EUROPEAN SCIENCE FOUNDATION
SETTING SCIENCE AGENDAS FOR EUROPE

Exploratory Workshop Scheme

Standing Committee for the Humanities (SCH)

ESF Exploratory Workshop on

Words In Action: Interdisciplinary Approaches To Understanding Word Processing And Storage

Pisa (Italy), 11-14 October 2009

SCIENTIFIC REPORT

Vito Pirrelli and Claudia Marzi

Co-sponsored by ① Istituto di Linguistica Computazionale (CNR Pisa, Italy)

ISTITUTO DI LINGUISTICA COMPUTAZIONALE
"ANTONIO ZAMPOLLI"

Executive Summary

On the 12th and 13th of October 2009, in the Research Area of the Italian Council for National Research (CNR) in Pisa, 26 scholars from Europe, Canada and the United States were convened by Vito Pirrelli to take part in the European Science Foundation Exploratory Workshop "Words in Action: Interdisciplinary Approaches To Understanding Word Processing And Storage".

The workshop brought together experts of various scientific domains and different theoretical inclinations to advance the current awareness of theoretical, historical, psycholinguistic, computational and neurophysiological issues in morphological processing and learning, with a view to assessing levels of research convergence and exploring the potential for synergy and strategic co-operation. The comparative number of attendees, their international scientific reputation and the variety of knowledge areas they represented made the event a rare opportunity for inter-disciplinary exchange. The need for a timely initiative of this kind was acutely felt by all attendees. Scientists all over Europe are currently pursuing highly related and complementary lines of work in this field through support of nationally-funded projects or bi-lateral cooperation programmes. However, with few exceptions, funding initiatives are not particularly generous and typicallly small-scale. A larger-scale integrated European effort, focusing on common medium-term objectives, is the way ahead to promote interdisciplinary cross-fertilization and synergy, and optimize research investments in terms of more convergent and complementary efforts.

The workshop started at 9 a.m. with a short welcome address by Andrea Bozzi, Director of the Institute for Computational Linguistics of the Italian Council of National Research, who emphasized the central role of computer modelling, machine learning and language technology in shedding light on fundamental aspects of language learning and issues in the architecture of language and cognition. He wished all attendees a fruitful meeting. Marko Tadic, representative of the ESF Standing Committee for the Humanities, took the floor to illustrate the organization of the European Science Foundation and its current plans to sustain research synergy and management in key strategic scientific domains ranging from Physical and

Engineering Sciences to Humanities and Social Sciences. Several indications were given concerning prospective follow-up initiatives.

Workshop presentations started at 9.45 a.m., articulated into four thematic sessions:

- Typological and variational trends in language morphologies (12 October, morning session)
- Neuro-psychological Evidence on Morphological Processing and Storage (12 October, afternoon session)
- The Lexicon-grammar divide in the current debate on Theoretical Morphology (13 October, morning session)
- Psycho-computational approaches to Word Processing and Storage (13 October, afternoon session).

For each session, two key-note speeches and two position talks were delivered in turn (see enclosed workshop programme), with each key-note speech being followed by a related position talk and a 15 mins discussion involving the entire audience. Each pair of consecutive speakers was selected so as to maximize complementarities of approach and scientific background. Materials of key-note speakers were made available to all workshop speakers well ahead of time through a dedicated web site (`http://webilc.ilc.cnr.it/~pirrelli/ESF_workshop`). This made it possible for each pair of consecutive speakers in the same session to address related contents and develop a shared core of arguments from different perspectives. The resulting discussion turned out to be very dense and stimulating, without being competitive or tensed. Attendees could address many fundamental questions in the light of considerably different research agendas and took the opportunity to do so in a relaxed, friendly atmosphere.

A two-hour poster session was held in the afternoon of the first day, with 8 presentations by comparatively younger scholars who provided a refreshing perspective on traditional issues. Attendees had the opportunity of exchanging thoughts and ideas at their leisure in a free informal way. The event was then followed by a social dinner.

The second day of workshop followed the same structure. In the afternoon, at the end of presentation sessions, a round table was devoted to discussing “Follow-up research activities and collaborative actions”. The discussion showed that key players in Europe want to collaborate, but that they need to work hard at deeply understanding each other’s perspectives and their relevant implications for each other’s work. There was a general consensus on the value of providing opportunities for postgraduates, in terms of interdisciplinary training, exchange visits and international scientific meetings. Furthermore, as several workshop participants are currently pursuing funded research programmes in the area of word structure, the proposed network would spread the benefit of existing funding to other networked actors.

It was felt that the European research scenario is particularly conducive to these objectives, thanks to the robustly empirical character of European research in a vast range of scientific domains (encompassing processing models of the mental lexicon, short-term and long-term memory issues, typological and historical trends) where European scientists appear to be playing a leading role. There is growing awareness that failure to produce such an effort is bound to progressively undermine the impact of this potential and in the end provide an objective advantage to other international actors.

Several different ways to keep up the momentum gathered in the workshop were considered and discussed in some detail. All participants eventually agreed on the idea of submitting a joint proposal to the European Research Networking Programme. Vito Pirrelli took the responsibility of producing and circulating a first draft of the proposal in few days after the workshop, to get feedback and signs of interest. It was agreed that the network should gather more actors than those attending the workshop. Each participant provided more names in her/his own scientific and geographical areas.

The round table ended at around 7,30 p.m. The workshop closed at the same time. Departures were scheduled on the following day.

A European Research Networking Proposal was eventually submitted.with the title "The European Network on Word Structure. Cross-disciplinary approaches to understanding word structure in the languages of Europe" and the acronym "NetWords". The proposal includes over 50 research institutions in 16 European countries. Success of the proposal will consolidate the European primacy in this knowledge area and will considerably speed up progress in the field through international

Scientific Content of the Event

Words are the basic building blocks of language productivity, establishing the most immediate connections between language and our conceptualization of the outside world. Besides, they represent complex and elusive interface units, which are not only parts of larger constructions such as phrases or sentences, but are themselves, in all European languages, made up out of simpler meaningful sub-lexical constituents (traditionally known as "morphemes"), such as roots and affixes.

Such a dual status of morphologically complex words, at the interface between lexicon and grammar, raises a number of fundamental questions, many of which still remain unanswered. How are words processed in working memory and eventually understood? Are they stored in long-term memory as a whole or are they rather composed "on-line" in working memory from stored sub-lexical constituents? Do both knowledge-based factors, such as formal regularity and semantic transparency, and usage-driven factors, such as word length and frequency, play any role in this? Does word-level knowledge require parallel development of form and meaning representations, or do they develop independently at a different pace and interact only after development? How do word meanings dynamically function and combine in communicative contexts, evolve through learning and get categorized into high-level syntactico-semantic classes? To what extent does lexical knowledge affect on-line processing and what principles govern this knowledge? How do the dramatic differences in word structures across the languages of Europe impact on the processing models worked out typically on the basis of a single language? Last but not least, what neurobiological patterns of connectivity sustain word processing and storage in the brain?

Almost all levels of language knowledge and processing (from phonology, to syntax and semantics) are known to be affected by knowledge of word structure at varying degrees. A better understanding of the human strategies involved in learning and

processing word structure thus lies at the heart of our comprehension of the basic mechanisms serving both language and cognition and is key to addressing some fundamental challenges for the study of the physiology of grammar.

According to dual-route approaches to word structure (Prasada & Pinker 1993, Pinker & Prince 1988, among others), recognition of a morphologically complex word form involves full-form access to the lexicon (an assorted long-term repository of exceptions and sub-regularities), possibly followed by recourse to grammar (a set of productive combinatorial rules taking care of on-line word segmentation). Such a view, recently challenged by several scholars (e.g. Burzio 2004, Bates & Goodman 1999 and Bybee 1995), rests on the hypothesis of a direct correspondence between principles of grammar organization (lexicon vs rules), processing correlates (storage vs computation) and localization of the cortical areas functionally involved in word processing (Ullman 2004). Although such a direct correspondence is probably the most straightforward model of the grammar-processing relation (Miller & Chomsky 1963, Clahsen 2006), it may only be the artifact of outdated views of memory as rote storage (Baayen 2007). In fact, other theoretical models have put forward a more nuanced indirect correspondence hypothesis. For instance, the morphological lexicon may be hierarchical, with cascading defaults representing increasingly specific information (as in the Network Morphology account of Corbett & Fraser 1993, further elaborated in Dressler et al. 2006). In the Word-and-Paradigm tradition (Matthews 1991, Pirrelli 2000, Stump 2001, Blevins 2006), fully inflected forms are associatively related through possibly recursive paradigmatic structures, defining entailment relations between forms. Any serious appraisal of such an indirect correspondence i) requires extensive empirical testing on a wide array of morphologically rich languages of the sort spoken in Europe, ii) is likely to exceed the limits of both human intuition and box-and-arrow models of cognition. Increasing availability of multi-lingual data sets and computer models of language learning and processing will have much to say in this respect in the near future.

All workshop contributions were devoted to shedding light on fundamental aspects of the Lexicon & Grammar interplay. In his inaugural talk “On the ‘Deep Morphology’ of the Romance Languages and its Implications for Word-Structure”, **Maiden** showed that, although the Romance “morphemes” (in the Aronovian sense) originate as binary allomorphy within the root, their various diachronic manifestations frequently involve elements lying outside the root or stem, including person and number endings, or make reference to whole word-forms. Moreover, the resulting alternations may involve the grafting of whole ‘paradigm-slabs’ of one lexeme onto the paradigm of another. Such historical facts support a rigorously

'separationist' approach to the relation between meaning and word-structure in which the morphome is conceived simply as a relation between a specified arbitrary set of paradigm cells on the one hand, and lexical signata on the other. This has also an impact on phenomena of language contact and variation, as persuasively argued in **Nerbonne**'s talk ("Morphological Variation") who showed that language change emerges most clearly from the complex interaction of several independent and paradigmatically interfaced grammar modules, rather than being ascribable to the overwhelming influence of one such module only. Details of sound change implementation and diffusion are better understood, if one assumes that the coexistent but heterogeneous phonetic outcomes to which speakers are typically exposed in unstable phases of language evolution are eventually ordered through abstract paradigm schemata (also known in the literature as indexing schemata), and selectively spread through these orderly clusters in the mental lexicon of the speaker.

As illustrated by **Baayen** in connection with experimental evidence on sentence reading ("There Is More To Prime Than Meets The Eye"), convergent psycholinguistic findings support the conclusion that surface word relations constitute a fundamental domain of morphological competence, with particular emphasis on the interplay between form frequency, family frequency and family size effects within morphologically-based word families. The idea of using psycholinguistic evidence on reading abilities as an access point to issues of word processing and storage was further elaborated by **Burani** in her talk "Derivational morphology: The case of reading in skilled and poor readers".

This evidence is coherent with theoretical models of paradigmatic organization as stochastically modulated networks of lexical representational entailments, illustrated by **Burzio** ("Desiderata for a Theory of Morphology: Parallelism and Distributed Representations"), exemplified by construction-based approaches to lexical organization á la **Booij** ("The hierarchical lexicon and morphological constructions") and implemented as either Temporal Hebbian Self-Organizing Maps (in **Pirrelli**'s talk "Paradigm Self-organization in Time & Space") or Memory-based architectures for morphological processing (as proposed in **Daeleman**'s talk "Memory-based Inflectional Morphology").

Such a new conceptualization of morphological competence as paradigmatic self-organization raises a whole range of learnability issues which, in turn, are thrown in sharp relief when we confront ourselves with the wide spectrum of typological complexity exhibited by the morphological paradigms attested in the world languages (see **Corbett** "Morphological complexity: a typological perspective). **Plag**

("Morphological Complexity: inflection classes and probabilistic allomorph selection") further suggested a possible connection between issues of paradigm-based complexity and the notion of allomorphy selection as a process of constraint resolution over graded statistical patterns.

Another fundamental open issue is how theoretical models relate to neurobiologically-grounded models and theories of word structure, as outlined by **Pulvermüller**'s talk "Discrete Elements: The Essence Of Language? Comments on the neural side of words and rules", and further elaborated by **Marangolo** with specific emphasis on word derivation processes ("Language And Its Interacting Components: The Right Hemisphere Hypothesis In Derivational Morphology"). **Tyler** ("Modulation of the fronto-temporal language system by different grammatical markers") and **Marlsen-Wilson** ("Neurobiological foundations for human language: General and specific interacting systems") reported recent evidence of automatic sublexical segmentation of monomorphemic words triggered by pseudo inflectional endings (or inflectional rhyme patterns, cf. Post, Marslen-Wilson, Randall & Tyler 2008). The evidence lends support to a less deterministic and modular view of the interaction between stored word knowledge and on-line processing, based on simultaneously activating patterns of cortical connectivity reflecting (possibly redundant) distributional regularities in the input at the phonological, morpho-syntactic and morpho-semantic levels. At the same time, the evidence argues for a more complex and differentiated neuro-biological substrate for human language than connectionist one-route models (McClelland & Patterson 2002) are ready to acknowledge. It is suggested that brain areas devoted to language processing maximize the opportunity of using both general and specific information simultaneously, rather than maximize processing efficiency and economy of storage, a point also argued for by **Libben** in his talk "Comment on the hierarchical lexicon and morphological constructions".

Such a dynamic view of the brain language processor is also connected with what we know about the relation between language acquisition and processing and the human ability to retain sequences of symbols in Short Term Memory (Baddeley & Hitch 1974, Baddeley 1986, 2007, Burgess & Hitch 2006, Hitch et al. 2009). Serial sequences are recalled more easily if they are repeatedly encountered in the subject's input (Baddeley 2000). This means that verbal elements that are frequently sequenced together are stored in the Long Term Memory as single chunks, and accessed and executed as though they had no internal structure. Such a crucial interaction between Short Term and Long Term Memory structures points to a profound continuity between word repetition/learning and other levels of

grammatical processing in language, as reported in **Houghton**'s talk ("Neuro-Computational models of lexical organisation and processes") and is in line with neurobiological approaches according to which Long Term Memory refers to structural networks and Short Term Memory is activation of the same networks.

Assessment of the results and contribution to the future direction of the field

The lively participation and intense cross-disciplinary discussion of the two-day workshop confirmed that this is an important time in the evolution of EU research on word structure. Europe has firm and deep roots in as diverse disciplinary fields as theoretical models of language architecture, brain sciences, cognitive modeling, language development, short-term and long-term memory processes, psycho-computational models of lexical processing and storage, predictive models of language behaviour, machine learning, diachronic, diamesic and diastratic evidence of language varieties. The present healthy condition of European research makes time ripe for a larger-scale cross-disciplinary European effort into word structure aiming at:

- exploring the implications of domain-specific approaches for other fields in this area
- testing claims by broadening the empirical basis for their support
- examining whether extensions of theoretical claims can be developed
- learning how those extensions can inform the original proposals
- promoting interdisciplinary cross-fertilization and synergy
- focusing on common medium-term objectives
- optimizing research investments in terms of more convergent and complementary efforts

There is growing awareness that interdisciplinary cooperation in this area will have much wider chances of success than traditional specialist work in highly focused knowledge domains and that it will consolidate European excellence in the field.

After thourough discussion of possible alternative ways to keep up the workshop's momentum in the near future, attendees discussed the suggestion of submitting a joint large-scale proposal in the framework of the European Research Networking Programme. The intended Network is expected to set common research priorities, develop joint training programmes and establish virtual cross-disciplinary laboratories and research infrastructures. Collaboration will unfold through the following steps:

- discuss and develop consensual word representations in context
- establish common experimental protocols and suggest novel ones
- take stock of and integrate multilingual evidence based on the large array of European languages spoken and investigated in the Network
- transfer best practice in use of new computational and statistical techniques for lexicon modeling
- share experimental data, software and equipment
- facilitate, through community building, the development of optimum cross-disciplinary and cross-linguistic research strategies
- prompt and extend collaboration between partners
- link European activities with the wider community world-wide.

A series of scientific meetings will be organized over a four year period, and a common basis of shared facilities and research infrastructures will be established. The Network is intended to promote training and development of young scientists through short visits, exchange grants and Summer schools, and will encourage the integration of new partners. To maximize synergy, the Network will define a list of shared key issues of general interest (e.g. word reading, word segmentation from speech, NN compound interpretation), having the potential of shedding light on fundamental challenges in word structure from a wide range of perspectives. For each shared issue, a dedicated Network Internet Forum will be created to take stock of relevant know-how, empirical data, dedicated software tools, dedicated equipment, experimental and evaluation protocols, figures of merit and data exchange formats. The forum will discuss domain-specific approaches and explore ways of integrating and extending approaches and planning focused collaborative work, with a view to building credible partnerships for focused, application-oriented European projects/initiatives. Last but not least, thanks to the participation of Gary Libben, it was agreed that the Network will also have a global dimension with collaborations with the Mental Lexicon Research Group in Canada.

A European Research Networking Proposal with the acronym “NetWords” was eventually submitted by William Marslen-Wilson, Ingo Plag and Vito Pirrelli. The proposed Network includes over 50 research institutions in 16 European countries. Success of the proposal will consolidate the European primacy in this knowledge area and considerably speed up progress in the field through international scholarly cooperation and know-how exchange.

PROGRAMME

Sunday, 11 October 2009

Afternoon *Arrival*

Monday, 12 October 2009

09.00-09.05 **Welcome by convenor**

09.05-09.20 **Presentation of the European Science Foundation (ESF)**
Marco Tadic, ESF Standing Committee for the Humanities (SCH)

09.20-12.45 **Morning Session: Typological and variational trends in language morphologies**

09.20-10.05 **Presentation 1 "On the 'Deep Morphology' of the Romance Languages and its Implications for Word-Structure"**
Martin Maiden (Oxford University, Oxford, UK)

10.05-10.35 **Discussant**
John Nerbonne (Rijksuniversiteit, Groningen, The Netherlands)

"A Variationist Perspective on Morphology"

10.35-10.50 **questions & answers**

10.50-11.15 *Coffee / Tea Break*

11.15-12.00 **Presentation 2 "Morphological Complexity: a typological perspective"**
Greville G. Corbett (University of Surrey, Guildford, UK)

12.00-12.30 **Discussant**
Ingo Plag (Siegen University, Siegen, Germany)

"Morphological Complexity: Inflection Classes and Probabilistic Allomorph Selection"

12.30-12.45 **questions & answers**

12.45-14.00 *Lunch*

14.00-17.00 **Afternoon Session: Neuro-psychological Evidence on Morphological Processing and Storage**

14.00-14.45 **Presentation 3 "Discrete elements: the essence of language? Comments on the neural side of morphemes and rules"**
Friedemann Pulvermüller (MRC Cognition and Brain Sciences Unit, Cambridge, UK)

14.45-15.15 **Discussant Paola Marangolo** (Dipartimento di Neuroscienze, Università Politecnica delle Marche)

"Language and its interacting components: The right hemisphere hypothesis in derivational morphology"

15.15-15.30 **questions & answers**

15.30-16.15 **Presentation 4 "Modulation of the fronto-temporal language system by different grammatical markers"**
Lorraine K. Tyler (Cambridge University, Cambridge, UK)

16.15-16.45 **Discussant**
Cristina Burani (ISTC CNR, Rome, Italy)

"Morpho-lexical reading and comprehension in dyslexic and skilled readers"

16.45-17.00 **questions & answers**

17.00-17.15 *Coffee/Tea Break*

17.15-19.00 *Poster Sessions*

Valentina Bambini *(Scuola Normale Superiore di Pisa)*
Tracking metaphor through eye-movements: from words to meanings

Krista Lagus *(Adaptive Informatics Research Centre, Helsinki University of Technology)*
Unsupervised induction of morphology and sentence constructions from text using Minimum Description Length

Emiliano Guevara *(University of Oslo, Norway)*
Compositionality in Distributional Semantics: Derivational Affixes

Mirjam Ernestus *(Radboud University Nijmegen & Max Planck Institute for Psycholinguistics)*
The role of acoustic reduction in the production and comprehension of affixes

Hélène Giaudo & **Fabio Montermini** *(Laboratoire "Cognition, Langues, Langage, Ergonomie" CNRS-UMR 5263)*
Sublexical vs. Supralexical models of morphological processing : towards a reconciliation

Paolo Acquaviva *(University College Dublin)*
Nominality: Grammar and Conceptualization in the Lexicon

Alessandro Lenci *(Università di Pisa)* & **Marco Baroni** *(Università di Trento)*
Distributional Memory: a Generalized Framework for Corpus-Based Semantics

Gert Westermann *(Department of Psychology, Oxford Brookes University)*
Inflecting the English past tense - regular vs. irregular or easy vs. hard?

20.30 *Social Dinner*

Osteria dei Cavalieri, v. S. Frediano 16, Pisa

Tuesday, 13 October 2009

09.00-12.30	**Morning Session: The Lexicon-grammar divide in the current debate on Theoretical Morphology**
09.00-09.45	**Presentation 1 "The hierarchical lexicon and morphological constructions"** **Geert Booij** (Universiteit Leiden, Leiden, the Netherlands)
09.45-10.15	**Discussant** **Gary Libben** (University of Calgary, Calgary, Canada)
10.15-10.30	**questions & answers**
10.30-11.00	*Coffee / Tea Break*
11.00-11.45	**Presentation 2 "Desiderata for a theory of the Lexicon: parallelism and distributed representations"** **Luigi Burzio** (Johns Hopkins University, Baltimore, USA)
11.45-12.15	**Discussant** **Vito Pirrelli** (ILC CNR, Pisa, Italy) "Paradigm self-organization in Time and Space"
12.15-12.30	**questions & answers**
12.30-13.45	*Lunch*
13.45-16.45	**Afternoon Session: Psycho-computational approaches to Word Processing and Storage**
13.45-14.30	**Presentation 3 "Computational accounts of lexical organisation and processes"** **George Houghton** (Bangor University, North Wales, UK)
14.30-15.00	**Discussant** **Walter Daelemans** (University of Antwerp, Antwerp, Belgium) "Memory-based Morphological Processing"
15.00-15.15	**questions & answers**
15.15-16.00	**Presentation 4 "There is more to process than meets the eye: A study of paradigmatic effects in reading case-inflected words"** **Harald Baayen** (University of Alberta, Edmonton, Canada)
16.00-16.30	**Discussant** **William Marslen-Wilson** (MRC Cognition and Brain Sciences Unit, Cambridge, UK) "Neurobiological foundations for human language: General and specific interacting systems"
16.30-16.45	**questions & answers**
16.45-17.00	*Coffee/Tea Break*
17.00-18.45	*Round Table:* ***Follow-up research activities and collaborative actions***
18.45	*End of Workshop*

Wednesday, 14 October 2009

morning	*Departure*

Statistical Information on Participants

Overall no. of participants		**26**
female attendees		**8**
male attendees		**18**
participating countries		**14**
participating institutions		**23**
countries of origin		**15**
age structure	under 40	**5**
	under 50	**13**
	under 60	**8**
knowledge areas involved	Brain Sciences	**10**
	Linguistics	**8**
	Computer modeling	**8**

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