or low ironic speaker. Sentences like "That's really rich" achieved an ironic meaning when they were embedded in discourse contexts which contradict their literal meaning (i.e. receiving a very small dish). Since the target sentence final word was critical for an ironic or non-ironic meaning of the sentence, ERPs were analyzed at the sentence final position. In Session 1, ironic sentences expressed by the low ironic speaker evoked a LPC effect compared to those by the high ironic speaker. Inversely, a LPC component was shown for ironic sentences of the high ironic speaker in Session 2. In addition,

an early positivity was observed for ironic sentences expressed by the high ironic speaker and an N400 component for ironic-sentences when uttered by the low ironic speaker. Findings of Session 2 indicate that pragmatic knowledge can have a surprisingly early effect on the comprehension of non-literal sentences and does also affect the interpretation of the sentence meaning. Thus, the knowledge about speakers seemed to exert an influence on the construction of an appropriate interpretation when comprehending ironic sentences.

Modelling brain activity understanding self-embedded sentences

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Traditionally a model of serial language processing has been implicated based on the definition of left brain hemisphere centers: a posterior sensory decoding region (auditory cortex, Wernicke area, angular gyrus) and a frontal executive speech area (Broca area) interconnected via a perisylvian arcuate fiber tract. In recent years, however, inspired by modern imaging techniques (PET, fMRI) a bidirectional parallel network model, has been favoured. Reading, an explicitly learned faculty using visual input involves frontal functions related to attention and working memory. In a PET study by Stromswold et al (1996) the differences in brain activation between center-embedded and right branching sentences were analyzed. Interestingly, a component of activation of the frontal eye fields was found, possibly indicating repeated screening of the input.

Our paper deals with grammatical complexities and suggests that working memory overload is a reason why it is difficult to process self-embedded sentences such as *The rat that the cat that the dog chased bit fled.* Such sentences are analyzed by a computerized Generalized Phrase Structure Grammar (GPSG) which theoretically models brain activity and pinpoints the problems.

Grammatical analysis (sample rules)

Our GPSG rules are more complex than Chomsky's as they are enriched by information to the left of the arrow where functional (S) and phrase structure (F) representations are built. The grammar is called by the command esent(S,F,X,[]) which processes X, gives a subject-predicate representation in S and a phrase structure representation in F (see DEMO).

> esent([subj(Np), pred(V)],[np(Nx),vi(Vx)]) –> enp(Np,Nx),evifin(V,Vx).
> enp([N,Rs],[n(N),rels(Rf)]) –>
> en(N,Nf), [that],erdef(N,Rs,Rf). % rule causing self embedding

DEMO

> esent(S, F, [the, rat, that, the, cat, that, the, dog, chased, bit, fled], [])
>
> S = [subj([therat, [subj([thecat, [subj(thedog), pred(chased), obj(thecat)]]), pred(bit), obj(therat)]]), pred(fled)], % subj repr
>
> F = [np([n(therat), rels([that, [n(thecat), rels([that, n(thedog), vt(chased)])]], vt(bit)])]), vi(vi(fled))] % phrase repr

Note the relative sentence (rels) inside a rels and the final series of 3 verbs (vt,vt,vi).

Why are self-embedded sentences difficult to process?

I. A sentence occurring within a sentence of the same type, assumed to be difficult to process (Miller & Chomsky).

II. More than two subjects introduced without immediate matching predicates difficult (more than 2 free subjects problem).

III. The second subject (the cat) is separated from its predicate (bit) by a new clause with its subject (the dog) and predicate ((chased) (clause splitting subordinate nexus problem).

IV. More than two predicates appearing in sequel at the end cause problems to know which belongs to which subject (more than two predicates problem).

V. The brain has to process the long noun-verb pattern *N1 N2 N3 V1 V2 V3,* and combine the parts to get the corresponding subjects
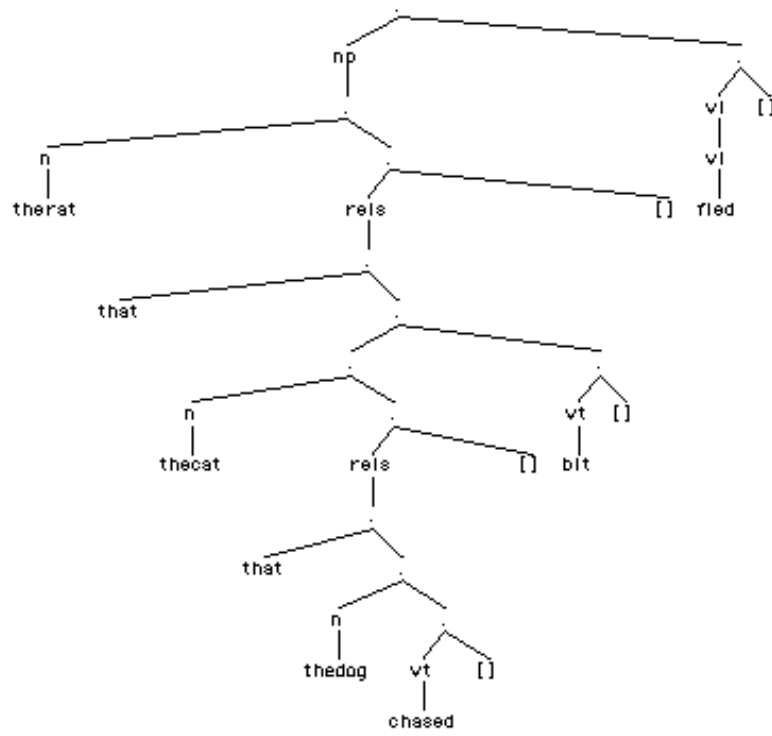
Figure 1: Phrase structure diagram

and predicates. Alternatively the brain has first to find the inner-most pattern rendering *The dog chased the cat* and then continue to get *The cat bit the rat* and finally *The rat fled.* Both processes should overload working memory. Working memory is generally (after Miller) described as having a limited span of 7 +/- 2.

Psycholinguistic research, e.g. Chistianson et al (2007) and eye-tracking experiments may shred light over the processes discussed.

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Exploring the high dimensional semantic space in the brain

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Processing of words activates networks of semantic representations in the human brain. Earlier research has investigated this by subtracting brain activity evoked from two types of stimuli, chosen prior to the experiment, and differing in some quality of interest. Here we show that arbitrary semantic representations in the brain can be investigated by utilizing high dimensional semantic spaces, which can be generated from the information of co-occurrence in huge text corpora. This method is applied to data were subjects study words list during EEG recording. We correlate estimates of semantic distance with ERP potentials to study semantic representations in the brain. The results show semantic correlates in ERPs from 200 to 800 ms post-stimuli. A major advantage with the current method is that it allows for an exhaustive search of the semantic space, where the evoked brain activity from a large number of different semantic categories can be studied simultaneously. Approximately half of the semantic clusters in our analysis show significant brain correlates. In comparison, previous literature on neural representation has studied a small subset, approximately a tenth of the space in our study. Temporal analysis of word categories suggests a wave of semantic activations around 180ms after word onset. Topographical distributions of the clusters we study suggest a general left side lateralization, which is consistent with previous findings. However, specific categories can evoke quite different and widespread activations. Taken together, these results suggest that the focus in earlier literature on concrete nouns such as animals and tools, are islands in a largely uncharted space. The proposed method is an attractive complement with novel features such as studying of arbitrary word classes, and single concepts. Furthermore, using semantic spaces this way does not require a non-semantic control condition, or trial-by-trial matching between the psychological construct and brain measure.

Hemispheric differences in parafoveal processing: Evidence from eye-fixation related potentials

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Parafoveal-on-foveal effects occur during reading when the gaze on a currently fixated (foveal) word is modulated by the properties of the next (parafoveal) word. These effects are used to examine whether attention in reading is allocated serially to one word at a time, or whether it is spatially distributed so that several words are processed in parallel.

We used eye-fixation-related potentials (EFRP), a novel technique that combines eye-tracking and electroencephalography (EEG), to investigate parafoveal-on-foveal effects. A prime word was always presented in the middle of the screen together with a parafoveal word that was either in the left (LVF) or in the right visual field (RVF). For both directions, there were three semantic association conditions: the two words were either semantically associated, non-associated, or the second read word was a non-word.

Our data suggested facilitated analysis of parafoveal word information when the second word was presented in RVF. This was indicated by longer first fixation durations on the prime word when the parafoveal stimulus was a word than when it was a non-word. ERPs measured from occipital sites showed that parafoveal word stimuli were differentiated from non-words after approximately 200 ms from stimulus onset. This effect was visible only when the parafoveal word was presented in RVF.

Our results are consistent with eye-tracking studies reporting that for readers of Germanic languages, such as English and Swedish, the region of effective vision during reading is asymmetric, and that readers acquire more information to the right of fixation than to the left.