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A brain network for integration of tone and suffix

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9th International Morphological Processing Conference

Potsdam, Germany
18th - 20th June 2015



Programme summary

Thursday 18 th June	Friday 19 th June	Saturday 20 th June
09.00 Registration	09.00 Registration	
09.30 Welcome 09.40 Talks Session 1 Chair: Gary Libben	09.40 Symposium 2 <i>The timing of morphological processing</i> Chair: Jonathan Grainger	10.00 Talks Session 5 Chair: Kira Gor
11.00 Coffee	11.20 Coffee	11.20 Coffee
11.20 Symposium 1 <i>Morphology in agreement processing</i> Chair: Nicola Molinaro & Simona Mancini	11.40 Talks Session 4 Chair: Laurie B. Feldman	11.40 Talks Session 6 Chair: Harald Clahsen
13.10 Lunch	13.10 Lunch	13.00 Concluding Remarks
14.30 Talks Session 2 Chair: William Marslen-Wilson	14.30 Symposium 3 <i>Morphology in multilingual language processing</i> Chair: João Veríssimo	
15.50 Coffee	16.10 Coffee	
16.10 Talks Session 3 Chair: Pienie Zwitserlood	16.30 Keynote <i>Synonymy: The role of competition in morphological processing</i> Mark Aronoff	
18.30-21.30 Poster Session House 8, foyer	Conference Dinner	



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9th International Morphological Processing Conference

Potsdam, Germany

18th - 20th June 2015

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Front cover image: Courtesy of Vera Heyer

Welcome

9th INTERNATIONAL MORPHOLOGICAL PROCESSING CONFERENCE

We would like to welcome you all to the 9th edition of this biannual conference, the first one to take place in Germany. This very special conference series has grown out of a set of small workshops originally initiated in 1999 by Ram Frost and Jonathan Grainger. The goal of the workshops was to bring together researchers interested in the role of morphological processing during language comprehension and production. The event has since then grown into a proper conference – with almost 100 participants this year – and has taken place in different locations across Europe (1999: Aix-en-Provence, 2001: Nijmegen, 2003: Aix-en-Provence, 2005: Cambridge; 2007: Marseilles, 2009: Turku, 2011: San Sebastián, 2013: Cambridge).

Research on morphological processing has greatly benefitted from Ram and Jonathan's original initiative and from the work presented at the conferences, as is attested to by a series of high-standard collections of research articles on morphological processing, most of which were presented at the conference:

Frost, R. & Grainger, J. (2000). Cross-linguistic perspectives on morphological processing. *Special issue of Language and Cognitive Processes*. Hove, UK: Psychology Press.

Baayen, R. H. & Schreuder, R. (2003). Morphological structure in language processing. Berlin: Mouton.

Frost, R., Grainger, J. & Rastle, K. (2005). Current issues in morphological processing. *Special issue of Language and Cognitive Processes*. Hove, UK: Psychology Press.

Frost, R., Grainger, J. & Carreiras, M. (2008). New directions in morphological processing. *Special issue of Language and Cognitive Processes*. Hove, UK: Psychology Press.

Bertram, R., Hyona, J. & Laine, M. (2011). Morphology in language comprehension, production and acquisition. *Special issue of Language and Cognitive Processes*. Hove, UK: Psychology Press.

Rueckl, J., Carreiras, M. & Frost, R. (2013). New advances in morphological processing. *Special issue of Language and Cognitive Processes*. Hove, UK: Psychology Press.

Leminen, A., Lehtonen, M., Bozic, M. & Clahsen, H. (2014). Research Topic: Morphologically complex words in the mind/brain. *Frontiers in Human Neuroscience*.

The current conference will address - through papers, symposia, and posters - core issues in morphological processing research. There will be two additional foci this year. The first is on the linguistic side of things, with a keynote address given by Mark Aronoff, one of the most prominent morphologists in the world, and a symposium on the processing of morphosyntax. The second additional focus is on morphological processing in different populations, with a symposium on bilinguals and a number of papers on populations other than the commonly studied healthy adults. In addition, the programme includes a pre-conference hands-on workshop introducing new tools for analysing eye movements during language processing.

Potsdam does not only have a thriving research-active university, but its parks and palaces also form a UNESCO World Heritage site, and we are very pleased to host the conference in one of these palaces. We hope you will enjoy not only the conference but also your visit to this rather special place.

Harald Clahsen, University of Potsdam

Organising committee: Vera Heyer, Gunnar Jacob, Helena Krause, Jana Reifegerste, Michaela Schmitz, João Veríssimo

The conference is organised in collaboration with the UP Transfer GmbH.



We wish to thank our sponsors for their generous financial support.

Useful information

Conference Venue

The conference will be held at the Potsdam University campus "Am Neuen Palais". The talks will be presented in House 9, room 1.02.

Registration

Conference registration will take place in the foyer of House 9 on Thursday 18th June at 9 am. For those who are unable to arrive on Thursday, there will also be a registration session on Friday morning at 9 am. The registration desk will be staffed during the breaks to assist you with any queries you might have.

Coffee and Lunch

Coffee will be served in the foyer of House 9 (outside the lecture hall) as indicated in the programme. For lunch, there are several options on campus. The Mensa serves hot meals (daily offers, including a vegan and a vegetarian option), the cafeteria snacks and the café hot meals and snacks. The locations are indicated in the map in the back of your booklet.

Oral Presentations

Please make sure that your presentation is uploaded to the presentation computer well before your talk (in the break before your scheduled session at the latest) or let us know if you want to use your own computer. There will be a technician available in the lecture hall to assist you.

Posters

The poster session will be held in the foyer of House 8 on Thursday 18th June from 18.30-21.30. There will be a buffet dinner during the session.

The room will be open for presenters from 17.30. Magnets are available for hanging posters – do not use any other method of securing posters to boards. Please ensure you remove your poster

at the end of the session. Presenters are expected to stand at their poster during the session.

Conference Dinner

The conference dinner will be held on Friday 19th June in the evening. The exact time and location will be communicated at the conference. Pre-booking and payment is required for this event.

Internet access

Wireless internet is available on campus. For the *UPcampus* network, an individual user name and password is provided at the registration desk.

Name badge

Delegates are kindly requested to wear their name badge for the duration of the conference.

Travel information

From Potsdam main station, you can take the buses 605, 606, 695 and X5 to the stop "Campus Universität/Lindenallee". Trains arrive at the station "Potsdam Park Sanssouci" (from Potsdam main station: RB20; from Potsdam or Berlin: RB21, RB22, RE1); the conference location is a 10-minute walk from the station (or two stops with the above buses).

Social activities in Potsdam

Here are some ideas of activities you may wish to enjoy during your stay. More detailed information about leisure activities in Potsdam is in your conference pack and available at the registration desk.

Parks - Our conference location is situated right at the edge of *Park Sanssouci*, with the palace *Neues Palais* right behind the university buildings and the famous *Sanssouci palace* (30-min walk). Furthermore, *Neuer Garten (Cecilienhof palace)* or *Park Babelsberg* offer some beautiful scenery and buildings.

Lakes - Potsdam is surrounded by several lakes, e.g. *Heiliger See*, *Fahrländer See*. If you want to go for a swim, the registration desk can provide you with information about where it is safe to go for a dip.

Diversity - There are various international influences reflected in Potsdam's city landscape. For instance, you can explore various little shops and cafés in the *Dutch quarter*, go for a stroll through the Russian colony *Alexandrovka* with its beautiful wooden houses or find the *Chinese House* or the *Roman baths* in Park Sanssouci.

Cycling - Potsdam is a bike-friendly city. If you want to explore the sights by bike, you can rent one at different places. At Potsdam main station (platform 6/7), you can rent a bike at *Potsdam per pedales* (8-10.50€/day). They also offer guided tours and audio guides (www.potsdam-per-pedales.com/bike-rental/potsdam-main-station.html). Another public bike rental service is *nextbike*, with 21 locations across the city (www.nextbike.de/en/potsdam; 9€/day). You need to register online and pay by credit card for this service.

Walking tours - The Potsdam tourism office offers several guided walking tours (www.potsdam-tourism.com). If you want to explore Potsdam in your own time, there is a free audio guide that covers sights all over Potsdam (www.potsdam.tomis.mobi/en). You can download the audio files and save them on your phone or mp3 player.

Bus tours - The guided bus tour *Alter Fritz* has tour guides who explain the sights in German and English and includes short walks at Cecilienhof palace, Sanssouci palace and the Neues Palais (16-18€; www.schloesserrundfahrten.de). The bus leaves daily from Potsdam main station at 11.00 and 14.00. If you prefer a hop-on-hop-off version, *Potsdam City Tours* buses leave from Luisenplatz every half hour from 9.55 to 15.55 (www.berlin-city-tour.de/en/potsdam-city-tour_en; 14-17€).

Museums - Apart from the exhibitions inside the various palaces, Potsdam offers various other museums documenting Potsdam's history, from Prussian rule to WWII up to modern times (e.g. *House of the Brandenburg-Prussian History*, *Potsdam Museum*). For more information, see www.en.potsdam.de/content/museums.

Babelsberg Studios - Do you want to see where Oscar-winning films like "Inglorious Basterds" or "The Pianist" were filmed? The *Babelsberg Studios* offer guided tours (Mon-Fri, German only, 25€/person, needs to be booked 10 days in advance; www.studiobabelsberg.com/en/public-relations/studio-tour). The *Filmpark Babelsberg* offers a mixture of looks behind the scenes of movie-making and theme-park attractions (Tue-Sun, 17-21€, www.filmpark-babelsberg.de/en/).

Berlin - Plus, there is always Berlin. It is only a 30-minute train ride to the German capital, with its rich cultural and historical attractions.

Pre-Conference Workshop

Eye tracking paradigms for morphological processing

Meike Mischo & Martin Pötter (SMI)

The workshop will introduce different eye tracking paradigms that can shed light on how the human cognitive system processes morphologically simple and complex words. The workshop contains hands-on training with SMI SensoMotoric Instruments eye tracking hardware and software that is developed to optimize experimental research in the fields of linguistics and psychology. Participants will program short experiments of morphological processing with SMI in-house software Experiment Center, learn to operate SMI remote eye-trackers to collect data as well as use SMI's in-house analysis software BeGaze. The special focus will be on the Proportion of Looks Module and the Reading Module that are designed to facilitate research in the field.

Date: 17 June 2015, 5 - 7 pm
Location: Bildungsforum Potsdam (Wissenschaftsetage)
Am Kanal 47
14467 Potsdam



Conference Programme

Thursday 18th June

09.00-09.30 Registration (House 9, foyer)

09.30-09.40 Welcome (House 9, room 1.02)

Talks Session 1 **General Talks**

Chair: Gary Libben

09.40-10.00 **GT01** The suffix priming effect without stems: New evidence for automatic morphological decomposition. *Miguel Lázaro, Víctor Illera & Javier Sainz*

10.00-10.20 **GT02** Semantics does play a role at early morphological processing stages. *Alice Blumenthal-Dramé*

10.20-10.40 **GT03** Investigating morphological effects in sentence reading: Early morpho-orthographic and early morpho-semantic effects. *Simona Amenta, Marco Marelli & Davide Crepaldi*

10.40-11.00 **GT04** Neurocognitive substrates of derivational morphology: Evidence from Italian. *Francesca Carota, Mirjana Bozic & William Marslen-Wilson*

11.00-11.20 Coffee

Symposium 1 Morphology in agreement processing
Chair: Nicola Molinaro & Simona Mancini

- 11.20-11.40 **S01** Morphosyntactic production of coordination agreement in South Slavic: A comparative study. *Jana Willer-Gold, Boban Arsenijević, Mia Batinić, Nermina Čordalija, Marijana Kresić, Nedžad Leko, Lanko Marušič, Tanja Miličev, Nataša Miličević, Ivana Mitić, Andrew Nevins, Anita Peti-Stantić, Branimir Stanković, Tina Šuligoj & Jelena Tušek*
- 11.40-12.00 **S02** Does the ending matter? Influence of gender-to-ending consistency during agreement processing. *Sendy Caffara & Horacio Barber*
- 12.00-12.20 **S03** Inflection in and out of context: spatiotemporal dynamics of morphological processing in sentences. *Alina Leminen*
- 12.20-12.40 **S04** From minimal dependencies to sentence context: Evidence for a common neural system involving different functional networks working hand by hand. *Ileana Quiñones*
- 12.40-13.00 **S05** Final remarks. *Nicola Molinaro & Simona Mancini*

13.10-14.30 Lunch break

Talks Session 2 General Talks
Chair: William Marslen-Wilson

- 14.30-14.50 **GT05** The role of the nominal-pattern morpheme in lexical access in Hebrew: Evidence from written-word perception and single-word production. *Avital Deutsch*
- 14.50-15.10 **GT06** Morpheme interference in Hebrew. *Maya Yablonski & Michal Ben-Shachar*

15.10-15.30 **GT07** Role of root morphology in Hebrew auditory lexical access. *Marina Oganyan, Richard Wright & Julia Herschensohn*

15.30-15.50 **GT08** Abstract representation of the root morpheme: A magnetoencephalography study of spoken Arabic. *Laura Gwilliams & Alec Marantz*

15.50-16.10 Coffee

Talks Session 3 General Talks

Chair: Pienie Zwitserlood

16.10-16.30 **GT09** Compound priming in German: Disentangling morphological from semantic effects in visual and auditory word recognition. *Antje Lorenz, Jens Bölte & Pienie Zwitserlood*

16.30-16.50 **GT10** Derivational Morphology as a State of Mind. *Gary Libben, Gonia Jarema, Alessandra Riccardi, Danuta Perlak & Bruce Derwing*

16.50-17.10 **GT11** Effects of covert morphological complexity: The processing of zero-derived words. *Jeannique Darby*

17.10-17.30 **GT12** Schemas in storage and processing. *Jenny Audring & Ray Jackendoff*

18.30-21.30 Poster session and buffet supper (House 8, foyer)

Friday 19th June

09.00-09.40 Registration

Symposium 2 The timing of morphological processing

Chair: Jonathan Grainger

- 09.40-10.00 **S06** Form, meaning, and order: Why morphology and timing are important. *Jonathan Grainger*
- 10.00-10.20 **S07** Form-then-meaning in recognizing morphologically-complex words. *Kathy Rastle*
- 10.20-10.40 **S08** Lexical competition and morphological processing. *Joanna Morris*
- 10.40-11.00 **S09** Semantic context effects in morphological processing: Late, lexical, and not top-down. *Caroline Whiting, Jana Klimova & William Marslen-Wilson*
- 11.00-11.20 **S10** Morphological processing in language production. *Niels Schiller*

11.20-11.40 Coffee

Talks Session 4 General Talks

Chair: Laurie B. Feldman

- 11.40-12.00 **GT13** Interaction between morpho-syntactic complexity and frequency during spoken language comprehension. *Yun-Hsuan Huang, Mirjana Bozic & William Marslen-Wilson*
- 12.00-12.20 **GT14** The language skeleton after dissecting meaning: A functional segregation within Broca's Area. *Tomás Goucha & Angela D. Friederici*
- 12.20-12.40 **GT15** Gender features in German: Evidence for underspecification. *Andreas Opitz & Thomas Pechmann*

12.40-13.00 **GT16** Processing free affix order. *Ivan Kapitonov*

13.10-14.30 Lunch break

Symposium 3 Morphology in multilingual language processing
Chair: João Veríssimo

14.30-14.50 **S11** How do native and nonnative morphological processing differ? *Kira Gor*

14.50-15.10 **S12** Neural correlates of morphological processing in older late bilinguals. *Kristin Prehn, Benedikt Taud, Jana Reifegerste, Harald Clahsen & Agnes Flöel*

15.10-15.30 **S13** Is all morphology created equal? The processing of derived vs. inflected words in L2 German. *Gunnar Jacob, Vera Heyer & João Veríssimo*

15.30-15.50 **S14** Inflectional processing in native and nonnative speakers of English. *Laurie Beth Feldman, Jelena Radanovic, Kit Cho & Petar Milin*

15.50-16.10 **S15** Discussion: Future directions in multilingual morphological processing. *João Veríssimo*

16.10-16.30 Coffee

Keynote **Synonymy: The role of competition in the organization of morphology**
16.30-17.30 **Mark Aronoff**

Conference dinner

Saturday 20th June

Talks Session 5 General Talks

Chair: Kira Gor

- 10.00-10.20 **GT17** Mechanisms of morpho-syntactic prediction in natural sentence processing. *Anastasia Klimovich-Smith, Elisabeth Fonteneau & William Marslen-Wilson*
- 10.20-10.40 **GT18** Pupillometry as a window to real time processing of grammatical aspect in Russian. *Aki-Juhani Kyröläinen, Vincent Poretta & Juhani Järviö*
- 10.40-11.00 **GT19** French stems in verbal inflection: Structure, rules, and allomorphy. *Gustavo Lopez Estivalet & Fanny Meunier*
- 11.00-11.20 **GT20** Spatio-temporal dynamics of morphological processing in visual word recognition: A priming study using MEG. *Eddy Cavalli, Pascale Colé, Jean-Michel Badier, Christelle Zielinski, Chotiga Pattamadilok & Johannes Ziegler*

11.20-11.40 Coffee

Talks session 6 General Talks

Chair: Harald Clahsen

- 11.40-12.00 **GT21** Automatic rapid acquisition of complex word forms in children, but not adults: EEG evidence. *Miika Leminen, Alina Leminen, Juuso Ojaniemi, Teija Kujala, Marja Laasonen & Yury Shtyrov*
- 12.00-12.20 **GT22** Morphological processing in end-state second language acquisition. *Filiz Rızaoğlu & Ayşe Gürel*

12.20-12.40 **GT23** Participle inflection in German children and adolescents with Down Syndrome. *Martina Penke, Bernadette Witecy, Ruth Szustkowski & Eva Wimmer*

12.40-13.00 **GT24** Effects of morphological family on word recognition in Alzheimer's disease. *Alexandre Nikolaev, Minna Lehtonen, Eve Higby, JungMoon Hyun, Sameer Ashaie, Merja Hallikainen, Tuomo Hänninen & Hilikka Soininen*

13.00-13.10 Concluding remarks and end of programme

Poster session programme

- P01** The computation of agreement in L1 vs. L2: Effects of verb position, attraction, and word order. *Sandra Pappert*
- P02** Agreement attraction in native and non-native speakers of German. *Sol Lago & Claudia Felser*
- P03** Non-parallel effects in production and comprehension of agreement attraction. *Natalia Slioussar, Natalia Cherepovskaia, Anton Malko, Tatiana Matyushkina & Anna Stetsenko*
- P04** Capturing relational information in compound words: A distributional-semantic approach. *Marco Marelli, Christina L. Gagné, Thomas L. Spalding & Marco Baroni*
- P05** When a word is un-understandable: From lexical co-occurrences to the meaning of novel derived words. *Marco Marelli & Marco Baroni*
- P06** English-speaking children's interpretation of novel deverbal compounds. *Poliana Gonçalves Barbosa & Elena Nicoladis*
- P07** The role of morphological variables in reading aloud derived nouns: Evidence from an eye-tracking study with primary school children. *Daniela Traficante, Marco Marelli & Claudio Luzzatti*
- P08** The use of morphology in word and pseudoword recognition across reading development. *Jana Hasenäcker, Pauline Schröter & Sascha Schroeder*
- P09** Morphological encoding in German children's language production: Evidence from an ERP study. *Anna Jessen, Elisabeth Fleischhauer & Harald Clahsen*
- P10** Electrophysiological evidence for stem access in regular and irregular German participles. *Eva Smolka & Carsten Eulitz*

- P11** Consolidation changes the influence of type and token frequencies on the generalisation of inflectional affixes. *Lydia Viñals, Jelena Mirković, Gareth M. Gaskell & Matt H. Davis*
- P12** Neural signatures and cross-linguistic effects of morphological learning in L2. *Viktória Havas, Antoni Rodríguez Fornells & Matti Laine*
- P13** Incidental acquisition of grammatical gender in L1 and L2 German. *Denisa Bordag, Amit Kirschenbaum, Maria Rogahn, Andreas Opitz & Erwin Tschirner*
- P14** Processing morphological ambiguity: The case of Russian homographs. *Julia Edeleva, Anna Chrabaszcz & Kristina Bondarenko*
- P15** Processing of case-marking and inflectional cues in object-verb-subject sentences: Is there an SVO-bias? *Sandra Hanne, Frank Burchert & Shravan Vasishth*
- P16** The impact of morphological features on object relative clause comprehension in German. *Romy Lassotta, Anne Adelt, Frank Burchert, Nicole Stadie & Flavia Adani*
- P17** When morphology makes syntax easier: Number dissimilarities facilitate the comprehension of OVS sentences in German-speaking children. *Flavia Adani & Maja Stegenwallner-Schütz*
- P18** Semantic transparency affects free stems: The Orthography-Semantics Consistency. *Simona Amenta, Marco Marelli & Davide Crepaldi*
- P19** Form and meaning in early morphological processing: A masked priming study on Turkish. *Samet Deniz, Bilal Kırkıcı*
- P20** The morphological processing of derived words in L1 and L2 Turkish. *Pınar Gacan Ertuğrul & Bilal Kırkıcı*

- P21** Comparing second language learners' sensitivity to Arabic derivational and inflectional morphology at the lexical and sentence levels. *Suzanne M. Freynik, Polly O'Rourke & Kira Gor*
- P22** Decomposition and processing of highly complex forms: A case study of German nouns. *Swetlana Schuster*
- P23** The influence of morphophonological rules in production: Evidence from aphasia. *Stacey Rimikis & Adam Buchwald*
- P24** A brain network for integration of tone and suffix. *Mikael Roll, Pelle Söderström & Merle Horne*
- P25** Morphological processes and reading directions. *Koji Miwa & Ton Dijkstra*
- P26** More than a noun, less than a verb: Observing the noun-verb distinction from the noun-verb continuum perspective. *Francesca Postiglione, Chiara Finocchiaro, Maria De Martino & Nicola Molinaro*
- P27** Inflectional encoding during word production: Insights from word-picture interference paradigm with Italian verbs. *Maria De Martino & Alessandro Laudanna*

Abstracts

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Synonymy: The role of competition in the organization of morphology

Mark Aronoff

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Competition plays a central role in the organization of many types of natural systems, from biological evolution to brain development, as well as in social and economic systems. Work on competition in language has proceeded in isolation from basic findings in other fields. I will show that a fundamental principle of competition in evolutionary biology, Gause's Axiom, accounts for a range of linguistic phenomena involving synonymy and a variety of principles that linguists, psycholinguists, and developmental linguists have adduced to explain them. On a broader level, this result underscores the importance of understanding the interaction of multiple factors in the structure, processing, and development of language, not only those unique to humans or language, but also those that operate in any reasonably well-organized system.

Morphosyntactic production of coordination agreement in South Slavic: A comparative study

Jana Willer-Gold, Boban Arsenijević, Mia Batinić, Nermina Čordalija, Marijana Kresić, Nedžad Leko, Lanko Marušič, Tanja Miličev, Nataša Miličević, Ivana Mitić, Andrew Nevins, Anita Peti-Stantić, Branimir Stanković, Tina Šuligoj & Jelena Tušek

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We conducted a comparison of preverbal and postverbal subject-verb agreement in an elicited production study carried out with 60 speakers of different language varieties in South Slavic, spanning Bosnian, Croatian, Serbian, and Slovenian at six local universities. These languages have three genders, and we measured the response type and total reaction time for production for the nine possible combinations of two plural noun phrases. Elicited production experiments for the preverbal and postverbal versions were conducted separately, with 54 items and 54 fillers. A sample target item involved a model sentence, immediately followed by a replacement phrase, and participants had to produce the entire sentence that resulted from combining the new replacement subject noun phrase (a coordination, such as *the books and the magazines*), with the remaining predicate, making morphosyntactic adjustments where necessary (e.g. in agreement). Our analysis of the gender agreement reveals that preverbal versus postverbal positioning make a large difference in the availability with the linearly *furthest* conjunct: while highest agreement is possible preverbally (e.g. the FN and NF columns), lowest-conjunct agreement is essentially unattested postverbally. In terms of reaction times, we find longest latencies for the conditions where speakers have the most grammatical options to choose among, suggesting that all three strategies are in principle available, although constrained by syntactic (hierarchical) and morphological factors (default masculine and relative markedness). The

consequences of these results will be discussed with respect to three recent theoretical models of closest-conjunct agreement in South Slavic (Boskovic 2009, Puskar & Murphy 2014, Marusic, Nevins & Badecker 2015).

Does the ending matter? Influence of gender-to-ending consistency during agreement processing

Sendy Caffarra & Horacio Barber

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University of La Laguna, Spain
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Detecting and computing agreement relations is crucial for language comprehension, especially in languages where agreement dependencies are widely used, such as in morphologically rich languages (e.g., Romance languages). When different sentential constituents create agreement relations, they share the same morphosyntactic feature value. Among these features, grammatical gender can be defined as a lexical property, whose value needs to be defined for each noun. Although this feature is abstractly stored in the lexicon, it can entail consistent relations with the word form of nouns. Since these regular correspondences do not seem to be essential for gender retrieval, they have been thought to represent redundant information for gender processing. However, it is still unclear whether and when this distributional information is detected during lexical processing and, if so which would be its role in the agreement computation. Two ERP experiments were conducted in order to describe the time course of formal gender cues processing during word pairs and sentence reading. In the first experiment, Spanish article-noun word pairs were subsequently presented while participants had to perform a grammaticality judgment task. Noun endings could be reliable cue to gender (i.e., transparent) or not (i.e., opaque). ERP differences between these two types of nouns could be observed between 350 ms and 500 ms after the noun onset for both agreeing and disagreeing word pairs, with greater negativities for transparent nouns. Also, noun transparency could be detected earlier (i.e., 350- 500 ms) when nouns were presented to the right visual hemifield (which is thought to be related with left hemisphere computation), compared to the

left visual hemifield (i.e., 500-750 ms). In the second ERP experiment, the same word pairs were embedded in Spanish sentences. Participants had to read and perform a grammaticality judgment. Again, ERP differences were observed between transparent and opaque nouns, with long-lasting greater negativities for transparent nouns. Within a sentence context, noun transparency could be detected even earlier than at the word pair level (i.e., 200 ms after the target noun). Again, a similar transparency effect was observed for both agreement and disagreement condition. Agreement manipulation elicited a LAN-P600 pattern, which was similar for transparent and opaque nouns. These results suggest that distributional information conveyed by the noun ending can be detected at an early stage of processing (i.e., 350-500 ms with word pairs; 200-300 ms in a sentence context), and the left hemisphere is more skilled at quickly detecting formal gender cues. Although these formal cues can be useful in gender retrieval, there is no evidence whether they influence agreement computation.

Inflection in and out of context: Spatiotemporal dynamics of morphological processing in sentences

Alina Leminen

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Are the neural mechanisms underlying word- and phrase-level morphological processing overlapping or distinct? Is processing of inflected words different in sentence context than without one? The two experiments presented here investigate morphological processing with and without sentence context using the Finnish language. In the first experiment (combined EEG and MEG), participants read a) correct serially-presented sentences as well as sentences containing b) morphosyntactic violations (adjective-noun number agreement violations), c) morphological violations (incorrect stem allomorph and inflectional suffix combination), and d) combined violations. Signal space and neural source reconstruction results showed that morphosyntactic violations elicited a left anterior negativity effect, generated particularly in the left inferior frontal area. Morphological violations elicited a widespread negativity, resembling the N400. The neural sources of this negativity were localized most prominently to the right temporal cortical networks. Furthermore, all violations elicited late positivity (P600) effects, generated in the bilateral fronto-temporal cortices. Our findings suggest distinct subnetworks in the fronto-temporal cortices for word-level and phrase-level parsing at least during the earlier stages of parsing processes.

In the second experiment (simultaneously recorded eye-movements and high-resolution 128-channel EEG), participants read monomorphemic and inflected words either embedded in meaningful sentences or in sequences of unrelated words that did not form a meaningful phrase. The position of the target word was always the same within the word sequence in both conditions. The experiment contained only correctly inflected words. Event-related

fixation potential results revealed that, in line with several previous findings, inflected words elicited a larger centro-parietal N400-like negativity effect, at approximately 450 ms after the onset of the first fixation of the target. The negativity was present for both isolated inflected words and inflected words embedded in the meaningful sentence context. However, the negativity was more pronounced and widespread in the sentence context than in the isolated word condition. We also observed an additional component, which was present for inflections in sentences but not when they were isolated. The neural source analysis showed that the effect was generated in the left temporal cortices.

The results from these two experiments suggest that reading of correctly inflected words elicits a robust morphological processing cost, both when they are presented in isolation or in a meaningful context. According to our findings, reading of correct inflections most prominently activates left temporal areas. However, when a morphological rule is violated, neural activity spreads to the right hemisphere. As the absence of rule violation does not yield a left anterior negativity, our findings support the assumption that the LAN reflects difficulties with morphosyntactic structure building. Taken together, the N400 findings in both studies suggest that, at least in Finnish, the morphological processing cost stems primarily from the semantic-syntactic level of processing. Moreover, the morphological processing cost, previously observed mostly with isolated words, does not stem from a lack of sentence context.

From minimal dependencies to sentence context: Evidence for a common neural system involving different functional networks working hand by hand

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Language comprehension is incremental, involving the integration of formal and conceptual information from different words, together with the need to resolve conflicting cues when unexpected information occurs. However, despite the extensive amount of findings regarding how the brain deals with this information, two essential and still open questions are (1) whether the neural circuit(s) for coding syntactic and semantic information embedded in our linguistic code are the same or different, and (2) whether the possible interaction(s) between these two different types of information leaves a trace in the brain activity. A convenient tool to isolate these two different types of information is offered by the Spanish agreement system. Interestingly, taking advantage of the diversity of this system it is possible to tune down some of these factors (i.e. syntactic and lexico-semantic) and, as a consequence, boost others, allowing us to disentangle the different mechanisms sub-serving agreement comprehension. The current study seeks to investigate this phenomenon from a neuro-anatomical perspective.

Experimental manipulations concerning different agreement features and the constituents involved in an agreement relation, allowed us to characterize the neural network underlying agreement processing. This study comprised seven experiments: while experiments I, II and III explored nominal dependencies in local as well as non-local relations, experiments IV, V and VI explored subject-verb relations in a more complex sentence context. Different types of agreement relations and/or agreement features were manipulated in well- and ill-formed constructions to distinguish between purely syntactic mechanisms and those where

semantic and syntactic factors interact during language comprehension. The interaction between the different factors included in each experiment is always the critical comparison.

In general, our results evidence firstly a functional dissociation between well-formed and ill-formed constructions: while ill-formed constructions recruited a bilateral distributed fronto-parietal network associated to conflict monitoring operations, not language specific, well-formed constructions recruited a left lateralized fronto-temporo-parietal network that seems to be specifically related to different aspects of phrase and sentence processing. Secondly, there was an anterior to posterior functional gradient associated with the middle and superior temporal cortex that consistently appears across experiments. Specifically, while the posterior portion of the left MTG-STG seems to be related to the storage and retrieval of lexical and morpho-syntactic information, the anterior portion of this region was related to syntactic-combinatorial building mechanisms. Critically, in the most anterior part of the left temporal cortex, corresponding with the middle and superior temporal pole, form-to-meaning mapping processes seem to be represented. Thirdly, the response of the left temporal cortex appears to be controlled by the left inferior frontal regions (LIFG). Finally, left parietal regions such as the angular gyrus showed increased activation for those manipulations involving semantic factors (e.g., conceptual gender and Unagreement constructions), highlighting its crucial role in the processing of different types of semantic information (e.g., conceptual integration and semantic-discourse integration). Overall, these findings highlight the sensibility of the agreement system to syntactic and semantic factors embedded into an agreement relation, opening new windows to the study of agreement computation and language comprehension.

Form, meaning, and order: Why morphology and timing are important

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Knowledge about the relative timing of component processes in language comprehension and production is crucial for understanding how the brain orchestrates these component processes in order to achieve the fluency that is typical of expert users of a language. Morphological processing is no exception, and the talks in this symposium will demonstrate how information about relative timing, obtained using different techniques such as event-related brain potentials (ERPs) and magnetoencephalography (MEG), has helped develop our understanding of the role that morphological structure plays during language comprehension and language production. Investigating the timing of morphological processing provides a privileged window onto the contribution of *form* and *meaning* when processing linguistic information, which, when combined with *order* (provided by *time* in the auditory modality), form the holy trinity of psycholinguistics.

Form-then-meaning in recognizing morphologically-complex words

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Everybody agrees that the recognition of printed morphologically-complex words requires the analysis of orthography and the analysis of meaning. However, the literature has seen intense debate over the temporal characterisation of these processes, with one theory arguing that they arise sequentially (Rastle & Davis, 2008) and one arguing that there is substantial temporal overlap between them (e.g. Diependaele et al., 2009; Feldman et al., 2009; Grainger & Ziegler, 2011). In this talk, I review recent ERP evidence regarding the processing of derivational and inflectional forms that unequivocally supports the sequential view, and that identifies clear temporal windows in which these different processes arise. This evidence fits neatly with the large body of morphological priming data and with emerging findings using other neuroscientific techniques.

Lexical competition and morphological processing

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Many studies have shown a clear effect of the surface morphological structure of the prime in masked priming studies. To explain these effects, a form of automatic morpho-orthographic decomposition operating early in visual word recognition that is sensitive to the superficial morphological structure of strings, (i.e. the simultaneous presence of a root and an affix) has been proposed. However, the process by which roots and affixes are identified and extracted remains unspecified. I will present evidence consistent with a parsing model in which a derived word's full form is activated at the same time as its constituents. I will show that readers are able to morphologically decompose novel words, and this process does not depend upon the simultaneous presence of a stem and affix—a stem can be recognized in the absence of a legal affix, and an affix in the absence of a legal stem. Moreover, the effects elicited by the morphological constituents are modulated by the properties of the whole word. In particular the influence of lateral inhibition operating between the embedded stem and the whole-word along with the consequences of a successful or unsuccessful parse of the word form.

Semantic context effects in morphological processing: Late, lexical, and not top-down

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In a recent account of the real-time functional architecture of visual word recognition (Whiting, Shtyrov & Marslen-Wilson, 2014) we used magnetoencephalographic (MEG) results to argue for a two-phase neurocognitive process. Primarily feedforward orthographically-driven analyses, located in ventral occipito-temporal regions, segment the visual input into potentially meaningful linguistic substrings (words and morphemes) for projection, at around 300 ms post-stimulus onset, onto morphologically structured lexical representations in middle and anterior temporal lobe regions. This account was built, however, on responses to isolated single words, presented without constraining context. In new research we have tested this model, using combined electro- and magneto-encephalography (EMEG) and working primarily in source space, to examine the effects of the presence or absence of potential top-down contextual constraints. Participants saw morphologically complex (*farmer*), pseudo-complex (*corner*) and simple (*pebble*) English words preceded by a semantically related or unrelated word. Using source-level spatiotemporal analyses, we asked where and when these contextual constraints would modulate first-pass processing of the three different word types, and, in particular, if these effects would be seen in the earliest phase of visual word recognition (up to 250 ms post-onset) and whether they would be located in posterior occipito-temporal sites. Significant semantic priming was seen from 250-500 ms in left posterior middle and superior temporal and anterior inferior temporal regions, showing decreased activity when targets were preceded by a semantically-related word. These late effects, in brain regions associated with access to lexical

representations, showed spatially distinct patterns for complex and pseudo-complex targets. These results are consistent with an account positing early bottom-up segmentation of word structure, not under top-down control, with contextual constraints only modulating later access to word meaning.

Morphological processing in language production

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This talk will be about how we plan and produce speech. More specifically, how do we put together words and sentences and what are the linguistic units that need to be activated and retrieved from long-term memory? Words can consist of smaller meaningful elements called “morphemes”, e.g. the Dutch compound *vaatwasser* (‘dishwasher’) consisting of *vaat* (‘dirty dishes’) and *wasser* (derived from *wassen* ‘to wash, to clean’). How do we represent words like *vaatwasser* in our memory – as one holistic entity or do we also store the morphemes *vaat* and *wasser* separately? The present study investigated morphological priming in Dutch as well as its time course and neural correlates in overt speech production using a long-lag priming paradigm. Prime words were compounds (e.g. the word *jaszak*, ‘coat pocket’) that were morphologically related to a picture name (e.g. *jas* ‘coat’) or form-related monomorphemic words (e.g. *jasmijn*, ‘jasmine’ for *jas*). The morphologically related prime compounds could be semantically transparent (e.g. *eksternest*, ‘magpie nest’) or opaque (e.g. *eksteroog*, lit. ‘magpie eye’, but meaning ‘corn’ on a toe, for a picture of a magpie, Dutch *ekster*). Behavioral (reaction time) and event-related potential (ERP) data were collected in separate sessions. The production of morphologically related and complex words facilitated subsequent picture naming and elicited a reduced N400 compared with unrelated prime words. The effects did not differ for transparent and opaque relations. Mere form overlap between a prime word and a target picture name did not affect picture naming. These results suggest that morphological priming in language production cannot be reduced to semantic and/or phonological processing. Recently, we replicated these results with Dutch (L1) - English (L2) bilinguals in two studies. In the first study,

we demonstrated that the morphological priming survived a switch from the L1 to an L2. That is, when bilingual participants named a Dutch compound word such as *landtong* ('finger of land'), naming English words and pictures in between before naming the target picture *tong* ('tongue') did not diminish the priming effect. This is difficult to explain for models of bilingual lexical access that assume sustained reactive inhibition following language switches. In the second study, different participants from the same pool of bilinguals named compound words and pictures in the L2. We obtained similar priming effects as before when participants named in their L1, both in pure L2 blocks and in switching blocks. I will discuss these results in the context of current models of mono- and bilingual word production.

How do native and non-native morphological processing differ?

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Nonnative speakers are able to process inflected words in the auditory and visual input. Given that their mental lexicons are smaller than in native speakers (i.e., they store fewer items) and that there is evidence that they show facilitation in overt priming and processing costs in lexical decision tasks for inflected words, they are hypothesized to decompose inflected words in lexical access. However, they are less efficient at lexical access of inflected words with complex stem allomorphy, at fast decomposition, as in masked priming, and are less sensitive to morphosyntactic violations in sentence processing. Therefore, nonnative and native morphological processing show both similarities and differences.

The findings obtained in two auditory lexical decision and two priming experiments targeting inflected Russian nouns discussed in the presentation have identified several nonnative features in morphological processing. (1) Nonnative morphological decomposition depends on affix stripping to access lexical meanings through stems, but may ignore the recomposition and checking stage under specific conditions at lower proficiency levels (affix stripping without recomposition). (2) Sensitivity to case probabilities in noun phrases (NPs) gradually emerges as proficiency increases. (3) In gender and number agreement in NPs, nonnative speakers show facilitation for congruent prime/target mappings, but no inhibition for incongruent pairs observed in native speakers (facilitation without inhibition).

The following evidence is cited in support of these conclusions:

Two auditory lexical decision tasks used a Latin-square design and compared the processing costs for overtly and zero-inflected nouns in the Nominative (citation) and Genitive (oblique) case. Low-proficiency, but not high-proficiency or native speakers of Russian

failed to show decomposition costs for zero inflections in the oblique case. When nonwords with real stems and inflections in illegal combinations were added to the ones with nonexistent stems, nonnative processing costs appeared for zero-inflected real nouns. Thus when nonnative speakers needed to focus on recomposition to decide whether the inflected word was real, they processed the inflection, either overt or zero. This suggests that lower-proficiency speakers rely on affix stripping as a default strategy to access lexical entries through the stem and may discard inflectional information by skipping the rechecking stage. In cross-modal priming with ambiguous case-inflected adjective primes and noun targets, native speakers responded faster to high-type-frequency Genitive-inflected nouns, while this response bias emerged only in the high-proficiency nonnative group. In a visual priming experiment with adjective primes and noun targets forming phrases with congruent and incongruent gender and number agreement, native speakers showed a pattern of facilitation for the congruent trials and inhibition for incongruent trials. It corresponded to the expectations based on the defaultness of the masculine gender and the singular number. Nonnative speakers showed facilitation for the congruent trials in the absence of inhibition for the incongruent ones.

These effects suggest that nonnative morphological processing relies on fuzzy representations and rules. Correct mappings between the stem and the affix are weakly expected, but incorrect ones are not rejected. This claim connects nonnative morphological processing with reduced morphosyntactic sensitivity in sentence processing.

Neural correlates of morphological processing in older late bilinguals

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The populations of Western societies are becoming both increasingly older and more multilingual. While vocabulary and lexical skills of older bilinguals have attracted extensive research, little is known how the neural correlates of morphological processing in older bilinguals differ from native speakers and whether or not any differences are related to general cognitive abilities.

We used a grammaticality judgment task in which participants were presented with correct regular and overregularized *-t* participle forms (e.g. *getanz-t*, **gelauf-t* 'dance-d', **run-ed*) as well as with correct irregular and overapplied (*-n*) forms (e.g. *gelauf-en*, **getanz-en*) in a 2 x 2 experimental design. Twenty older late bilinguals (15 English- and 5 Russian-speaking natives, 12 women, mean age 62.90 years) performed this task while neural correlates were recorded using functional magnetic resonance imaging (fMRI). Bilinguals were compared with 20 native German speakers. Groups did not differ with regard to gender ($p = .311$), age ($p = .221$), and German proficiency ($p = .099$).

With regard to response times (RTs), there were no main effects or interactions with Group, but instead a Regularity x Correctness interaction ($p = .005$) plus main effects of Regularity ($p = .035$) and Correctness ($p < .001$). While RTs were overall slower for incorrect than for correct forms, RTs for overregularized *-t* forms were significantly slower than for any other condition.

With respect to error rates, there was a Group x Correctness interaction ($p < .026$) and main effects of Correctness ($p < .001$) and Group ($p < .001$). These results indicate that while both groups made more errors in rejecting incorrectly inflected word forms than in accepting correct ones, bilinguals produced more judgment errors than native German speakers, especially when incorrect forms had to be rejected.

Finally, and most importantly, the fMRI data for the bilinguals (compared to the monolingual controls) revealed increased activity in the bilateral medial superior frontal gyrus (SFG; MNI coordinate of peak activation: -6/38/46; $p < 0.05$, FWE corrected) during the processing of incorrectly inflected participles compared to correct ones. This contrast was particularly pronounced for overregularized *-t* forms, for which bilinguals showed significantly more activation in bilateral SFG than German native speakers.

The most interesting contrasts, both behaviorally and in the imaging data, come from overregularizations such as **gelauft*. We argue that due to the segmentation of the *-t* affix plus the activation of the corresponding correct irregular form (*gelaufen*) overregularizations engage both combinatorial processing and lexical retrieval (e.g. Penke et al., 1997). In this domain, we also found differences between bilinguals and German native speakers. We speculate that increased activity in medial SFG for *-t* overregularizations may indicate compensatory recruitment of executive control in bilinguals compared to native German speakers, a hypothesis to be explored further in “virtual lesion” studies using theta-burst transcranial magnetic stimulation (e.g., Hartwigsen et al., 2013).

Penke, M., Weyerts, H., Gross, M., Zander, E., Münte, T. F., & Clahsen, H. (1997). How the brain processes complex words: An event-related potential study of German verb inflections. *Cognitive Brain Research*, 6(1), 37–52.

Hartwigsen, G., Saur, D., Price, C. J., Ulmer, S., Baumgaertner, A., & Siebner, H. R. (2013). Perturbation of the left inferior frontal gyrus triggers adaptive plasticity in the right homologous area during speech production. *Proceedings of the National Academy of Sciences of the United States of America*, 110(41), 16402–7.

Is all morphology created equal? The processing of derived vs. inflected words in L2 German

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The question to what extent morphological processing in non-native (L2) speakers differs from native (L1) processing has led to a controversial debate in psycholinguistic research. In particular, some masked-priming studies (e.g. Silva & Clahsen, 2008; Neubauer & Clahsen, 2009) suggest that L2 processing relies less on morphological decomposition of complex words, and is instead based more on whole-word-form storage and retrieval. Other studies, however, have found no differences between L1 and L2 speakers (e.g. Feldman et al., 2010; Diependale et al., 2011), suggesting that L2 speakers can, at least in principle, acquire native-like processing mechanisms for complex words. In a recent study by Kırkıcı & Clahsen (2013), which comprised experiments on both inflected and derived Turkish words, differences between L1 and L2 processing only emerged for inflected, but not for derived forms, suggesting that such differences might be specific to particular types of complex words. The present study explores this possibility further by directly comparing the processing of derived and inflected stimuli within a single experiment.

In a masked-priming study (SOA: 50 ms), 36 highly proficient native Russian speakers of L2 German and a control group of 40 native German speakers performed lexical decisions on German infinitive targets after being primed with either an inflected prime (the past participle of the same verb, e.g. *'geöffnet-ÖFFNEN'*), a derived prime (the nominalization of the same verb, e.g. *'Öffnung-ÖFFNEN'*) an identity control prime (e.g. *'öffnen-ÖFFNEN'*), or a matched unrelated control prime (e.g. *'streng-ÖFFNEN'*). Mixed-linear models on the lexical decision times revealed a significant

interaction between prime-type and subject group, with native speakers of German showing significant priming effects for both derived and inflected forms, and L2 speakers showing significant priming only for derived, but not for inflected items. Control conditions with semantically and orthographically related stimuli showed that, for both subject groups, these priming effects cannot be explained through the semantic or orthographic similarities between primes and targets.

The lack of a priming effect for inflected forms in L2 speakers is consistent with the idea that L2 processing relies more on storage and retrieval of whole-word-form entries, and less on decomposition. The fact that L1/L2 differences are restricted to inflection can be explained through linguistic properties of derived vs. inflected words: Unlike inflection, derivation creates new lexemes (Anderson, 1992). If the lexical entries for a derived form and its corresponding base form partially overlap in the mental lexicon (as suggested by Crepaldi et al., 2010, for irregular forms), this constitutes an alternative source for priming effects.

Inflectional processing in native and nonnative speakers of English

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We use patterns of facilitation from the forward masked lexical decision task with native and nonnative speakers of English to compare processing of morphologically complex word forms. According to a decompositional account, morphological processing should be based on decomposition of the prime into stem and affix followed by reactivation of the stem when the target appears. Therefore, as only regulars can be decomposed, properties of the stem can predict facilitation following regular but not irregular forms. In Experiment 1, we compare patterns of facilitation for verb targets with regular and irregular past tense primes. Specifically, to test predictions of a decomposition account, we ask whether target decision latencies are faster after regularly (TOSSED) than after irregularly (THREW) inflected past tense primes. Also, we test whether target latencies are comparable after progressive primes (TOSSING, THROWING) whose past tense forms are irregular. Finally, we ask whether reading skill influences early recognition processing as indexed by patterns of morphological facilitation. In Experiment 2, we vary target as well as prime complexity and compare facilitation to inflected targets (e.g., TOSS, TOSSED, TOSSING; THROW, THREW, THROWING) with the same primes.

We used principle component analysis to reduce multicollinearity between predictors related to orthographic form and frequency with General Additive Modeling (GAM). The model for native speakers revealed significant effects of control predictors: targets with fewer letters and with higher frequency tended to be recognized faster. Furthermore, there were faster decision latencies for identical (e.g., TOSS–TOSS; THROW–THROW), than for inflected

pairs in ED or ING (TOSSING–TOSS; THROWING–THROW; TOSSED–TOSS; THREW–THROW) and they, in turn, were faster than for unrelated pairs (CHAINING–TOSS; SWIPING–THROW). In addition, facilitation for primes in ED vs. ING for TOSS and THROW type targets did not differ (i.e., facilitation was comparable for TOSSING–TOSS; THROWING–THROW; TOSSED–TOSS; THREW–THROW type pairs). Importantly throughout, effects of target regularity failed to arise and failed to interact with frequency or prime type, meaning that overall decision latencies and patterns of facilitation did not differ for verbs with regularly and irregularly inflected past tense forms. Finally, effects of reading skill were present but interacted with patterns of morphological processing only when task complexity was increased by varying target affix (Exp. 2).

Results for native speakers fail to support predictions from decompositional accounts. They suggest instead that similarity of prime and target, as revealed by patterns of facilitation, draws on mappings between the letter sequence that constitutes the stem and the many words with which the target is similar in form and meaning. Further, similar meaning can partially offset decreased similarity of shared form as arises when facilitation is comparable for THREW–THROW and THROWING–THROW type pairs. At the same time, similar meaning cannot fully offset decreased similarity of form, due to the presence of an affix, because facilitation is less for THROWING–THROW than for THROW–THROW type pairs.

Analyses of data from 74 SerbianL1–EnglishL2 speakers are underway.

Discussion will compare native and nonnative inflectional processing.

Discussion: Future directions in multilingual morphological processing

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The question of whether the representation and processing of a second language (L2) relies on similar mechanisms to those employed in a native language (L1) has been the subject of considerable debate within psycholinguistics. Generally speaking, there is evidence that L1-L2 differences are greater in the domain of complex grammatical operations (rather than in lexical representation; Clahsen & Felser, 2006), but finer characterizations of what is native-like in L2 processing have remained elusive. The investigation of morphologically complex words has the potential to play an important role in this debate, because morphology stands at the intersection between lexicon and grammar – a privileged place in the architecture of the language faculty.

Despite its significance, little is known about multilingual morphological processing. Theoretical accounts are fragmentary or tailored to specific results, and the outcomes of different studies are often inconsistent (cf. Silva & Clahsen, 2008; Voga et al., 2014). In this discussion, we identify potential reasons for this state of affairs: a) L2 speakers are often analysed as a single group, with little consideration of subject-level differences; b) morphology is sometimes treated as a homogeneous domain, while linguistic distinctions take a secondary role; c) potential moderator variables fail to be controlled for and their contribution is not systematically analysed; d) the effects of such variables are assumed to be linear, rather than showing discontinuities; and e) there is an emphasis on the empirical facts and on building narrow models, rather than on comprehensive theoretical understanding.

The aim of this symposium was to bring together the most recent research in this field, which shows that the above limitations are being overcome. The four presentations reported research on a variety of languages and methodologies, and investigated the role of several different subject-level and linguistic variables: proficiency, chronological age, affixation, regularity, and inflectional/derivational status. We will add to this by presenting results from two projects that attempt to do justice to the empirical and theoretical complexities of the field.

The first (Veríssimo, Heyer, Jacob, & Clahsen, submitted) is a masked priming study comparing inflectional and derivational priming on a large sample of Turkish/German bilinguals, who acquired German at different ages (0–38 years). The results show facilitation from both inflected and derived forms for simultaneous bilinguals, but a selective effect of age of acquisition on inflectional (but not derivational) priming. Non-linear methods allowed identifying a bounded age band for which inflectional priming is native-like (0–6 years), after which there is a sharp decrease in facilitation. We interpret the results as indicating the existence of a critical period for the acquisition of inflectional rules.

The second project (Veríssimo, Heyer, & Patterson, in preparation) is a meta-analysis of L2 morphological priming studies. Its goal is to precisely estimate average priming effects, assess the amount of heterogeneity across studies, and systematically investigate the role of different moderator variables. The preliminary results indicate that the most important moderator of masked priming effects in L2 is the inflectional or derivational status of the prime, with derived forms producing a larger and more robust facilitation effect. Nevertheless, there is also a (small) facilitation effect for inflected primes, which appears to be modulated by variables like prime duration.

The amount and quality of recent research in multilingual morphological processing allows for optimism. We believe that a more consistent empirical picture is beginning to emerge, that the domains in which native and non-native processing differ are being identified, and that theoretical accounts are slowly moving in the direction of greater explanatory adequacy.

The suffix priming effect without stems: New evidence for automatic morphological decomposition

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In this communication we present the results of a masked lexical decision experiment in which we explore the morphological segmentation of Spanish suffixed or pseudosuffixed words through the suffix priming effect. Instead of priming the bases or pseudobases with their suffixed or pseudosuffixed forms, as is usual in the experiments that seeks to understand the processes underlying morphological segmentation in visual word recognition with masked priming lexical decision (e.g. *darkness* - *DARK*; *corner* - *CORN*), we compare the effect of suffix priming on the lexical decision of suffixed (*ero* - *JORNALERO*) and pseudosuffixed words (*ero* - *CORDERO*), as well as the effect of the orthographic priming on non-suffixed words (*eba* - *PRUEBA*). The results show that in the case of suffixed and pseudosuffixed words, related primes (*ero* - *JORNALERO*; *ero* - *CORDERO*) significantly accelerated response latencies in comparison to unrelated primes (*ista* - *JORNALERO*; *ura* - *CORDERO*), while for simple words there was no facilitation from the orthographically related prime in comparison to the unrelated prime (*eba* - *PRUEBA*; *afo* - *PRUEBA*). These results are consistent with the existence of the so called morpho-orthographic segmentation process in the course of visual word recognition that might be independent at the same time from purely orthographic factors as well as from purely semantic factors. Our results also support the view that the morphological segmentation takes place irrespective of whether a stem is present in a word and therefore complement previous studies dealing with *CORNER*- and *BROTHEL*-like stimuli.

Semantics does play a role at early morphological processing stages

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The time course of access to semantics has been the subject of considerable debate in the morphological processing literature. According to dominant ‘form-then-meaning’ accounts, all potential morphemes contained in a word are initially activated, with activation being automatic and independent of whole-word semantics (Davis & Rastle 2010, Lavric et al. 2012). This assumption, however, has recently been challenged by studies reporting distinctive effects of semantics at early processing stages (Feldman et al. 2012, Morris et al. 2013).

After pointing out some conceptual and methodological issues with research in the ‘form-then-meaning’ framework, this talk will present the results of an event-related fMRI study comparing masked visual priming (SOA: 60 ms) for morphologically complex (*greedy* – *GREED*, *teacher* – *TEACH*) and pseudo-complex (*irony* – *IRON*, *mister* – *MIST*) pairs.

It will be shown that a tight match between both stimulus groups on a number of dimensions that have been neglected in the past results in a significant advantage for transparent over pseudo-complex pairs in terms of reaction times and accuracy. The fMRI results show more BOLD activity for morphologically complex than pseudo-complex pairs in areas related to early visual processing (bilateral primary visual cortex encroaching upon ventral extrastriate regions, including posterior fusiform gyri) and semantic processing (bilateral superior and middle temporal gyri, bilateral angular gyri, left parahippocampal gyrus), with no effects in the opposite direction.

These results highlight the influence of semantic top-down effects on brain areas traditionally assumed to be purely stimulus-

driven (Szwed et al. 2012), and suggest that both stimulus groups are assigned to different routes from the very first processing stages. The talk will conclude by sketching a possible cognitive explanation for the results.

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Investigating morphological effects in *sentence reading*: Early morpho-orthographic and early morpho-semantic effects

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How semantics inform morphological analysis at the early stages of visual word identification has been traditionally studied through *masked priming*, yielding results that are not completely uncontroversial. The majority of the studies suggest that semantics is not a factor during early morphological analysis, but there are also data showing that semantics do affect how we process morphemes early after a complex word has been seen (e.g., Davis & Rastle, 2010).

In a move towards more ecological testing conditions, in the present study we addressed this issue in *natural sentence reading*. In particular, we exploited a feature of several derived Italian words, that is, that they can be read in a “morphologically transparent” way (as genuine derivations) or in a “morphologically opaque” way (as pseudo-derivations) *according to the sentence context* where they belong. For example, the word *copertina*, which is made up of the stem *copert-*, blanket, and the productive diminutive suffix *-ina*, can either refer to a small blanket, thus being a fully transparent derived word, or to a book/CD cover, which has nothing to do with blankets.

Thirty-one of these words were embedded in sentence contexts that elicited either their transparent or opaque interpretation. By means of *eye-tracking*, we analyzed whether the effect of the stem frequency changes according to whether the (*very same*) word is read as a genuine derivation vs. as a pseudo-derived word, under the assumption that stem feature effects track morphological segmentation/analysis. Crucially, we focused on first fixations so as to make sure that we were looking at early stages of processing.

A mixed-model analysis revealed a *stem frequency effect* in both opaque and transparent contexts, thus showing that stems were accessed independently of whether they contributed to word meaning, that is, word decomposition is indeed blind to semantics. However, while the stem frequency effect was *facilitatory* in the transparent context, it was *inhibitory* in the opaque context, thus showing an early involvement of semantic representations. In other words, in the transparent context the word "copertina" is segmented into "copert+ina" and "copert-" act as a proper stem, thus facilitating the processing of the whole word. In contrast, in the opaque context, the word "copertina" is still segmented, but the pseudo-stem "copert-", not contributing to the whole-word meaning, actually hinders the processing of the derived form.

In conclusion, our data provide new and strong evidence that derived words are indeed segmented into their constituent morphemes when visually encountered, *also in natural reading*. However, this blind-to-semantics process activates morpheme representations that are *semantically connoted*, and their meanings can affect *early* stages of visual word recognition.

Davis M.H. & Rastle K. (2010). Form and meaning in early morphological processing: Comment on Feldman, O'Connor and Moscoso del Prado Martin (2009). *Psychonomic Bulletin & Review*, 17(5), 749-755.

Neurocognitive substrates of derivational morphology: Evidence from Italian

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Spoken language comprehension involves a bihemispheric fronto-temporal network supporting perceptual/semantic interpretation of whole-word forms and a left-lateralised fronto-temporal subsystem, specialised for decomposing combinatorial grammatical sequences (Marslen-Wilson & Tyler, 2007; Bozic et al., 2010). Previous cross-linguistic work from English and Polish showed that morphological derivation engages the bilateral fronto-temporal network, but does not selectively involve the LIFG (Bozic 2013), suggesting that derived words are stored as whole-word forms rather than analysed decompositionally. However, transparent productive words (*brave-ly*) pattern with simple words (*brave*), whilst the bilateral competition effects appear to be predominantly driven by opacity. These results suggest that the word internal structure might be relevant for processing transparent productive words, leading to the question whether distinct bihemispheric patterns are associated with different types of morphological complexity along transparency/opacity, productivity and 'storedness' dimensions.

Here, we addressed this question by investigating the morphological system of Italian, an inflectional fusional/synthetic Romance language, with a root-based morphology similar to Polish (as opposed to English whole-word stems), conveying different types of semantic and morpho-syntactic information (*gelat*[stem]-*eri*[derivational suffix]-*a*[number, gender]: ice-cream shop). These morphological properties were expected to generate rich combinatorial derivational mechanisms under some complexity conditions, raising the question whether these would elicit selective LIFG activation.

We manipulated combinatorial/compositional complexity across 5 conditions: (1) transparent productive (*gelat-eria*, ice-cream shop); (2) transparent non-productive (*pin-eta*, pine forest); (3) opaque productive (*tomb-ino*, manhole); (4) opaque non-productive (*camp-itura*, hatch); (5) simple words (*albero*, tree). 20 right-handed native Italian speakers listened to 400 words interspersed with 200 acoustic envelope-shaped length-matched baseline and 200 nullevents (pseudo-randomised across 4 runs of 12 minutes each in an fMRI fast sparse EPI protocol, TR = 3.4s), with an occasional (5% of trials) 1-back semantic judgement task. Data were analysed with SPM8, Representational Similarity Analysis (RSA) toolbox and SnPM.

Univariate contrasts showed a stronger involvement of the bihemispheric system in the processing of semantically opaque forms, especially when formed with non-productive suffixes, but no selective LIFG activation to transparent words. Results from parametric modulator analyses specified how this bilateral activity was modulated as a function of key analytical variables: increased lexical competition (between the whole form and the onset-embedded stem or pseudo-stem) elicited stronger bilateral temporal activations, as did weaker semantic relatedness between whole form and stem. Suffix productivity triggered a marginally significant bilateral activation of the IFG. These effects were seen only in non-compositional opaque words and were absent in transparent forms.

To further explore information encoding within the fronto-temporal systems, continuous voxel-by-voxel maps of neural activity were computed for each condition and participant. Using searchlight RSA, these maps were correlated to theoretical models coding for the effects of the relevant variables. Lexical competition and semantic relatedness correlated significantly with the bihemispheric system, whilst suffix productivity in transparent words selectively activated the LIFG.

These findings suggest that the neurocognitive properties of Italian derived words reflect underlying whole-word stored representations, but also a degree of decompositional processing specific to transparent forms, with preserved marking of word internal structure in the language system.

The role of the nominal-pattern morpheme in lexical access in Hebrew: Evidence from written-word perception and single-word production

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Words in Hebrew are composed of two non-concatenated units: (1) a consonantal *root* embedded within (2) a *nominal or a verbal-pattern* morpho-phonological unit composed of vowels or vowels + consonants. Research in Hebrew has revealed robust effects of the roots in both written word-perception and word production. Furthermore, investigation of the influence of word-patterns in perception revealed a robust effect for the verbal patterns, *but not* for the nominal patterns. This difference has been explained by the different distributional properties of the nominal versus the verbal-patterns. Although a statistical explanation is plausible, the observed null effect for nominal-patterns in perception creates theoretical difficulties for describing the extraction of the root morpheme in written-word perception. The hypothesis that there is a mediating role of nominal patterns in lexical access is also motivated by the root effect demonstrated in production. This is because locating the root consonants alone is not very significant for production, as the root is dispersed among the syllabic units. Furthermore, the influence of the nominal-pattern on production has been demonstrated before, but it has surprisingly been found to be conditioned by the semantic relatedness between words derived from the same nominal-pattern.

Experiment 1 explored the hypothesis that the absence of a nominal-pattern effect in studies *in perception* is a quantitative rather than a qualitative issue. That is, the potential facilitative effect induced by a shared nominal pattern was probably annulled in previous studies by an interference effect induced by the competition between the roots of two words derived from different

roots but the same nominal pattern. To pursue this hypothesis, we used the fast-priming paradigm, in which target words are embedded in sentences in places that are initially occupied by a random letter string, so that no parafoveal information is available. During the saccade in which the eyes move into the target space, the random string is changed into the prime, which consists of the nominal-pattern letters, whereas the root letters are replaced by dashes. After an SOA of 33 ms the prime is changed into the target. This procedure allowed us to isolate the initial influence of nominal-patterns on lexical access. The results, obtained by measuring eye-fixation latency, demonstrated a significant facilitatory effect induced by nominal-pattern primes relative to orthographic control primes.

Experiment 2 explored the effect of nominal patterns on *word production*, using the picture-word-interference paradigm with auditorily presented distractors, at 4 different SOAs (ranging from -200 ms to 300 ms). Compared to an unrelated distractor, the results revealed a facilitatory nominal-pattern effect in the time window of -200 ms to 300 ms. This effect was distinguished from a phonological effect (based on its time course), and was not conditioned by semantic similarity between words sharing a nominal pattern.

The results are discussed in relation to the role of the word-pattern as an organizing principle of the Hebrew lexicon, together with the root morphemes.

Morpheme interference in Hebrew

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An extensive body of research suggests that word reading involves automatic extraction of the base morpheme (for review see Amenta & Crepaldi, 2012). For example, in priming studies, morphologically complex words facilitate response to their base morpheme. Morphological decomposition is further supported by the Morpheme Interference Effect: Responses to pseudowords composed of real morphemes are slower and less accurate than to pseudowords composed of non-morphemes. The MIE was first demonstrated in English (Taft and Forster 1975), and has since been replicated in English and Italian (Caramazza et al. 1988; Crepaldi et al. 2010), languages with linear morphologies in which morphemes are attached to one another in a serial manner. In Hebrew, in contrast, the root morpheme is embedded within a word pattern in an interleaved manner. While certain morphological effects (e.g., morphological priming) generalize to Hebrew, some of the hallmarks of orthographic processing in European languages (e.g. orthographic priming, letter position flexibility) do not apply to nonlinear morphologies (Frost 2012). The aim of the current study was to examine whether the Morpheme Interference Effect applies to Hebrew visual word recognition, and whether it generalizes across the nominal and verbal systems. 51 undergraduate students performed a lexical decision task on visually presented Hebrew stimuli. We manipulated the internal structure of the pseudowords: all pseudowords encompassed real Hebrew word patterns, but half of them were derived from a real root and the other half from an invented root (for example, maDLeGa contains the real root D.L.G. in an existing pattern, while maLTeKa contains an invented root, L.T.K., within the same pattern). This manipulation was carried out

in the verbal and nominal systems, separately. The experimental conditions were carefully matched for orthographic neighborhood size and length. Pseudowords were presented mixed with real Hebrew words in a pseudorandom order. The results showed robust morpheme interference effects in both the verbal and nominal domains. Specifically, Hebrew pseudowords consisting of real roots induced significantly lower accuracy and significantly longer RTs compared to pseudowords consisting of invented roots. These findings generalize the morpheme interference effect across the major lexical categories in Hebrew. Further, a correlation analysis revealed that participants' verbal and nominal MIEs were highly correlated with each other, suggesting that MIE captures a general sensitivity to morphological structure. Importantly, individual MIEs were found to correlate positively with their overall accuracy in response to real words. This finding suggests that morphological decomposition is an efficient strategy in Hebrew visual word recognition.

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Role of root morphology in Hebrew auditory lexical access

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This study builds on previous findings that the morphological structure in Hebrew interacts with visual lexical retrieval in reading tasks by extending the scope to the auditory modality. Specifically, it investigates whether lexical retrieval is inhibited more by obscuring root information than non-root information in the acoustic signal.

In languages with mostly concatenative morphologies (e.g. Indo-European), words are typically composed of lexical stems and affixes that derive various word forms (e.g. car+s plural cars). In these languages, written letter position is flexible in lexical access and transposed letters (TL) words still act as primes (e.g. Forster 1987 [English], Duñabeitia et al 2007 [Spanish, Basque]). In direct contrast to such languages, the transposition of two root letters inhibits reading in templatic Semitic languages Hebrew and Arabic (Velan & Frost [V&F] 2011, 2009, 2007; Perea et al. 2010). In Semitic languages most words are root, not stem-based, with roots typically consisting of fixed order triple consonants that fit into a pattern (e.g. the Hebrew root K.T.V. whose meaning is associated with writing can be combined with a verb pattern H-T-R1-R2-R3, yielding the word HTKTV¹, pronounced ‘hitkatev’, meaning ‘correspond’). This morphology is argued to play a role in the non-flexibility of letter position in Semitic languages (Frost 2012). Transposing letters in opaque non-templatic (English-like) borrowings into the language (V&F 2009) or transposing non-root consonants (Oganyan et al 2014) in a root word did not inhibit priming, suggesting that it is the roots that are stored in the mental lexicon and that these must be parsed out for lexical access (V&F 2009). Given the importance of root information to reading in Hebrew, this study investigates root information in auditory lexical access.

¹ In Hebrew and Arabic, most vowels are omitted from the orthography and are excluded here to represent this orthography.

Subjects (24 native Hebrew speakers 20-59 years) performed a phonemic restoration task. Subjects were presented with templatic and non-templatic words (borrowings), with a consonant and part of a bordering vowel masked with brown noise. Words were controlled for frequency and for the environment around the deleted consonants between the two word types. Filler unmasked words (templatic and non-templatic) were also presented.

Subjects identified control words correctly with an average accuracy across subject of 99.3%. The log-likelihood of words being identified correctly is .4323 ($p < .01$) for templatic words and .4506 greater than that ($p < .02$) for non-templatic words. Non-templatic words are 1.6 times more likely to be recovered than templatic ones.

Masking of root information was more inhibitory to auditory lexical access just as transposing root letters is more inhibitory in reading. This finding is in line with an account of morphological parsing of un-affixed words in Semitic languages and of opaque words being treated differently. This provides further evidence for the importance of root information for Hebrew lexical access. Furthermore, this suggests that the parsing and role of the root are integral parts of general lexical access, rather than reading strategies alone.

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Abstract representation of the root morpheme: A magnetoencephalography study of spoken Arabic

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A fundamental aspect of language comprehension is the mapping of physical stimuli onto entries within a mental dictionary, which is achieved with notable speed and accuracy. Crucial to understanding this feat is gaining insight into whether morphologically complex words are represented in their whole form (e.g., *disappears*), or through sub-lexical structural units, such as morphemes (e.g., *dis*, *appear*, *s*). Although the significance of morphological structure is established in visual word processing, its role in auditory processing remains unclear. In languages with non-concatenative morphologies such as Arabic, consonants of the root morpheme (e.g., {ktb}) are positioned within a skeletal pattern (e.g., *CaCaC*; *katab* 'write'), resulting in no clear separation between morphemes during the unfolding speech stream. The aim of the current study is to investigate the role of the root morpheme for spoken word recognition. We recorded 24 native Arabic speaker's neurophysiological responses to 280 spoken words and 280 spoken nonce words using magnetoencephalography (MEG). The experiment was designed to probe the significance of the root morpheme for spoken Arabic words with two experimental manipulations. First, the valid word materials were designed to compare a model of auditory processing that calculates probable lexical outcomes based on word-whole competitors $P(B|KATA)$, versus a model that only considers the root as relevant to lexical identification $P(B|KT)$. We correlated neural activity in the superior temporal gyrus (STG) and transverse temporal gyrus (TTG) - two regions associated with phoneme prediction - with the orthogonalised whole-word and root-specific measures of lexical outcome. Second, the non-word items allowed for an assessment of

violations to the root-specific Obligatory Contour Principle (OCP), which disallows consonant gemination in first and second position within the root morpheme [*kkb]. Our results show the root-sensitive model of lexical prediction to significantly correlate with neural activity in the STG and TTG, independent of predictions based on whole word competitors. There was also a marginal effect of whole word prediction in the STG, in the same time-course as the root-specific effect. Furthermore, words that violated the OCP constraint were significantly easier to dismiss as valid words than probability-matched counterparts, supporting an abstract representation of the root morphemes in order for the constraint to manifest. Together our findings suggest that lexical auditory processing is dependent upon morphological structure, and that the root forms a principal unit through which spoken words are recognised.

Compound priming in German: Disentangling morphological from semantic effects in visual and auditory word recognition

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Priming studies on the processing of morphologically complex words in Indo-European languages suggest that semantic transparency has an impact when the prime stimuli can be processed consciously: Priming is usually observed for semantically transparent words, but not for opaque words.

Our study examines effects of semantic transparency and morphological compositionality in German, using noun-noun compounds as primes (Gürtelschnalle [belt buckle]) and their first constituents as targets (GÜRTEL [belt]) in a visual lexical decision task. Semantic transparency was varied by using compound pairs for each target. The compounds of each pair overlapped in their first constituents but differed in semantic transparency (Gürtelschnalle [belt buckle] vs. Gürtelrose [“belt rose” = herpes zoster]). In addition, pseudo-complex, monomorphemic prime stimuli were used, which overlapped in word-initial position with the target noun. Both pseudocompounds (Zinnober [vermillion] – ZINN [tin] (OBER [waiter]) and pseudo-derived nouns of the “corner” type (Kammer [chamber] – KAMM [comb]) were included. Finally in an orthographic control condition, prime stimuli overlapped with the target noun in word-initial position (Herzog [duke] – HERZ [heart]), without being decomposable into two existing morphemes.

The identical materials were included in three different priming experiments: Experiment 1 used a masked-priming paradigm with short prime exposure durations (49 ms) and a forward mask, which prevented conscious prime processing. In Experiment 2 the primes were presented with longer exposure durations (230 ms). In Experiment 3, a cross-modal priming paradigm was used, with

auditory primes and visual targets. Each experiment was run with a different group of 44 participants.

The results showed significant priming effects for both semantically transparent and opaque compounds in all experiments. The data add to the evidence for decomposition irrespective of semantic transparency in the processing of German complex words (e.g., Smolka, Preller, & Eulitz, 2014). Contrasting results were observed for pseudo-complex prime-target pairs, showing significant effects in the masked paradigm (Exp.1), small but significant effects in the uni-modal paradigm (Exp.2), but no effects in the cross-modal paradigm (Exp.3). Furthermore, none of the experiments showed significant effects for the orthographic control condition. The data will be discussed in the framework of current accounts.

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Derivational Morphology as a State of Mind

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We present the view that morphological structure is fundamentally a psychological phenomenon that is subject to variation within an individual as a result of specific task demands and experience over time.

We present evidence from the processing of derived words such as *fatalism* and *formalism*. These are structures that are easily perceived to belong to a common morphological family based on the presence of the suffix string *-al-ism*. Yet, it is precisely the presence of this suffix string that creates challenges for a psycholinguistically motivated explanation for how such words are processed and represented in the mind.

Our investigation was cross-linguistic and centered on a common set of doubly-suffixed derived stimuli (such as *fatalism*, *fatality*, *formalism*, *formality*) that are cognates across three languages (English, French and Italian) so that stimuli are almost identical (e.g., E. *fatality*, F. *fatalité*, I. *fatalità*) and by conducting identical experiments across languages.

Sixty native speakers of each language participated in the study. Each took part in three tasks. The first was a progressive demasking task (Grainger & Segui, 1990), in which stimuli gradually become visible on a computer screen and are named as quickly as possible. For each stimulus presentation, this was followed by a typing task (Libben, Curtiss, & Weber, 2014; Will, Nottbusch, & Weingarten, 2006). Following the combined progressive demasking and typing tasks, participants were presented with a set of derived words and asked to judge whether or not each word contained the letter sequence “al”.

Recognition difficulty was assessed through progressive demasking. Morphological effects were analyzed through typing latencies within the different putative morphological regions of derived words. Morphological effects were also evaluated through the Find-al task in which accuracy and latency were measured for words containing “al” in the root (e.g., *female*), as the only suffix (e.g., *formal*), as the head of a suffix string (e.g., *formality*) and as the final element of a suffix string (e.g., *functional*).

Our findings point to the view that all morphological elements within a derived word can play a role in lexical processing. The extent to which they do so depends on individual factors (e.g., multilingualism, level of education), language factors (in which for example, roots that are opaque in English (e.g., the *fin* in *finality*) are transparent in Italian and French (in which, for example, both *fin* and *finalité* are free forms).

Our results also point to a substantial role played by frequency as encapsulating morphological substrings. Thus, the recognition of “al” within a suffixed word (e.g., *formal* or *formalism*) is diminished by larger frequency values for the string *formal* and enhanced by larger comparative frequency values for root representations such as *form*). Thus, a word such as *formalism* may have different mental configurations for different speakers at different times. We thus see a word such as *formalism* as not having morphological structure, but rather as having morphological opportunity. In this way, derivational morphology may be best described as a state of mind.

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Effects of covert morphological complexity: The processing of zero-derived words

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In English, there is a widespread pattern of word class alternation often referred to as ‘zero derivation.’ This involves pairs of semantically related nominal and verbal forms which do not differ in their surface phonology (e.g., KNOT, BITE). Some researchers (e.g., Kiparsky 1982/1983; Arad 2003) have claimed that these pairs vary according to which form is derived from the other, with the derived form having a more complex morphological structure than its base:

Verb Base (VB): $[[\text{BITE}]_V]_N$ *derived from* $[\text{BITE}]_V$

Noun Base (NB): $[[\text{KNOT}]_N]_V$ *derived from* $[\text{KNOT}]_N$

Such models therefore propose that the forms within a pair are asymmetrically related, and that the direction of this asymmetry varies across different pairs. Alternatively, others have argued that there is no difference in morphological complexity, nor any morphologically encoded distinction between V_B and N_B pairs. Instead, zero-related pairs are argued to be either two words whose relationship is purely semantic (e.g., Lieber 1981), or else forms of a single, shared lexical entry with no inherent word class (e.g., Farrell 2001).

This paper explores these claims and their implications for morphological processing, using three delayed priming lexical decision tasks. This paradigm has been argued to distinguish morphological effects from those of purely semantic similarity (Henderson et al. 1984; Drews and Zwitserlood 1995). Taking speaker intuitions as a starting point, the first two tasks (one auditory, one visual) investigated four target groups: hypothesised base nouns (N_B Nouns); their corresponding denominal verbs (N_B Verbs); hypothesised base verbs (V_B Verbs); and their derived

nominal counterparts (V_B Nouns). Relative frequency differences between base and derived forms were matched across the N_B and V_B groups. A third task also compared groups of N_B Nouns and V_B Nouns with frequency-matched forms like *guard* whose 'basic' form was judged to be relatively less clear. All nouns were preceded by 'A/AN', and all verbs by 'TO.' Each target appeared 6-8 items after either its verbal *-ing* form prime (e.g., *knotting*), or an unrelated *-ing* form.

The first two tasks revealed a different pattern for N_B as opposed to V_B items across both modalities, with a consistent lack of facilitation for only N_B Nouns. In contrast, all other targets were similarly and significantly facilitated. This pattern is compatible with a different level of complexity for N_B primes like [[[*knot*]_N]*ing*] as compared to V_B primes like [[*bite*]_V]*ing*]. While both prime types activate their respective verbal stems, the N_B primes require additional processing in order to be fully decomposed into the base noun, thus mitigating the degree of activation that the noun receives. Nevertheless, the third task also revealed that priming effects were greater for 'unclear' nouns like A GUARD, as compared to either V_B or N_B Nouns. This is suggestive of a closer relationship between forms like *guarding* and their corresponding nouns, potentially arising from a shared lexical entry. Together, these experiments support a mixed model in which the grammar distinguishes between different kinds of zero-related pairs based on their underlying morphological relationships – a covert distinction to which morphological processing is sensitive.

Schemas in storage and processing

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New advances in morphological theory spawn new questions for morphological processing. In this paper, we sketch one such advance and outline the potential psycholinguistic consequences.

Morphology – just like syntax – traditionally distinguishes *lexical items*, which are stored in the lexicon, and *rules*, which constitute the grammar of a language. As a consequence, words and rules are perceived as structurally different and as located in different – metaphorical or neurotopographical – places. As a consequence, storage and computation are treated quite disparately in the processing literature.

Recently, however, theoretical morphology has challenged the lexicon-grammar dichotomy. Constructionist theories such as Construction Morphology (Booij 2010) or Parallel Architecture Morphology (Jackendoff & Audring forthcoming) are arguing for a theory based on the following assumptions:

- I. There is abundant lexical storage of composite items (derived and inflected complex words, idioms and other multi-word units).
- II. Rules have the same format as words, except that they contain one or several variables.

Thus, a constructionist theory posits that complex words such as *fishy* or *catty* are lexically stored (1) and that they are linked to a schema for denominal -y adjectives (2), which is also stored.

1) a. FISH-LIKE, DUBIOUS

[_A N -aff]
/fɪʃi/

b. CAT-LIKE, MALICIOUS

[_A N -aff]
/kæti/

- 2) X-LIKE
[_A N -aff]
/... i/

The schema is listed in the same format as the words it instantiates, capturing their similarities in a constant and their differences in a variable. While replacing rules by schemas may seem like a minor theoretical move, it has far-reaching and interesting consequences for psycholinguistic theory. First, the theory fits well with usage-based accounts of word learning, as schemas represent generalizations over stored instances of words. This means that rules do not come into being independently of words, and that they arise without shifting to a different domain. Second, by virtue of their word-like form, schemas participate in the network of lexical relations and can serve as an organizing and motivating force. Third, for the same reason, schemas can have properties such as frequency-dependent and primeable activation levels. As such, they might play an active role in online processing by amplifying the activation of their instances.

Moreover, since schemas need not be completely productive, this effect is not tied to productive morphology, but potentially applies to a wide range of morphological patterns.

For these and other reasons, we argue that a constructionist perspective suggests a range of novel questions and challenges to psycholinguistic research on morphological processing.

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Interaction between morpho-syntactic complexity and frequency during spoken language comprehension

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It has been proposed that spoken language comprehension is jointly achieved by two functionally distinct but spatially partially overlapping networks in the brain (Marslen-Wilson & Tyler, 2007). The bilateral temporal network, which includes both left and right temporal areas, supports the lexico-semantic processing of simple words. Superimposed on this widely distributed network is a left perisylvian network, involving the left inferior frontal gyrus and left superior and middle temporal gyri, which supports key combinatorial morpho-syntactic processes.

Neuroimaging studies have confirmed that morpho-syntactically complex items such as morphologically inflected words and syntactically ambiguous sentences engage the left perisylvian network (e.g. Bozic et al., 2010; Tyler et al., 2013). However, more recent evidence has shown that not only simple words but also both derivationally complex forms (Bozic et al, 2013) and short phrases such as 'I go' and 'I walk' (Bozic et al., 2014) are predominantly processed by the bilateral temporal network. This suggests that the bilateral network may have the more general function of handling the representation and access of linguistic forms that can be stored and retrieved as integrated units, in line with distributional approaches to grammar (Bybee, 2006).

This predicts that the functional partition between the two language networks is codetermined by morpho-syntactic complexity and frequency of occurrence. When a complex item is highly frequent, as in the phrase 'I go', this will be stored as a single collocational unit in the bilateral network from which its meaning can be directly retrieved. On the other hand, when the item is low in frequency, and a combinatorial process of interpretation is

required, the decompositional left perisylvian network will be recruited.

We ran a passive listening fMRI experiment in which 3 levels of frequency (low, mid, high) and 3 levels of syntactic complexity (*word* 'furnish', *short phrase* 'I quote', *long phrase* 'I want it') were co-varied across 9 factorial conditions. Univariate analyses, consistent with previous findings, showed that words and short phrases produced bilateral STG and MTG activation whereas sentences showed more LIFG and bilateral temporal activation compared to an acoustic baseline. Specific regression analyses showed that the frequency of words negatively correlated with activation in left STG. Contrary to the predictions of distributional accounts, the frequency of long phrases also correlated with activation only in left STG and MTG but not in LIFG even at a more lenient threshold. No effects were seen for short phrases. Multivariate pattern analyses (RSA, Kriegeskorte et al., 2006) gave very similar results, with no evidence of LIFG involvement for long phrases as a function of frequency.

Our results showed that as expected the frequency of words modulated the activation of the bilateral network. By contrast, the collocational frequency of morpho-syntactically complex phrases did not affect the left perisylvian network, suggesting that in contrast to the predictions of distributional accounts, frequently encountered morpho-syntactically complex phrases are not stored and retrieved as a whole in a similar manner to words.

The language skeleton after dissecting meaning: A functional segregation within Broca's Area

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Broca's area is proposed as a crucial brain area for linguistic computations. Language processing goes beyond word-level processing, also implying the integration of semantic and syntactic information. There is an on-going debate about the specialisation of the subregions of Broca's area—Brodmann areas (BA) 44 and 45—regarding the processing of content and form. In this study, we investigated the contribution of lexical information, derivational morphology and inflectional morphology to sentence parsing. We tested whether cues regarding syntactic information are specifically processed in BA 44, whereas BA 45 is mainly recruited for when content-relevant cues are present. We contrasted conditions with sentence structure against conditions with random word order in two fMRI experiments, where we systematically removed the amount of semantic information available in stimuli. This was achieved in Experiment 1 by replacing content words (word stems) by phonologically matched pseudowords and keeping function words and derivational morphemes. Within real words conditions we found broad activation in the left hemisphere, including the inferior frontal gyrus (BA 44/45/47), the anterior temporal lobe and posterior superior temporal gyrus (pSTG) and sulcus (pSTS). For pseudowords we found a similar activation pattern, still involving BA 45. In Experiment 2 we tested whether the activation in BA 45 was due to the presence of derivational morphology, as a source of relevant cues for semantic processing. We therefore only left inflectional morphology and function words, which are essential for determining syntactic structure in German (e.g. agreement and case marking). Now, in the absence of semantic information, including

derivational morphology, only BA 44 was active. Additional analyses showed a selective responsiveness of this area to syntax-relevant cues, i.e. function words in comparison to content words. These findings confirm BA 44 as a core area for the processing of pure syntactic information. This furthermore suggests that the brain represents structural and meaningful aspects of language separately.

Gender features in German: Evidence for underspecification

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Traditionally, instances of a certain grammatical category (e.g., gender) are categorically labeled to differentiate between distinct classes (e.g., feminine, masculine, neuter). Current morphological theories, however, propose more fine-grained analyses of these categories. *Feature decomposition* and *underspecification* are essential concepts of almost all current theoretical approaches to inflectional morphology. The over-all idea behind these two concepts is a decomposition of ‘traditional’ labels of categories into more abstract, binary features, thereby yielding the possibility to refer to natural classes of such categories. Thus, the three instances of grammatical gender in German could be described by two abstract binary features $[\pm f]$ and $[\pm m]$: ‘feminine’ $[+f, -m]$, ‘masculine’ $[-f, +m]$, ‘neuter’ $[-f, -m]$. The question whether morphological processing relies on more traditional or more fine-grained, abstract categories has been rarely addressed in psycholinguistic research (but see Clahsen et al., 2001; Opitz et al., 2013, Penke, 2006). All of the studies so far addressed the processing of inflectional morphology (affixation and stem alternations). In contrast, the lexical representation of uninflected stems is regarded as fully specified with respect to inherent features. Our findings from a series of three experiments investigating the processing of gender in German, however, challenge this view.

Experiment 1 examined differences between nouns embedded in short phrases. Grammaticality judgments for visually presented stimuli (e.g., *durch guten Geschmack* (‘by good taste’)) yielded significantly longer reaction times and higher error rates for phrases containing masculine nouns compared to phrases containing feminine nouns (738 ms vs. 777 ms, 9.9% vs. 3.4%).

Two other experiments examined the processing of *bare nouns* without any syntactic context.

Experiment 2 investigated the influence of grammatical gender and word frequency on lexical decisions. Results indicated delayed responses for masculine nouns. This effect was observed only for words of high frequency (573ms (masc) vs. 547ms (neut) and 557ms (fem)).

In *Experiment 3*, the impact of explicit gender-determining affixes (e.g. *-ung* for feminine nouns) in a gender decision task was examined. While the presence of an affix did not have any effect, we again observed significant differences regarding grammatical gender (769 ms (masc) vs. 715 ms (fem)).

Thus, we consistently found that masculine nouns (although controlled for potentially confounding factors) showed indications of an increased processing load compared to feminine or neuter nouns. We interpret these results as reflecting differently specific lexical representations of gender features for German nouns: lexical entries of nouns might differ regarding their amount of featural content. While masculine gender might be represented by two features [+m, -f], feminine and neuter gender might be represented by only one feature each ([+f] for feminine and [-f] for neuter).

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Processing free affix order

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Processing of scrambling (non-canonical word order) received significant attention in psycholinguistic research (e.g., Sekerina (2003); Kaiser and Trueswell (2004) and references therein). There is remarkably less work on processing of free affix ordering. The order of affixes in English has been addressed with a processing-based explanation in Hay and Plag 2004, Plag and Baayen 2009. The present paper contributes to the field with a behavioural study of morpheme order variation in Adyghe (Northwest Caucasian). We show that in agreement processing, ‘morphological scrambling’ does not increase the load, but relativization over the agreement slots does.

Adyghe is a polysynthetic language with highly elaborate verbal morphology, which includes polypersonal agreement with its arguments and some adjuncts (participants), TAM-suffixes, syntactic role and some other markers. Non-core arguments are introduced in applicative complexes. The verb is traditionally described as having templatic make-up, but recent research showed that some affixes may be scopally (compositionally) ordered (Korotkova and Lander 2010). Important here is that some agreement prefixes may appear in reversed (i.e., not default) order, subject to idiosyncratic restrictions on stem/affixes combinations. Sometimes a dispreferred reversed order is rescued if the participant whose prefix moved leftwards is relativized, which resembles leftward A0-movement. Adyghe allows relativization of any participant that has a corresponding agreement marker.

These grammatical facts were manipulated to create a 2x2 design. We employed a benefactive applicative and a neutral locative applicative complex, whose default ordering is “locative precedes benefactive”. One parameter was the order (default vs.

reversed), and the other relativization (present or absent on the left morpheme). We conducted a self-paced reading study with native speakers to measure the reading times of the verb in the four conditions.

There are two research questions we address with the described design. One is whether reversing the order of the morphemes produces effects comparable to scrambling in syntax: increased processing load, reflected in greater reading times (especially given the ban on some reversals, pace Hawkins (2004)). The other is, what is the import of relativization? On the one hand, we might expect it to increase reading times, since it is arguably more complex than absence of relativization. On the other hand, the observation that relativization can rescue a reversed order suggests that it may be easier (especially compared to reversed order without relativization).

The data obtained were statistically processed in R using analysis of variance and Tukey's HSD. The results strongly support the hypothesis that relativization is harder to process in both the default and the reversed order (for both $p < .001$), comparable to wh-movement-related complexity. Overall, relativization had a significant effect ($F(1,756) = 61.12$, $p < .001$), while the order did not ($F(1,756) = 1.22$; $p = .27$). Thus, reversing the order of the applicatives influenced the reading times neither in the presence nor in the absence of relativization (no scrambling-like effects). We will discuss the implications for the morphological processing theory, and in particular for free affix order languages.

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Mechanisms of morpho-syntactic prediction in natural sentence processing

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Languages are built around predictable regularities that reflect the ordering of linguistic elements in a sentence and the grammatical relations between them. Cortical mechanisms underlying the processing of more or less predictable elements in a natural sentence context are not, however, well understood. Several recent studies show that contextual predictability of various linguistic elements (such as suffixes, articles, words and phrases) affects their processing within the fronto-temporal language areas. Mismatch negativity (MMN) over the left hemisphere (Hasting et al., 2007, Herrmann et al., 2009) and fronto-temporal cortex (Shtyrov et al., 2003), early left negativity (Wicha et al., 2003), and N400 effects (DeLong et al., 2005) have all been related to contextual predictability in language. The majority of these studies, however, examine brain responses to phrases or sentences with grammatical errors or violations of strong expectations and only report effects after the onset of the predicted item. It is unclear whether the reported effects indicate predictive processing of these linguistic elements or are related to associated grammatical and lexical information integration and reanalysis, processes that are also related to increased fronto-temporal activations (Tyler et al., 2013; Friederici et al., 2010).

In this study we exploit the high temporal resolution of combined electro- and magnetoencephalographic (EMEG) imaging and multivariate representational similarity analysis (RSA), with 20 Russian native speakers, to capture the dynamic effects of contextual predictability on inflectional suffix processing. To minimise the effects of prediction violation and re-analysis we used

natural error-free Russian language sentences to compare activation patterns associated with inflectional suffixes in two different contexts: first, where the singular/plural value of an agreement suffix can be predicted from the preceding context (such as 'moj brat igr-aet na pianino' - 'my brother play-s piano') and second, where the value of the suffix is not contextually predicted ('na pianino igr-aet moj brat' - 'piano play-s my brother'). In both contexts we used two agreement suffixes: '-aet' third person singular and '-aut' third person plural. We hypothesised that predicted suffixes, despite being acoustically identical to the unpredicted ones, will produce differential activations within the frontotemporal network, potentially detectable well before the acoustic onset of the suffix. We compared the two conditions using the source space RSA Searchlight approach (Su et al., 2012) within a -200 to +200 ms time window, aligned to suffix onset. Results show that activation patterns associated with predicted and unpredicted suffixes begin diverging in bilateral superior temporal and left supramarginal areas around 100 ms before suffix onset. At the same time only predicted suffixes generated differential activation patterns in a larger set of bilateral temporal areas, including left superior temporal, right superior, middle and inferior temporal areas.

These results show that during sentence comprehension, contextual predictability affects inflectional suffix processing. Observed effects are likely to be related both to early phonological processing differences between predicted and unpredicted suffixes, and to effects of predicted suffix recognition and integration.

Pupillometry as a window to real time processing of grammatical aspect in Russian

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Grammatical aspect is involved in the conceptualization of the internal flow of time in an event and can influence the perception of event descriptions (e.g. Madden & Zwaan, 2003; Anderson, Matlock, & Spivey, 2013) and the processing of events (e.g. Ferretti et al., 2007). However, very little is known about how morpho-semantic aspectual information influences the time-course of morphological processing. We used eye-tracking with lexical decision to investigate the time-course of processing of distributional information associated with perfectivizing prefixes in Russian, contributing to the long-standing debate regarding the rule-based vs. semantically-motivated nature of this morphological category (see Janda et al., 2014). In addition to fixation-based measures (e.g., Kuperman et al., 2009), we inspected changes in pupil dilation through time (Laeng et al., 2012). Pupillometry has been shown to reflect changes in cognitive load, e.g., the intensity of mental activity (Beatty, 1982), retrieval of memories (Papesh et al., 2012), and frequency-effects (Kuchinke et al., 2007).

Native Russian participants ($n = 26$) performed visual lexical decision on either grammaticalized (*po-dum-a-t'* 'think') or lexicalized (*na-dum-a-t'* 'make up one's mind') perfective verbs. All verbs ($n = 160$) were tetramorphemic, controlling for length and segmentability. Because a given imperfective base verb <*dum-a-t'* 'think'> can combine with many different perfectivizing prefixes, Prefix Family Size was calculated. Further distributional information, in the form of six frequency measures, was extracted from the Russian National Corpus. To remove collinearity, frequency measures were submitted to principle component analysis, resulting in three components: PC1 relates to the overall distribution of the

morphological construction <po-dum-a-t'>; PC2 contrasts the distributional difference between the root <-dum-> and the prefixed verb <po-dum-a-t'>; and the difference between the root <-dum-> and the base verb <dum-a-t'> is captured by PC3. Finally, participant age ($M = 28.8$, $SD = 5.5$) was included as a proxy for accumulated experience across the lifespan (see Bybee, 2010; Ramscar et al., 2014).

Pupil response was modeled as a time series (2000 ms) beginning at the onset of the stimulus. We used generalized additive mixed-effects modeling (Wood, 2014) to account for the inherent non-linearity of the data. The model indicated a reduction in pupil dilation when the morphological construction frequency (PC1) was high. In contrast, dilation increased when the root was more frequent relative to the prefixed (PC2) or the base (PC3) verb. These results converged with total fixation duration. Increased Prefix Family Size resulted in reduced dilation early in time, something not seen in first fixation duration. After controlling for distributional properties, grammaticalized prefixes showed a small reduction in dilation later in time and shorter total fixation duration, supporting the semantically-motivated account of aspect. Finally, while there was no effect of age on any of the fixation measures, increased age significantly reduced dilation throughout the time-course. Thus, pupillometry may contribute to our understanding of the allocation of attentional resources during early morpho-semantic processing.

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French stems in verbal inflection: Structure, rules, and allomorphy

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Word recognition is mediated by morphological decomposition, structure, representation, and processing. Most Modern Romance languages, as Italian, Spanish, Portuguese, Catalan, and Romanian have in general three theme vowels (a, e, i) which define the verbal classes or conjugations. The theme morpheme is merged with the root forming the stem to which the inflectional suffixes will be merged. Thus, the theme morpheme is an example of pure morphology, given its empty semantic content and exclusive functional role in verbal class distribution. Further, stem formation is determined by allomorphy and rules through predictive structure and morphosyntactic features (Embick & Halle, 2005). However, French verbal classes are not defined in terms of theme vowel and present different degrees of regularity and allomorphy in stems (Aronoff, 2012). Therefore, morphological representation and processing must be clear stated and understood from the psycholinguistic perspective of language processing.

In this work, root, stem, and theme morpheme representations and processing from different verbal classes were investigated in French, which is a language with rich morphology, allomorphy, and undefined verbal theme morpheme. The main purpose of this research was to define the verbal structure, nodes, and morphemes represented in French speaker's mental lexicon, as also how these morphemes are processed in a combinatorial manner (Estivalet & Meunier, 2015).

Cross-modal and masked priming experiments with lexical decision task on visual targets were used to research the morphological priming effects on French inflected verbs with different stem morphological characteristics from the 1st class a)

parler/parlons ‘to speak/we speak’, b) *pésér/pèsent* ‘to weigh/we weigh’, and 3rd class c) *sentir/sentons* ‘to feel/we feel’, d) *prendre/prenons* ‘to take/we take’, e) *conduire/conduisons* ‘to drive/we drive’, and f) *joindre/joignons* ‘to join/we join’. The experiments had three different priming conditions: 1) Control (*aimer/parlons*), 2) Identity (*parlons/parlons*), and 3) Test (*parler/parlons*). We predict full priming in Identity and no priming in Control, thus Test can be compared against other both conditions to explain the morphological influence in word recognition. Partial priming was considered a different effect from full and no priming. All verbs investigated from the 1st and 3rd classes presented the same general behavior in both experiments. Identity condition had the fastest responses, Test the second one with no significant difference against Identity, and Control the slower responses with a significant difference against Identity and Test conditions. However, the results showed different priming effect sizes between the experiments and verb types, suggesting paradigmatic structures and combinatorial processes in word decomposition and recognition. Unlike other studies in Romance languages, these results suggest verbal theme morpheme representations and rule-based stem formation in all French verbal classes, as well as a complete decomposition for lexical access (Veríssimo & Clahsen, 2009).

Overall, inflected French verbs are recognized through early word decomposition into stem and inflectional suffixes for lexical access, and later stem decomposition into root and theme morphemes, with minimal morphemic activation, defined by allomorphy and rules, driven by morphosyntactic features in the word formation.

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Spatio-temporal dynamics of morphological processing in visual word recognition: A priming study using MEG

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The psycholinguistic properties of morphologically complex words are critical to assess the nature of their mental representations in the brain. Understanding how these words are organized in the mental lexicon and how the mapping between form and meaning is achieved in the brain represents a main challenge in reading research. Previous fMRI and EEG research has yielded incomplete and sometimes conflicting results. While fMRI cannot discriminate between early and late effects of morphology on reading, EEG cannot identify the cortical generators associated with morphological processing. In contrast, MEG allows us to gather information on both the spatial and temporal dynamics of morphological processing. Thus, in this study, we report results from an MEG priming experiment. The goal was to find out whether morphological effects could be dissociated from orthographic and/or semantic effects in different regions of interest, and if so, to assess at what time during word recognition this dissociation would occur. Four priming conditions were used: morphological, orthographic, semantic and unrelated. To avoid possible confounds and idiosyncratic effects that might come from using different target words in different priming conditions, the same target word was presented across the four different prime conditions. Twenty native French speaking adults (11 females – 9 males, aged 23.4 on average) took part in the study. The behavioral results showed a significant effect of morphological priming that could not be

explained in terms of orthographic or semantic overlap. The MEG results revealed a M350 response associated with morphological priming localized both in the left inferior temporal gyrus (LITG) and in the left inferior frontal gyrus (LIFG), which were different from both semantic and orthographic priming condition. Moreover, only morphological processing elicited an early M170 response in the LITG. Finally, results showed evidence for morpho-semantic processing during the time window of the M250 in the left superior temporal gyrus (LSTG). The present results support the claim that morphologically complex words have a specific status in the brain and that morphological processing and decomposition is achieved by a vast network that involves at least brain regions: LIFG, LITG and LSTG. These results are discussed in the context of recent morphological processing theories and models of written word recognition.

Automatic rapid acquisition of complex word forms in children, but not adults: EEG evidence

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Both children and adults are capable of automatic rapid acquisition of new lexemes, which, at least in adults, can be traced online electrophysiologically as a formation of new memory-trace activation patterns over just a few minutes of exposure to novel spoken forms. Are there similar mechanisms for learning morphosyntactically complex forms? If so, do they differ for derivational and inflectional morphology? Finally, do adult speakers and young children apply the same neural strategies to acquiring complex word forms? To address these questions, we used recent findings of neurophysiological indexes of lexicalization vs. syntactic parsing: an increased ERP response (mismatch negativity, MMN) to complex derivational forms, as opposed to reduced ERPs for both known inflectionally complex forms and complex pseudowords. They indicate that inflected words do not possess strong full-form representations while derived words appear to be represented neurally by whole-form memory traces, similar to monomorphemic items.

We presented adults and 3-year-old typically developing children with familiar derived and inflected words along with acoustically matched novel pseudo-complex forms, and measured the dynamics of ERP patterns elicited by these stimuli over the course of a repetitive passive exposure (5 minutes). In adults, MMN responses to all stimulus types declined over exposure, likely due to response habituation. This is different from the established pattern for monomorphemic ERPs that increase with repetitive exposure to novel items, reflecting rapid neurophysiological memory-trace

formation. This result indicates that the adult brain is not capable of fast lexicalization of morphosyntactically complex forms. A similar habituation-related decline was found in children only to well-known derived words, with presumably preexisting holistic representations. A strikingly different result was observed for MMNs elicited in children by inflected and pseudo-complex forms. These produced an increase of ERP amplitudes over the course of the experiment, indicating that, in 3-year-olds, repetitive exposure to even decomposable complex forms may lead to rapid automatic buildup of lexical memory traces for such items.

To conclude, the formation of neural networks representing morphologically complex words is qualitatively different in children and adults. Due to more flexible learning mechanism, children are able to quickly lexicalize words even through passive exposure, which also enables forming chunk-type supralexical representations for complex words.

Morphological processing in end-state second language acquisition

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Second language (L2) acquisition studies have reported a high degree of variation in the domain of morphology (White, 2003). Similarly, L2 processing studies generally report decreased sensitivity to morphological markers. It has been suggested that the two principal routes to processing of morphologically complex words (i.e., full-listing and decomposition) are available to native speakers but not to adult L2 learners (Clahsen et al., 2010). To illustrate, in the L1 English lexicon, irregular verbs (e.g., flew), are stored as a whole, while regular verbs are decomposed into the root and suffix (e.g., walk – ed) (Pinker, 1999). In the L2 lexicon, however, regularly inflected words, like irregular words, are assumed to be stored as chunks due to L2 learners' problems with implicit linguistic computations (Ullman, 2004). Whether this is a persistent problem extending to end-state L2 learners has been a matter of controversy.

The present study investigated this question via a masked priming experiment measuring response times (RT) for regular and irregular verbs in L2 English. The prime-target pairs were presented in three prime conditions: i) Identity (*save-SAVE; build-BUILD*), (ii) Test (*saved-SAVE; built-BUILD*), and (iii) Unrelated (*carry-SAVE; share-BUILD*). Preliminary data from adult L1 Turkish-L2 English learners with advanced L2 proficiency (n=45) and native English speakers (n=24) revealed significantly faster RTs for irregular verbs [$F(1,67)=11.828$, $p=0.001$] and a main effect of condition [$F(2,134)=39.474$, $p=0.00$]. Furthermore, paired-samples *t*-tests revealed priming effects only for regulars in both groups, suggesting decomposition. As for the irregular verbs, no priming effects were observed, possibly due to storage effects. These results lend support for the dual-mechanism view in morphological processing

of past tense inflection in English. It seems that end-state L2 English speakers can employ the decompositional route in accessing inflected forms in the L2 similar to native speakers, as suggested by some of the previous studies (e.g., Feldman et al., 2010; Gor & Jackson, 2013). Comparable processing patterns in native and nonnative groups obtained in the present study oppose to earlier views that L2 learners are less sensitive to the morphological structure of the target language compared to native speakers (e.g., Clahsen et al. 2010). Thus, our findings suggest that real-time processing of morphologically complex words can ultimately be native-like for adult L2 learners.

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Participle inflection in German children and adolescents with Down Syndrome

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Children with Down Syndrome, a genetic developmental disorder that leads to mild to moderate mental retardation, achieve developmental milestones in language acquisition only with a considerable delay and display noticeable problems in the acquisition of morphosyntactic structures (cf. overview in Roberts et al. 2008). A number of studies have reported difficulties with verbal inflection in individuals with Down Syndrome (e.g. Laws & Bishop 2003, Ring & Clahsen 2005). A controversial issue among these studies concerns the issue of whether these deficits encompass regular as well as irregular inflection. While Laws & Bishop (2003) report selective difficulties in regular verbal inflection, other studies did not find a difference between regular and irregular verbal inflection compared to controls (e.g. Ring & Clahsen 2005).

So far, research on Down Syndrome has been mostly confined to English-speaking individuals. The investigation of inflectional deficits in acquired and developmental deficit syndromes across different languages has, however, averted us to the influence language-specific factors might exert on the performance of language-impaired speakers. It has, for example, been found that a deficit with regular inflection that is a typical symptom of English speakers with Broca's aphasia does not occur in German and Dutch aphasic speakers (e.g. Penke & Westermann 2006). To investigate whether a deficit with verbal inflection is a characteristic sign in Down Syndrome across languages and to explore whether the inflection of regular and irregular forms is affected differentially, we will present data on past-participle inflection from German speaking individuals with Down Syndrome.

We investigated the language abilities of a group of 13 German-speaking children and adolescents with Down Syndrome (5 female, 8 male) without severe hearing loss or additional physical or psychological impairments. Chronological age ranged from 5;6 to 17;2 (mean: 10;7) and mental-age range was 3;8 to 5;2 (mean: 4;4). They were compared to a control group of unimpaired children matched according to mental age.

Past participle production was assessed using an elicitation task. We elicited 18 regular forms (e.g. “gelacht” *laughed*), 10 irregular forms (e.g. “gebacken” *baked*) and 5 nonce verbs (e.g. “*gekerst”).

Accuracy scores for regular and irregular inflection did not differ between the two subject groups (ANOVA). Both subject groups achieved high accuracy scores for generating participle forms of existing regular verbs. 11 of the 13 subjects with Down Syndrome fall into the accuracy range of the control group (60-100% correct regular past participles). Both groups perform worse with irregular past participle forms, but again achieve comparable accuracy scores. For both subject groups, the most frequent error is the overgeneralization of the regular suffix *-t* which is also applied to novel verbs in most cases. The results indicate that, as a group, German-speaking children and adolescents with Down Syndrome display no evidence for a deficit with verbal inflection in general and no evidence for a selective deficit with regular inflection in particular. We will contrast and discuss these findings against the findings obtained for English-speaking subjects with Down Syndrome.

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Effects of morphological family on word recognition in Alzheimer's disease

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The vast majority of studies on a word's morphological family argue that morphologically related words co-activate together with the target word in the mental lexicon during lexical processing tasks (e.g., Schreuder and Baayen, 1997). Since morphological family is a semantic variable, we should expect at least a weaker effect of activation for speakers with Alzheimer's disease (AD) as one of the characteristics of AD is semantic deterioration. Thus, in our lexical decision study, we revisited the facilitating nature of morphological family in lexical processing by including Finnish speakers with AD (13 participants). A group of healthy older adults served as controls (14 participants).

Most previous studies investigating effects of morphological family (family size and family frequency) have assumed that derived forms and compounds facilitate lexical access of the target word in the same way. We tested this assumption experimentally using Finnish, where compounds are an extremely productive class. Lexical decision studies (e.g., Duñabeitia et al., 2009) have shown that automatic semantic processing of a word is preserved in healthy aging and AD.

Accordingly, in our single word lexical decision experiment, we found a facilitatory effect in a measure of morphological family size and family frequency in both AD and healthy elderly group. However, our preliminary analyses suggest that when counting morphological family (size and frequency) from derived words only

(and not including compounds), a significant facilitating effect was observed only for elderly controls, but not for AD individuals. One possible explanation is that in Finnish, compounds are relatively transparent in their semantics while derived words are more opaque in their relation to the target word. Connections between words of a derivational family may thus be more susceptible to breakdown in AD.

We will discuss the effect of morphological family on language processing as evidence that semantic impairments in AD take place either as a consequence of dysfunctional semantic access/retrieval, (i.e., in processing, e.g., Nebes & Brady, 1990), or due to a breakdown of the semantic network itself, (i.e., in the knowledge/architecture, e.g., Hodges et al., 1992).

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The computation of agreement in L1 vs. L2: Effects of verb position, attraction, and word order

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In German, the finite verb agrees in person and number with the subject. In two experiments with first vs. second language (L1 vs. L2) speakers of German, the verb position, the agreement features of an attractor (a genitive phrase modifying the subject; Bock & Miller, 1991), and the relative order of subject and object were manipulated.

Experimental sentences displayed four alternative linearizations: SVO, SOV, OVS, and OSV. Unambiguous subjects were singular, case-ambiguous objects were plural, attractor number was varied. Sentences included synthetic verb forms with a gap for the auxiliary in second vs. final position. Adverbials increased the distance between the subject and the sentence-final position. Experimental sentences and filler sentences (plural correct) were completed by insertion of an auxiliary in a paper-and-pencil task.

An effect of distance was predicted with higher error rates in verb-final than in verb-second sentences. According to the Shallow Processing Hypothesis (Clahsen & Felser, 2006), L2 speakers process the linear structure whereas L1 speakers compute a hierarchical representation. Consequently, error rates were expected to be higher in L2 but not in L1 if the attractor intervened between controller and target (SV vs. VS). For all speakers, an effect of word order was predicted with higher error rates in OS as compared to SO sentences.

Experiments were run in the first session of introductory courses to German linguistics. There were 73 L1 speakers in Experiment 1 and 28 L2 speakers (at least at level B2 according to the CEFR) in Experiment 2. The group was heterogeneous with respect to L1 and age of acquisition (AoA) in L2.

Log-linear models on plural (vs. singular) responses in Experiment 1 with scaled independent variables and participants and items as random factors revealed main effects of word order (error rate SO 1.9%, OS 33.5%, $p < .001$) and verb position (error rate verb-second 7.7%, verb-final 22.9%, $p < .001$). Attractor number did not produce an effect, nor did any interaction yield significance.

Log-linear models on responses in Experiment 2 yielded main effects of word order (error rate SO 8.6%, OS 47.4%, $p < .001$) and attractor number (error rate singular 22.9%, plural 29.8%, $p < .05$). Verb position did not have an effect. None of the interactions were significant.

Only L1 speakers produced a robust effect of distance with more errors in verb-final than in verb-second sentences. L2 speakers with an SOV language as L1 showed a descriptive tendency towards a verb position effect, but factors were confounded (several speakers of Turkish learned German at Kindergarten). Future experiments will test the impact of L1 and AoA systematically.

Only L2 speakers were susceptible to attraction errors in the offline task. The effect was not modulated by verb position or word order. This finding suggests that the attraction effect arose in a hierarchical (vs. shallow) syntactic representation.

As expected, both experiments revealed significantly higher error rates in OS than in SO sentences. Commentaries by participants indicate that they misinterpreted objects as subjects.

Agreement attraction in native and non-native speakers of German

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We examine the computation of subject-verb number agreement in native (L1) and nonnative speakers (L2) of German using an agreement attraction paradigm. Speakers sometimes wrongly produce a plural verb when a singular subject phrase contains a plural attractor ("*the smell of the stables are*") (Bock & Miller, 1991). In L1 processing, agreement errors are modulated by structural distance: for example, when a singular head noun is modified by two prepositional phrases (e.g. "*the smell₁ of the stables₂ of the farmers₃*") errors occur more often with a plural second noun (hierarchically closer to the head) than with a plural third noun (hierarchically more distant from the head), even though the latter is linearly closer to the verb (**2nd-3rd noun asymmetry**; Franck, Vigliocco & Nicol, 2002). This pattern has been taken to suggest that the structural distance between an attractor and a head noun affects attraction more than its linear distance to the verb. We investigate this claim for subject-verb agreement in German, using a design that allows us to distinguish between structural and linear distance. Further, we examine whether the agreement errors of L1 Russian speakers, a language that has similar agreement and case properties as German, are similarly sensitive to structural distance.

We used a novel paradigm that shares aspects with both production and comprehension (Staub, 2009). Participants read German sentence preambles presented phrase-by-phrase in RSVP and then chose between plural and singular verbs (*ist* 'is' vs. *sind* 'are'). We manipulated the position of the plural attractor and the type of construction that modified the head noun. In the *embedded conditions*, 2nd nouns were hierarchically closer to the head noun

than 3rd nouns. In the *coordinated conditions*, both nouns were coordinated and thus the structural asymmetry between them was reduced. For native speakers, we predicted that a stronger 2nd-3rd noun asymmetry should be obtained in embedded than in coordinated conditions. We compared whether agreement errors in L2 were similarly modulated by structural distance.

In **Experiment 1** (n=40) L1 speakers made more agreement errors with 2nd than 3rd plural nouns but the asymmetry was not stronger in the embedded conditions. To examine whether the lack of an interaction was due to the low number of errors overall, task difficulty was increased by implementing a 2 sec response timeout and using word-by-word presentation. As predicted, in **Experiment 2** (n=40) we found both a 2nd-3rd noun asymmetry and an interaction with syntactic structure, which showed that the asymmetry was stronger in the embedded conditions. Interestingly, L2 speakers (**Experiment 3**, n=40) also showed a 2nd-3rd noun asymmetry in the embedded conditions but diverged from native speakers in the coordinated conditions, where responses did not differ. These results suggest that both L1 and L2 speakers' errors were modulated by structural distance, but that L2 speakers were non-native like when morphosyntactic representations conflicted with the lexical-semantic plurality signaled by the coordinator "and".

Conditions

Baseline.	Der Geruch _{.nom.sg} des Stalls _{.gen.sg} des Landwirts _{.gen.sg}
Embedded, 2 pl.	Der Geruch _{.nom.sg} <u>der Ställe</u> _{.gen.pl} des Landwirts _{.gen.sg}
Embedded, 3 pl.	Der Geruch _{.nom.sg} des Stalls _{.gen.sg} <u>der Landwirte</u> _{.gen.pl} 'The smell of the stable(s) of the farmer(s)'
Coordinated, 2 pl.	Der Geruch _{.nom.sg} <u>der Ställe</u> _{.gen.pl} und des Landwirts _{.gen.sg}
Coordinated, 3 pl.	Der Geruch _{.nom.sg} des Stalls _{.gen.sg} und der Landwirte _{.gen.pl} 'The smell of the stable(s) and the farmer(s)'

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Non-parallel effects in production and comprehension of agreement attraction

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Numerous production and comprehension studies in various languages analyzed so-called attraction errors in subject-verb agreement, like (1) (the dependent DP is termed *attractor* in such cases). They focused mostly on number agreement and usually found parallel effects in production and comprehension: attraction errors that are produced more often are less noticeable in comprehension. In particular, only plural attractors trigger significant effects in both modalities, while singular ones do not. We summarize several production and comprehension experiments looking at gender and case agreement in Russian to show that this tendency cannot be generalized to other features and agreement configurations.

For gender agreement, we asked participants to complete sentences with subject DPs like (2) to elicit errors in production and to read full sentences with and without errors to study comprehension. Russian has three genders, masculine, feminine and neuter, and we used different matching and mismatching combinations to estimate attraction effects. Masculine is the most frequent; neuter is least frequent, but is used as default (e.g. in impersonal sentences).

Overall results. (i) Unlike with number, all genders trigger attraction effects. (ii) In production, feminine attractors cause more mistakes than masculine ones, and masculine ones more than neuter ones. Similar results were obtained for Slovak (Badecker & Kuminiak 2007). (iii) In comprehension, the strongest effects are observed for masculine.

Capturing relational information in compound words: A distributional-semantic approach

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In many languages, compounding is a fundamental process for the generation of novel words. When this process is productive (as, e.g., in English), native speakers can juxtapose two words to create novel compounds that can be readily understood by other speakers. Crucially, this meaning is not only determined by the two words, but also by the (unexpressed) relation that links them together: we have a clear intuition that "snow building" means "a building MADE OF snow", even if we have never heard "snow building" in our entire life. In the present work, we propose a data-driven model, based on distributional semantics (Turney and Pantel, 2010), that correctly predicts relational effects in compound processing.

In the model, word meanings are represented as vectors encoding their lexical co-occurrences in the reference corpus (e.g., the meaning of "snow" will be based on how often "snow" appears with the other words). A combinatorial procedure is induced following Guevara (2010): given two vectors (constituent words) u and v , their composed representation (the compound) can be computed as $c=M*u+H*v$, where M and H are weight matrices estimated from corpus examples. The matrices are trained using least squares regression, having the vectors of the constituents as independent words ("car" and "wash", "rail" and "way") as inputs and the vectors of example compounds ("carwash", "railway") as outputs, so that the similarity between $M*u+H*v$ and c is maximized. In other words, the matrices are defined in order to recreate the compound examples as accurately as possible. Once the two weight matrices are estimated, they can be applied to any

word pair in order to obtain meaning representations for untrained word combinations (i.e., productive usage of compounding).

We tested our models against results from the conceptual combination literature. Gagné (2001) has shown that the compound relational structure contributes to priming in semantic processing: for example, sense-nonsense judgments to “honey soup” were faster when preceded by a compound with the same relation (“honey muffin”) than when preceded by a compound with a different relation (“honey insect”). However, this phenomenon is only observed when prime and target have a common modifier (first constituent); response times to “honey soup” did not differ when preceded by a same-relation prime using the same second constituent (e.g., “ham soup”) than when preceded by a different-relation prime using the same second constituent (e.g., “holiday soup”). The relational-priming effect, as well as its asymmetry, are correctly predicted by the proposed model: when generated compositionally, compounds that are characterized by the same relations are semantically closer, but only if they also share the modifier constituent.

The model simulations clearly indicate that relational information is reflected in language statistics. Human speakers are able to learn these aspects from language experience and automatically apply them to the processing of new word combinations. The present model is flexible enough to emulate this procedure, predicting sensible relational similarities and correctly capturing the central role of the modifier in conceptual combination.

When a word is un-understandable: From lexical co-occurrences to the meaning of novel derived words

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Morphological operations, when productive, are the primary source of novel words in a lexicon. However, novel morphological combinations are not always considered meaningful by language speakers, even when perfectly legal from the phonological and grammatical point of view. The present work tackles this understudied semantic side of novel-word generation. We used the FRACSS model (Marelli & Baroni, 2014) to compute distributional representations for novel derived forms, and test their predictions against speakers' intuitions about the word meanings.

The FRACSS model moves from the tenets of distributional semantics, and assumes that word meanings can be effectively represented by vectors recording their co-occurrence with other words in a large text corpus. Affixes, on the other hand, are considered functions (matrices) mapping stems into derived forms, and are trained from corpus data by means of machine learning techniques. As a consequence, derived-word meanings can be thought of as the result of a combinatorial procedure which transforms the stem vector on the basis of the affix matrix. This framework can be used to generate semantic representations for novel words; for example, the meaning of "quickify" can be obtained by multiplying the vector of "quick" with the matrix of "-ify". We evaluated the cognitive plausibility of these representations in two experiments.

In the first experiment, we focused on the quantitative properties of the novel vector representations. We collected meaningfulness ratings for 900 novel derived forms in a crowdsourcing study. These latter ratings were found to be significantly associated to model-generated measures.

Meaningfulness was found to have an inverse U-shaped relation with the proximity between the stem and the derived form: the novel word has to be optimally distant from the stem meaning to be considered meaningful, that is, the affixation process has to bring additional semantic information without changing too much the stem semantics. Moreover, the entropy of the vector was negatively associated with the word meaningfulness: combinations that are less prone to capture specific semantic features (i.e., higher entropy vectors) were considered less meaningful in human intuitions.

In the second experiment, we considered the qualitative predictions of the model concerning meaningful novel words. We used the vector representations to automatically extract novel-word semantic neighbors, and had them rated in a semantic-relatedness crowdsourcing task. Participants rated the model-generated neighbors to be closer to the novel-word meanings than to those of the original stems, showing that the FRACSS model enriches the stem semantics consistently with speakers' intuitions. For example, "barren", a model-generated neighbor for "pastureless", was judged to be closer to "pastureless" itself than to the stem "pasture".

In conclusion, the FRACSS model provides a framework for the study of the overlooked but all-important issue of the semantic representation of novel words. The model provides a quantitative definition of these meanings that is both in line with human plausibility intuitions and able to generate sensible qualitative characterization in terms of semantic neighborhoods.

English-speaking children's interpretation of novel deverbal compounds

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Deverbal compounds like “can opener” are still under construction among English-speaking preschool children (Nagpal, & Nicoladis, 2009). For example, English-speaking children sometimes produce ungrammatical constructions when attempting deverbal compounds of the form Noun-Verb-*er* like “floor sweeper” (Clark, Hecht, & Mulford, 1986). The errors include forms like misordering constituents (e.g., “sweeper-floor”) and omitting the morpheme (e.g., “sweep-floor”). This evidence is based on production data.

In this study, we are interested in the comprehension of deverbal compounds. We investigate what cues pre-school children use to identify agent/patient relation in deverbal compounds. According to Usage-Based Theories, children learn language from use, and when acquiring the knowledge of patient-agent relationship, they tend to first use local markers (e.g., morphemes) as cue to it instead of constituent ordering (Tomasello, 2003).

We present two studies, both testing children's sensitivity to potential cues to the meaning of compound words regarding agent-patient relation: the order of constituents and the presence/absence of the morpheme *-er*. We reasoned that since English compound words (deverbal or not) are usually right-headed, preschool children could be sensitive to this fact, making use of it when interpreting them. In contrast, the presence or absence of the morpheme *-er* may be salient to children since it is a local marker of agent-patient relation in Noun-Verb-*er* deverbal compounds.

In both studies, we test the comprehension of 10 novel deverbal compound forms composed of one noun and one verb (e.g., “ball pusher” or “pusher-ball” or “push-ball”). Children were asked to choose among four options (examples are given for deverbal

compounds with “push” and “ball”): the noun alone (a ball), a figure doing the action of the verb but with a different noun (someone pushing an envelope), the noun doing the verb (a ball pushing a block), and someone doing the verb to the noun (someone pushing a ball).

In Study 1, we compared English-speaking children’s interpretation of Noun-Verb-*er* compounds like “ball pusher” and Verb-*er*-Noun compounds like “pusher-ball”. Seventy-six children between the ages of three and five years were randomly assigned to interpret compounds of one kind or the other. In this study, children did not interpret the novel compounds according to their right-headedness: there was little difference in children’s interpretation of Noun-Verb-*er* and Verb-*er*-Noun compounds.

In Study 2, we tested English-speaking children’s interpretation of Verb-*er*-Noun compounds with Verb-Noun compounds. Forty-six children between the ages of three and four years were randomly assigned to interpret either compound words like “push-ball” or like “pusher-ball”. The results showed that children chose different referents depending on the presence or absence of the morpheme *-er*, i.e., there was evidence for children’s sensitivity to the morpheme *-er* in deverbal compounds.

The results are congruent with the Usage-Based Theories as preschool children in this study showed sensitivity only to local markers within the deverbal compounds (i.e., the morpheme *-er*), and did not rely in the ordering of the constituents as a cue to their interpretation. We discuss possible experiences leading children to attend to constituent ordering.

The role of morphological variables in reading aloud derived nouns: Evidence from an eye-tracking study with primary school children

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Several studies (see Rayner, 2009, for a review) focused on the variables that influence eye-movements in reading morphologically complex words. Yan *et al.* (2014) provided evidence for the role of the morphological structure of words on eye-movements in reading suffixed words. However, Häikiö *et al.* (2011) suggested that the use of morphemic structure can be influenced by reading skills, as slow 2nd grade readers are more prone to the processing of morphemic constituents than their fast peers and older children (4th and 6th graders).

The aim of this work is to assess the role of word morphology and grammatical class of base-words on eye-movements, in young Italian readers (from 3rd to 5th grades). In a previous study, Traficante *et al.* (2014) found that, in children, the access to morphological structure can either facilitate or hinder word processing on the basis of the root properties: the access to roots that can entertain several morphological relations (e.g., Italian verbs, that have very rich inflectional families) makes the word processing more difficult; on the other hand, the access to roots that have limited morphological families (e.g., Italian nouns) does not affect the processing of the complex form. In this study we further investigate this phenomenon by considering eye-movements when reading derived nouns embedded in sentence processing. Eye-tracking techniques, thanks to their fine-grained temporal resolution, can offer important insights as to how the base-category effect unfolds in word processing.

Participants. 31 children, attending 3rd to 5th grade, were recruited (mean age = 9 years; 13 M; 19 F) from a primary school in Northern Italy. *Materials and procedure.* 42 nouns derived from noun-base (e.g., *umorista*, humorist), and 29 nouns derived from verb-base (e.g., *punizione*, punishment) were selected and embedded in sentences. The target word appeared in the middle of the sentence and had a low cloze probability in the used context. Participants' reading skills were assessed with standardized tests. The experiment was carried out at school, in a quiet room. Eye-movements were recorded by SensoMotoric Instruments RED500 system.

Linear mixed models were used to assess effects of word length, grammatical class of the base word, whole-word and base frequency, and children's reading skills. First-fixation and gaze durations were taken as measures of early and late processing, respectively, and used as dependent variables.

We found a significant interaction between base frequency and base grammatical class, as reported by Traficante *et al.* (2014). However, this effect only emerged when considering first fixations and not in the analysis of gaze durations. Reading skills did not interact with morphological effects. The eye-tracking data provide converging evidence in favor of the base-category modulation reported in Traficante *et al.* (2014). Crucially, they also indicate, in line with Yan *et al.*'s (2014) results, that subtle statistical aspects of the roots are captured from early stages of lexical processing, even in young readers.

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The use of morphology in word and pseudoword recognition across reading development

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Developing readers often encounter a complex written word for the first time. If they are able to identify the single morphemes it is made of and access those in their orthographic lexicon, this will most likely facilitate the decoding of the entire word. Similarly, the combination of a known morpheme with an unknown morpheme or pseudomorpheme (e.g., “er”+“kiezen”) might impede word recognition, since a conflict arises between the known and the unknown constituent. Some evidence in favor of these assumptions comes from studies with Italian and French children (Burani, Marcolini & Stella, 2002; Quémart, Casalis & Duncan, 2012). In both studies, the use of morphology was found to be present in grade 3. However, the exact trajectory of morphological effects in developing readers is still unclear and we do not know whether children use morphology even earlier. To investigate the use of morphemes across the complete course of reading development, we examined the recognition of monomorphemic and morphologically complex words and pseudowords in a large cross-sectional sample in German. German is well-suited for investigating morphological effects in developing readers because of its transparent orthography and rich morphology.

The study was run as part of the *Developmental Lexicon Project*, which investigates visual word recognition across the lifespan. A lexical decision task was administered comprising a sublist of 30 pseudoword pairs, each consisting of a monomorphemic and a morphologically complex pseudoword. The latter were created by combining a pseudostem with an existing affix (e.g. “Unfant”). Moreover, the task comprised a sublist of 40 monomorphemic words, 40 derivations and 40 compounds. Data for the present

study was available from 740 children either at the beginning or end of grade 1, 2, 3, 4 and 6 and from 42 adults. Results showed that morphologically complex pseudowords took longer to be rejected from the beginning of grade 3 onwards. For real words, readers made fewer errors when encountering morphologically complex words and this effect became stronger with increasing age. Moreover, young readers up to the beginning of grade 3 were slower in recognizing morphologically complex words, while older readers were not slowed down.

The conclusion can be drawn that beginning readers rely on sublexical units smaller than morphemes and morphology is still demanding for them. In line with the findings by Burani et al. (2002) and Quémart et al. (2010), children start to automatically exploit morphology in word recognition processes from grade 3. Furthermore, children remain to use morphology throughout later reading development and even as adults. This finding highlights the importance to incorporate morphology in computational models of reading development as well as skilled reading.

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Morphological encoding in German children's language production: Evidence from an ERP study

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Models of the adult speaker posit a sequence of steps during production, from conceptual encoding to articulation (e.g., Indefrey & Levelt, 2004) supported by behavioral and neurophysiological evidence. The question, however, of whether the temporal sequencing of language production processes posited for adults also holds for children remains largely unanswered. The present study contributes new findings to this under-researched issue by investigating processes involved in children's (in comparison to adults') production of morphologically complex words using event-related brain potentials (ERPs).

We adopted the silent production plus delayed vocalization paradigm from Budd et al. (2013) to compare ERP correlates of regular (-t) versus irregular (-n) participle forms of German verbs relative to a control condition of present-tense forms, for which the same lexical verbs do not exhibit any regular/irregular distinction. ERPs were time-locked to one of two picture cues prompting participants to silently produce either a (-t or -n) participle or a 2nd sg. present tense form from a visually presented verb stem (e.g. *mach* 'make', *komm* 'come'). Subsequently, the picture of a loudspeaker cued participants for an overt vocalization of their response (e.g. *gemacht/gekommen* vs. *machst/kommst*). The materials of the two test conditions were matched for frequency and length. Eighty-six monolingual German speakers were tested, 55 children (divided in two age groups; 28 older children (age range: 11;1-13;4), and 27 younger children (age range 8;02-10;3)) and 31 adults.

Our main findings were that while behaviorally children performed like adults, their brain potentials differed from those of adults in terms of distribution, amplitude, and latency. High accuracy rates of the overt behavioral responses indicated that all participants were able to reliably produce the required verb forms. ERP results of the adult group showed a significant negativity between 300 and 450ms in the frontal right area for *-t* (relative to *-n*) participles but no such difference for the present tense control condition. Older children's brain potentials revealed the same significant negativity as adults' but with a broader and more posterior distribution (posterior central, mid central and posterior right), and a longer latency (300-550ms). The younger child group also showed a negativity, but in a later time window (800-1000ms) in the posterior right area.

The negativity for *-t* relative to *-n* participles for both children and adults replicates the effect Budd et al. (2013) found for regular *-ed* (vs. irregular) English past-tense forms for the older children. We interpret this negativity as reflecting processes involved in forming morphologically structured word forms (e.g. [walk-ed], [ge-mach-t]). The spatial and temporal differences of the children's ERPs to those of the adults indicate that the brain networks involved in language processing are subject to developmental changes during childhood. According to Lidzba et al. (2011) the development of language production evolves from a bilateral towards an increasingly lateralized frontal presentation during late childhood. Our results are in line with that and, in addition, show that at least younger children are slower and less efficient than adults in the processing of morphologically complex words.

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Electrophysiological evidence for stem access in regular and irregular German participles

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This study investigated whether German participles are decomposed and accessed via their stem or retrieved as whole words. The German participle formation is of particular interest, since it is concatenative for both regular and irregular verbs: the prefix *ge-* and one of two suffixes, *-t* or *-en*, are attached to the stem.

Unlike previous electrophysiological studies that applied either violation paradigms or repetition priming to contrast regular and irregular inflection, the present study combined these two methods. Event-related potentials were measured when regular (*kaufen*, 'buy') or irregular (*werfen*, 'throw') base verbs were preceded by (a) their correct participles (*gekauft* and *geworfen*, respectively), (b) violated participles that illegally combined existing stems and participle suffixes (VPs, *gekäuft*, *geworft*, *gewurft*), and (c) pseudostem participles that illegally combined form-related stems and participle suffixes (PPs, *gekaust* and *gewenft*, respectively). Priming was measured relative to (d) unrelated participles that were matched on frequency, length, and suffix type to the correct participles (*geprüft* 'checked' and *geholfen* 'helped', respectively). Both regular and irregular participles facilitated their base. They induced strong left frontal negativities (LAN) as well as reduced centro-parietal negativities (N400 modulations) relative to the unrelated participles. Even though the effects by regular participles were more pronounced than those by irregular participles, the similarity of the effects argues for the same processing system. Furthermore, both regular and irregular VPs were as effective as correct participles in facilitating the base verbs, inducing strong N400 modulations and frontal negativities. This indicates that the

stems in VPs were accessed, regardless of whether they originated from regular or irregular verbs. By contrast, form-relatedness by PPs did not induce effects. Altogether these findings strongly argue for a single system that processes both regular and irregular inflection via access to the stem. Such a single processing model is presented.

Consolidation changes the influence of type and token frequencies on the generalisation of inflectional affixes

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Within natural languages, the processing and generalisation of inflectional morphology has been shown to depend on both type and token frequency. Here, we are particularly interested in understanding how speakers can generalise when presented with novel forms that are phonologically similar to both existing high type frequency regulars and high token frequency irregulars (e.g. *plit* as in *fit-fitted* and *sit-sat*). In these ambiguous cases, speakers can generalise based on type (*plitted*) or token (*plat*) frequency and these frequency measures in combination with phonological similarity jointly determine generalisation behaviour. In this study, we were interested in assessing whether a period of overnight consolidation changes the representation of type and token frequency and in turn influences generalisation behaviour.

To address this question, without the confounding factors that are typical of natural languages, we extended a paradigm developed by Mirković and Gaskell (in prep.). We created a novel plural system for an artificial language containing two sets of plural affixes that combined with novel nouns referring to the occupation of male and female characters. Mimicking natural morphological systems, the plural forms of the novel words were designed such that the majority had regular plural affixes and a minority had irregular plural affixes. That is, regulars had high type frequency (12 items) and irregulars had low type frequency (3 items). The plural system also resembled natural morphological systems in that irregulars had a high token frequency (24 training presentations/item) relative to regulars (6 training presentations/item). One subset of irregulars

had an ambiguous phonological cue (e.g. *arb*: *varb*, *farb*) that was associated with a high token frequency plural affix in irregulars (*varbesh*) but a high type frequency plural affix in regulars (*farbaff* but also *grollaff*, *shilnaff*, etc.).

We trained 18 participants in 3 sessions over the course of a week on these new plural affixes. On day 1, participants learned 36 novel masculine and 36 novel feminine singulars. On day 8, participants learned the plural form for 18 words in one gender (consolidated affixes). On day 9, participants learned the plural form for 18 different words in the other gender (unconsolidated affixes). Participants then completed a generalisation test in which they were presented with novel gendered singular forms and had to produce what they thought was the most appropriate plural form. For novel singular forms containing the ambiguous phonological cue, participants were more likely to generalise based on token frequency for consolidated affixes but more likely to generalise on type frequency for unconsolidated affixes.

These results suggest changes in the representation of newly-learned inflected words following overnight consolidation that lead to differential influences of type and token frequency during generalisation. We suggest that these findings can be interpreted within a complementary learning systems framework in which fast hippocampal learning assigns single representations to individual stimuli, independent of token frequency, whereas slower neocortical learning assigns overlapping representations to similar stimuli allowing token frequency to exert a greater influence on generalisation behaviour.

Neural signatures and cross-linguistic effects of morphological learning in L2

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Being able to extract and interpret the internal structure of complex word forms such as the English word *dance+r+s* is crucial for successful language learning. To study this under experimental conditions, we devised a simple word-picture associative learning task in an artificial language. In this task, the target words included a suffix marking the gender of the corresponding animate object. The participants were not informed of the embedded suffix. After the short exposure phase, lexical and morphological learning was probed by a word recognition task, followed by a rule generalization task for the suffix.

In the first experiment, we tested Spanish and Finnish adult participants to examine whether the ability to extract morphological information during word learning is affected by the morphological structure of one's native tongue. We entertained two opposing hypotheses. On the one hand, Spanish speakers may be more effective in identifying gender in a novel language because this feature is present in Spanish but not in Finnish. On the other hand, Finnish speakers may have an advantage as the abundance of bound morphemes in their language calls for continuous morphological decomposition. The results support the latter alternative, suggesting that lifelong experience on morphological decomposition provides an advantage in novel morphological learning. Despite the group differences, both groups were able to learn and generalize the morphological rules of a new language system.

In the second experiment, we used this paradigm to study ERP responses to lexical-semantic and morphological violations a day

after learning in another group of Spanish speakers. We found evidence for N400 negativity for semantic violation and P600 positivity for morphological rule violation in the newly learned words similar to the ERP signatures found in L1 processing. This finding provides evidence that the participants managed to integrate the new information into their existing linguistic knowledge after a brief period of training.

Incidental acquisition of grammatical gender in L1 and L2 German

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In three experiments we explored the L1 and L2 incidental acquisition of grammatical gender of novel German nouns (NNs) that were assigned the masculine, feminine and neuter gender.

In a pilot Experiment 1 which was a part of a larger study on incidental vocabulary acquisition, advanced learners of German with Slavic and Romance native L1s read short texts, each with three occurrences of a NN presented within unambiguously gender marked NPs. The 20 NNs replaced existing low-frequent German nouns. After each text, several additional sentences were read in a self-paced manner (SPR). One of them contained the NN within either a congruently gender marked phrase with respect to the gender assigned to the NN in the text (plausible condition), or incongruent with it (implausible condition). The subsequent analyses revealed a significant Plausibility x Gender interaction: feminine NNs were significantly slower (38ms) in the implausible condition and the same tendency was observed for neuter nouns indicating that participants acquired these two genders and perceived the occurrence of the corresponding NNs within implausible NPs as violations. On the other hand, masculine NNs exhibited numerical tendency of 18 ms in the opposite direction.

Experiment 2 was specifically designed to explore gender acquisition with carefully controlled materials. Based on a rating study we selected 24 NNs (eight of each gender) such that each of the NNs was rated equally probable for two genders. In the SPR part of the task, a given NN was presented with one of the two genders in the text and with the other gender in the implausible condition for half of the participants. For the other half the combination with the two genders in the text and in the implausible sentence was

reversed. This balanced design guaranteed that there was no bias towards a particular gender based on the phonological form of a NN. The pattern of results of a comparable group of L2 participants as in Experiment 1 was the same: both feminine (38ms) and neuter (15ms) NNs were read significantly slower when presented within gender implausible NP in the SPR sentence, while masculine NNs tended to be slower (t_2 n.s.) in the plausible condition.

Experiment 3 was a replication of Experiment 2 with native speakers. The results revealed a (delayed) significant implausibility effect for neuter (22ms) and masculine (33ms) NNs: The word following the neuter and masculine NN was read slower in the implausible than in the plausible condition; no difference between the conditions was observed for feminine NNs. The results reveal different incidental acquisition and/or processing patterns both for the individual grammatical genders and the L1 and L2 participants. They will be discussed in the context of default processing, L1 influence and recent findings indicating processing difficulties for German masculine both in aphasia (Seyboth, Blanken, Ehmann, Schwarz, Bormann, 2011) and with healthy L1 adults (Opitz, Regel, Müller, Friederici, 2013).

Processing morphological ambiguity: The case of Russian homographs

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Studies into temporal ambiguity resolution at different levels of the language (morphological, word-formational, lexical and syntactic) have given rise to the emergence of three main accounts of how a parser deals with linguistic units that initially might have more than one interpretation. The interactive view predicts that the parser does not make any preference in favour of this or that interpretation until it encounters a disambiguating element in the neighbouring context (Gibson, 1998; MacDonald, Pearlmutter & Seidenberg, 1994; Tanenhaus, Dell & Carlson, 1987). On the encapsulation approach, both possible interpretations are expected to be activated all along (Fodor, 1983). Finally, the “good-enough” account postulates the activation of one of the interpretations based on word frequency or the language system’s own principles and a later reanalysis in case the initial decision fails (Frazier & Clifton, 1996). The major part of morphological ambiguity research has featured words in isolation (Feldman & Andjelkovic, 1992; Katz, Rexer & Peter, 1995), which made it impossible to challenge all the three views and, thus, might have led to erroneous judgments.

We report a study on the morphologically ambiguous written forms of Russian nouns which can be differentiated in speech through word stress (homographs), e.g., *учИтел-я uchitelja* for TEACHER.ACC.SG and *учител-Я uchitelja* for TEACHERS.NOM.PL. The homograph condition was contrasted with the control one, where the noun ending unambiguously specified the morphological form, e.g. *музыкант-а muzykanta* for MUSICIAN.ACC.SG and *музыкант-ы muzykanty* for MUSICIANS.NOM.PL. Twelve quadruples with animate and 12 with inanimate nouns were

created and embedded in sentences such that the disambiguating element came five words later. Additionally, filler items to control for word order were added.

Sixty native Russian speakers took part in a self-paced reading study with memory and comprehension checks. Our results for the homographic inanimate nouns support the “good-enough” model: the reading times in the temporary ambiguous region did not differ much, but triggered a later reanalysis in the disambiguating region, as evident by a significant slow-down in the oblique case condition. Strikingly, the results for the homographic animate nouns are in tune with word-in-isolation research data and reveal a processing cost associated with the homographic case forms as compared to their respective univocal controls but no significant difference at the disambiguating region between the nominative- and oblique-case homographs, implying that several morphological interpretations are activated. The findings suggest a processing distinction between animate and inanimate nouns (Bird, Howard & Franklin, 2000; Caramazza & Shelton, 1998); other possible explanations are also discussed.

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Processing of case-marking and inflectional cues in object-verb-subject sentences: Is there an SVO-bias?

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Cancelled

In German, comprehension of sentences with object-verb-subject (OVS) order is associated with increased processing demands in terms of higher end-of-sentence response times as compared to SVO sentences (Bader & Meng, 1999; Gorrell, 2000). This effect has been observed for locally case-ambiguous as well as case-unambiguous OVS sentences. It is assumed that the OVS-disadvantage is associated with a processing-bias for an SVO interpretation, which needs to be revised when the input provides conflicting cues. However, studies using the visual-world eye-tracking paradigm found evidence for incremental processing of case-marking and inflectional cues indicating OVS order (Kamide, Scheepers, & Altmann, 2003; Knoeferle, 2007). Given the finding of rapid cue integration in visual-world studies, the question arises of why OVS sentences with unambiguous case morphology nevertheless entail a processing disadvantage when end-of-sentence responses are considered.

The goal of the present study is to explore processing of German SVO and OVS sentences using a modified version of the visual-world paradigm: eye-tracking during sentence-picture matching. In contrast to the classical version, this method uses action pictures showing a target (matching the sentence) and a foil picture with reversal of the theta-roles. In addition to eye-movements, we measured reaction times in the matching task. The combination of eye-tracking and sentence-picture matching allows us to investigate incremental online processing as well as end-of-sentence processing demands simultaneously.

We present 3 experiments, each of which comprised 20 young adults. In experiment 1a and 1b, we investigated processing of

unambiguous case-marking cues in German SVO and OVS sentences. In contrast to the b-version, experiment 1a also comprised passive fillers. Experiment 2 targeted processing of a number-marking cue at the verb in locally case-ambiguous SVO and OVS sentences.

Regarding end-of-sentence reaction times, we found an effect of condition for case-marked (Exp. 1a and 1b) and number-marked sentences (Exp. 2), i.e., RTs in the sentence-picture matching task were significantly higher for OVS than SVO sentences. Concerning eye-movements, we found a significant target picture preference from the verb onwards in OVS, but not in SVO condition for the case-marked sentences in Exp. 1a, suggesting faster processing of the accusative as compared to the nominative cue. However, in the b-version, in which no passive fillers were included, participants showed a preference for the foil picture during NP1 in OVS condition, whereas there was no such preference in SVO condition. This suggests that without passive sentences included in the experiment, participants initially pursued an SVO-interpretation, despite the presence of unambiguous morphological information indicating an OVS structure. For the number-marked sentences in Exp. 2, we found a preference for the foil picture during the locally case-ambiguous NP1 and the verb, indicating a bias for an SVO prediction, which was rapidly reanalysed towards an OVS structure after processing of the inflectional cue at the verb.

The results will be discussed with reference to possible intra-experimental strategies adapted by the participants and interactions of task demands, SVO predictions and incremental cue processing.

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The impact of morphological features on object relative clause comprehension in German

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Psycholinguistic research attested children's difficulties in relative clause/RC comprehension until age 5, but the accountable morpho-syntactic factors remain unclear and have only been studied in isolation so far. As for syntax, more errors are made with object-extracted (ORC) than subject-extracted RCs (SRC). This and the ORC difficulty could be explained by the presence of an intervening, interfering element (the embedded subject) between the moved object and its trace, whereas no such intervention occurs in SRC (Grillo, 2008). ORC become easier with embedded pronominal subjects (Friedmann et al., 2009). Turning to the impact of morphological features in RC comprehension, fragmented evidence coming from a number of studies points towards a gradient of difficulty case>number>gender. In case-marking languages, case (vs. number) is the strongest disambiguating feature (Arosio et al., 2011; Burchert et al., 2003; Guasti et al., 2012). In languages where number and gender are comparable, number is the strongest (Adani et al., 2010; Belletti et al., 2012).

This study examines how the factors RC type (SRC/ORC), embedded DP type (full DP/pronoun) and feature type (case/number) interact during development. We administered an auditory referent identification task to 57 German-speaking children. Since 5 years seems to be a critical age, participants were divided into preschoolers (N=23; mean age: 5;1) and school children (N=34; mean age: 8;2). A sample of the test sentences is given in Figure 1.

Feature	DP	SRC	ORC	Illustration
CASE marking	full DP	Wo ist der Igel, der den Käfer fängt? <i>Where is the hedgehog that catches the beetle?</i>	Wo ist der Igel, den der Käfer fängt? <i>Where is the hedgehog that the beetle catches?</i>	
	pronoun	Wo ist der Igel, der ihn fängt? <i>Where is the hedgehog that catches him?</i>	Wo ist der Igel, den er fängt? <i>Where is the hedgehog that he catches?</i>	
NUMBER marking	full DP	Wo ist das Küken, das die Frösche kitzelt? <i>Where is the chick that tickles the frogs?</i>	Wo ist das Küken, das die Frösche kitzeln? <i>Where is the chick that the frogs tickle?</i>	
	pronoun	Wo ist das Küken, das sie kitzelt? <i>Where is the chick that tickles them?</i>	Wo ist das Küken, das sie kitzeln? <i>Where is the chick that they tickle?</i>	

Figure 1: Test sentences in the referent-identification task by RC type (SRC/ORC), embedded DP type (full DP/pronoun) and feature type (case/number).

Accuracy of referent-identification revealed that SRC>ORC ($p<.001$), pronoun>full DP ($p=.003$) and case>number ($p<.001$), see the results in Figure 2. While preschoolers performed better with ORC disambiguated by case marking than if they were number-marked ($p=.003$), the morphological cue did not modulate school children’s ability to correctly interpret RCs. Moreover, an embedded pronoun aided comprehension if disambiguation was driven by number, but no such effect arose with case ($p=.05$).

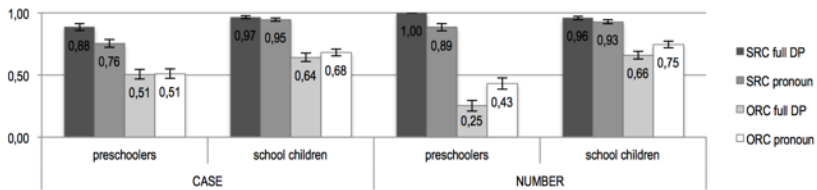


Figure 2: Accuracy of referent-identification by RC type (SRC/ORC), embedded DP type (full DP/pronoun) and feature type (case/number).

We propose that morphological marking (specifically case-marking) can facilitate the comprehension of German ORC, as the preschoolers’ data reveal. However, the intrinsic structural ORC complexity is resilient to the morphological manipulation, and ORC remain significantly harder than SRC also in school children. Implications for the (psycho-)linguistic theories of Relativized Minimality (Rizzi, 1990) and similarity-based interference (Lewis, 1996) will be discussed, together with eye-tracking data providing insights about online parsing processes (in preparation).

When morphology makes syntax easier: Number dissimilarities facilitate the comprehension of OVS sentences in German-speaking children

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Object-initial declarative sentences (OVS, e.g. *Die Frau küsst der Mann*, The_{ACC} woman kisses the_{NOM} man) are notoriously difficult for German-speaking children up to age 6 (e.g., Schipke et al., 2012). This difficulty could be explained as a violation of locality (Rizzi, 2013), triggered by the intervention of the subject constituent during the topicalization of the object constituent. In this study, we explore whether number morphology and, in particular, number dissimilarities between the subject and object DPs, facilitate the comprehension of OVS. Number morphology was shown to facilitate the comprehension of object relative clauses (e.g., Adani et al., 2014), another late-acquired structure, which presents word order similarities as compared to OVS (i.e., an initial object and an intervening subject).

We conducted a cross-sectional study with monolingual German-speaking children aged from 3 to 10 years (age range: 3;4-10;10), for a total of 236 participants. Family risk factors of language impairment were excluded using parental questionnaires. All participants were tested on canonical (SVO) and non-canonical (OVS) sentences using a picture-sentence matching task, which is part of a standardized test (Sieg Müller et al., 2011). For each *Word_Order* (SVO/OVS), two *Number* configurations were possible (*Match/Mismatch*). The verb arguments could either be both singular (*Match*) or one singular and one plural (*Mismatch*).

Seven-to-ten-year-olds performed at ceiling. Hence, only the accuracy scores of younger children were analysed using linear-mixed-models. The analysis of 4- and 5-to-6-year-olds reveals that SVO are easier than OVS ($p < 0.001$), *Mismatch* is easier than *Match*

($p < 0.05$). A significant Word_Order by Number interaction ($p < 0.01$) shows that the Match vs. Mismatch difference is more pronounced in OVS. Moreover, SVO are always above chance performance, OVS-Match are below chance and OVS-Mismatch are at chance in 4-year-olds but above chance in 5- to 6-year-olds. In contrast to older children, 3-year-olds only showed a main effect of Number (with Mismatch easier than Match; $p < 0.001$), with SVO and OVS-Mismatch at chance level and OVS-Match below chance level.

While these results replicate previous studies showing difficulties with the comprehension of some OVS sentences, we also found that number dissimilarities facilitated OVS differently across the age groups. The data of 4- to 6-year-olds support the intervention locality approach, which predicts OVS to be harder than SVO but particularly OVS are ameliorated via number mismatch on the subject (and agreeing verb) and object constituents. Number dissimilarities allow the passing from below chance performance (in OVS-Match) to chance (4yo) and above chance (5-6yo). The weaker effect in SVO-Mismatch (compared to SVO-Match) is explained as a generic effect independent of intervention, where a differentiation in the number of referents may simply facilitate theta-roles assignment (Belletti et al., 2012). In contrast to older children, 3-year-olds show an equal improvement on both sentence types in the Mismatch conditions. This reveals an early sensitivity to the number feature. This morphological information, however, is not yet able to compensate for OVS structural complexity, as evinced by chance level performance in OVS-Mismatch.

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Semantic transparency affects free stems: The Orthography-Semantics Consistency

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A largely overlooked side result in most studies of morphological priming is a consistent *main effect of semantic transparency* across priming conditions. That is, participants are faster at recognizing stems from transparent sets (e.g., farm), in comparison to stems from opaque sets (e.g., fruit), *regardless* of the preceding prime types (e.g., farmer vs. fruitless vs. unrelated primes). This suggests that the semantic transparency of the derived form may be also consistently associated with some property of the stem word.

We propose that this property is how predictable the *meaning* of a word is on the basis of its orthography. The word onset WIDOW is very informative because every word in the English lexicon that starts with it relates to the same meaning (WIDOWER, WIDOWED, WIDOWHOOD). Conversely, WHISK is a less informative orthographic chunk because the words that start with it refer to different meanings (WHISKEY, WHISKY, WHISKERED, WHISKER). We name this property Orthography-Semantics Consistency (OSC). In the present study, we exploit distributional semantic models to quantitatively characterize OSC, and test its effect on visual word identification relying on large-scale data taken from the British Lexicon Project (BLP; Keuleers, Lacey, Rastle & Brysbaert, 2012).

In Experiment 1, we confirm the reliability of the “stem transparency” effect by showing that it holds when testing 335 stems taken from previous masked priming studies on the BLP data. In Experiment 2, we proceed to compute OSC. For each item used in Experiment 1, we extract all the words with a similar onset, forming a family of “orthographic relatives”. Using distributional-semantics methods (Turney & Pantel, 2010), we automatically generate the

semantic similarity between a stem and each of its orthographic relatives. We compute OSC as the frequency-weighted average semantic similarity. The resulting OSC measure has a significant effect in the expected direction: stems taken from transparent sets have significantly higher OSC than stems taken from opaque sets, and OSC has a facilitatory effect on BLP latencies in lexical decision. Hence, items taken from previous morphological priming studies are mismatched with concern to OSC, and this contributes to different RTs observed in the transparent vs. opaque sets.

In Experiment 3, we show that OSC has a general effect in visual word recognition by testing it on 1821 words randomly selected from the stimuli included in the BLP database. Also when considering this large set of items, the effect of OSC on lexical decision latencies is significant even when all the other established predictors (e.g., length, frequency, family size) are taken into consideration.

Taken altogether, these results indicate that OSC can account for relevant aspects of the visual word recognition process. This evidence calls for a reconsideration of previous results on morphological priming.

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Form and meaning in early morphological processing: A masked priming study on Turkish

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It is commonly assumed that in the early stages of visual word recognition, an automatic morphological decomposition process is at work which is blind to semantic properties. Support for such a morpho-orthographic decomposition view mainly comes from masked priming studies in which comparable magnitudes of priming effects are reported for semantically *opaque* pairs, which share an apparent stem but are not semantically related (e.g., corner-corn), and *transparent* pairs (e.g., worked-work), which bear a genuine semantic relationship between the word form and its stem, (e.g., Longtin, Segui, & Halle, 2003; Rastle, Davis, & New, 2004). There are, however, also studies that point to the opposite direction, reporting that semantically opaque word forms actually fail to prime their stems and produce smaller priming effects than semantically transparent items (e.g., Feldman, O'Connor, & Moscoso Del Prado Martín, 2009; Feldman, Kostic, Gvozdenovic, O'Connor, & Moscoso Del Prado Martín, 2012).

The present study aims to contribute to this controversy by presenting the results from a masked priming experiment in Turkish, an agglutinating language that employs productive affixations of morphemes to roots. The experiment employed prime-target pairs in five types of conditions:

- (a) *transparent inflectional*: morphologically, semantically and orthographically related pairs containing an inflectional suffix (e.g., *geçti-GEÇ*, 'passed-PASS'),
- (b) *transparent derivational*: morphologically, semantically and orthographically related pairs containing a derivational suffix (e.g., *hızlı-HIZ*, 'fast-SPEED'),

- (c) *opaque inflectional*: morphologically and orthographically related, but semantically unrelated pairs containing an apparent inflectional suffix (e.g., *azim-AZ*, 'ambition-LITTLE'),
- (d) *opaque derivational*: morphologically and orthographically related, but semantically unrelated pairs containing an apparent derivational suffix (e.g., *kaygi-KAY*, 'anxiety-SLIDE'),
- (e) *form*: orthographically related, but morphologically and semantically unrelated pairs (e.g., *darbe-DAR*, 'strike-NARROW').

The experiment was conducted with 38 adult native speakers of Turkish and employed a stimulus onset asynchrony of 50 milliseconds.

The results revealed significant priming effects for the transparent conditions (*transparent inflectional* & *transparent derivational*) only. No significant priming effects were found in the two *opaque* conditions or in the *form* condition, however. While the results replicate earlier findings for Turkish (Kırkıcı & Clahsen, 2013), they fail to support models of lexical processing that assume semantically blind early morphological decomposition.

**The morphological processing of derived words in L1 and L2
Turkish**

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The processing of morphologically complex word forms has predominantly been studied in a handful of languages such as English and German (Silva & Clahsen, 2008; Clahsen & Neubauer, 2010), while Turkish, a non-Indo European language with a rich, productive, and agglutinating morphology, has not received much attention either as a first or a second language. In one of the very few studies on the morphological processing of complex word forms in Turkish, Kırkıcı and Clahsen (2013) investigated the processing of inflection and derivation and reached the conclusion that the processing of derived words by both native and non-native speakers of Turkish involves combinatorial rules and morphological decomposition. Against this background, the purpose of the present study was to further scrutinize the way in which derived word forms are processed in L1 and L2 Turkish and to uncover the processing similarities/differences between L1 and L2 speakers of Turkish.

Using masked priming experiments (SOA=50 ms), the processing of derived word forms involving the attributive suffix -li (e.g. *kullanışlı* “useful”) and the privative suffix -siz (e.g. *kullanışsız* “useless”) was investigated. The morphological processing of these two derivational suffixes was contrasted as both are, on the one hand, equally productive, transparent and frequent but, on the other hand, constitute morphological opposites. The critical items for the experiments consisted of a total of 40 item sets, for 20 of which the test (related) prime was a denominal adjective derived with -li and for the remaining 20 of which the test prime was a denominal adjective derived with -siz. 63 L1 and 20 L2 speakers of Turkish from various L1 backgrounds participated in the experiments.

L1 speakers of Turkish displayed robust priming effects for both suffixes, which can be taken as evidence for the automatic morphological parsing of derived words during visual word recognition in L1 Turkish. The L2 group, on the other hand, did not show any significant priming effects for either of the suffixes, which could be taken as an indication of full-form storage. The results will be discussed with reference to findings from cross-linguistic psycholinguistic investigations into L1 and L2 morphological processing.

Comparing second language learners' sensitivity to Arabic derivational and inflectional morphology at the lexical and sentence levels

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While second language (L2) learners are less sensitive than native (L1) speakers to morphological structure in general (Clahsen & Felser, 2006; Jiang, 2007; Neubauer & Clahsen, 2009), researchers disagree about the roles different features of morphological systems play in determining the time course and accuracy of their acquisition by L2 learners. Some studies suggest that L2 learners process derivational morphemes in a more native-like manner than inflectional ones (Silva & Clahsen, 2008; Kirkici & Clahsen, 2013). Other research demonstrates accurate acquisition of L2 inflectional morphology as well (Gor & Jackson, 2015; Hopp, 2003; Jackson, 2006; Sagarra & Herschensohn, 2010). To date, few studies have directly compared L2 acquisition of inflectional and derivational morphology (Silva & Clahsen, 2008; Kirkici & Clahsen, 2013). Arabic verbs exhibit a system of derivational morphology whose function in constraining event structures and theta roles allows for comparably direct comparison with inflectional morphemes at the sentence level.

Forty-four L2 learners and thirty-three native speakers of Arabic participated in the current study, which used two behavioral tasks: a primed lexical decision task and a self-paced reading task, to ascertain L1 and L2 Arabic learners' commands of derivational and inflectional morphology at the lexical and sentential levels. Results of the lexical decision and self-paced reading tasks indicated that both L2 learners and native speakers alike made use of Arabic derivational and inflectional morphological structure during lexical access and sentence processing. This pattern of results accords with previous research that found accurate processing of inflectional

morphology in proficient L2 learners. It also adds to a growing body of research suggesting that the distinction between derivational and inflectional morphology in Semitic languages may be more graded than it is in Indo-European languages (Marslen-Wilson, 2007).

Decomposition and processing of highly complex forms: A case study of German nouns

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In the literature on morphological processing, two types of models have traditionally been discussed in particular detail. Connectionist models reduce morphology to the interplay between phonology and semantics, and thus argue that morphology does not play an independent role in processing (Seidenberg & Gonnermann, 2010). Dual-route models incorporate a strong morphological component, in which processing is handled jointly by decomposition and the holistic retrieval of full-form representations. However, it is not always clear how these two routes interact.

Recent research further suggests the possibility that decomposition may proceed along a single-route. For instance, Clahsen, Sonnenstuhl & Blevins (2003) found that German diminutives like “Kindchen” showed full-form frequency effects in unprimed lexical decisions tasks, but also primed their base form “Kind”. In a single-route model, base form priming is the result of decomposition, whilst full-form frequency is understood to reflect the frequency at which stem and affixes recombine following initial decomposition and a subsequent compatibility check (Taft & Forster, 1975).

Against this background, the research presented here is the first to investigate the processing of 2-suffixed existent (“Teilbarkeit”) and non-existent, but possible derived words (“*Büßbarkeit”). In a delayed priming experiment, it was found that unprimed lexical decision responses to complex non-words took significantly longer, and elicited significantly more errors, than for matched control non-complex nonwords. Unlike existent words, however, they did not prime their roots. Full-listing approaches arguably fail to account for

this sensitivity to morphological structure in non-existent (i.e., unlisted) possible derived forms.

These results are instead more consistent with a single-route model in which existing morphologically complex words are represented as “X”-bar-keit: as words listed with their underlying morphological structure. Possible sequences of suffixes occupy adjacent positions in the web of morphological relationships represented in the lexicon. A speaker, upon encountering a root + “-bar” + “-keit”, identifies and strips off the affixes in an orderly fashion, i.e. first “-keit”, then “-bar”, as a result of which the speaker encounters a bin labelled “X” that contains all stems that participate in the derivational paradigm. It is possible that for every concatenation of base and affix, such a bin with different but overlapping stem entries exists. When a complex word is encountered, following decomposition into its constituent morphemes, the bin “X”, which is organized according to frequency of combination with the respective affixes, is searched for a match. A successful match with an entry in “X” confers a certain level of activation to the root, resulting in a priming effect. This effect will not extend to the roots of possible words, which do not have an entry in “X”.

As non-existent complex words are endowed with features that license them to become existent words, their roots bear the potential of being added to “X”. Future research will need to address questions pertaining to the relationship between learning and processing to shed light on the transition from learning a possible word to processing a newly acquired, existing word.

**The influence of morphophonological rules in production:
Evidence from aphasia**

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Previous research has indicated that a series of stochastic morphophonological rules may play a role in the morphological productivity of both regular and irregular novel verbs (e.g. Albright & Hayes, 2003). The present study examines the performance of an aphasic individual with an acquired morphological deficit to investigate whether a grammar of morphophonological rules impacts production more generally, including the production of known words. In order to establish the presence of a morphological deficit, we designed two tasks to decouple effects of morphology and phonology and evaluate regular and irregular verb production. These were followed by a past-tense elicitation task designed to analyze the impact of morphophonological rules on accuracy and error patterns in production.

Case Report. RMI, 39, right-handed male, presented with aphasia secondary to stroke. His production in spontaneous speech, reading, and writing, includes frequent morphological errors, with semantic and phonological errors also occurring.

Experiment 1. RMI was administered a single-word reading task containing homophone pairs that orthogonally varied morphological and phonological complexity (e.g. *prays-praise*, *locks-lox*). Over 606 productions, deletion of final consonants occurred significantly more often for morphologically-complex words (*locks*→*lock*) compared to homophones (*lox*→*[lak]*). This difference reveals a morphological deficit distinct from phonology.

Experiment 2. RMI was administered a single-word reading task containing 40 irregular verb pairs (*win-won*), 40 regular verb pairs phonologically-matched to the stem (*sin-sinned*), and 40 monomorphemic word pairs phonologically-matched to the

irregular verb pairs (*tin-ton*). Over three productions of these lists, RMI produced morphological deletion errors at comparable rates on inflected regular verbs (*sinned*→*sin*) and on inflected irregular verbs (*won*→*win*), whereas the analogous error (*ton*→*tin*) never occurred on the monomorphemic pairs.

Experiment 3. RMI was administered a past-tense elicitation task. Sentence frames including regular and irregular verbs were presented verbally and visually (e.g. “Every day I **run** a mile. Just like every day, yesterday I ____ a mile.”). We calculated a confidence score for each verb representing the amount of lexical support for a given inflectional pattern based on morphophonological rules (Albright & Hayes, 2003). Over 800 verb productions, this confidence score was a significant predictor of production accuracy and error types for both regular and irregular verbs, even when accounting for effects of other lexical variables.

The results of Experiment 1 indicated a morphological production deficit that is separable from phonological impairment, and the results of Experiment 2 further demonstrated that this morphological deficit extends to both regular and irregular verb production. Experiment 3 demonstrated that the production of both regular and irregular verbs was affected by the extent to which the morphophonological rules of an inflectional pattern are supported in the lexicon. Taken together, these findings provide evidence that morphophonological rules play a role in spoken production extending beyond the inflection of novel words.

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A brain network for integration of tone and suffix

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Previous studies distinguish between right-hemispheric processing of prosodic/tonal information vs. left-hemispheric processing of grammatical information, while left-hemispheric processing of lexical tones has also been suggested. Swedish word accents offer a prime testing-ground to better understand this division. Although similar to lexical tones, word accents are determined by words' morphosyntactic structure, which enables listeners to use the word accent tone at the beginning of a word stem to predict the grammatical ending. We recorded electrophysiological and hemodynamic brain responses to words where the stem tone matched or mismatched the inflectional suffix. Tones increased neural activity after 136 ms, correlating with BOLD activation in left primary auditory cortex, superior temporal gyrus, and inferior frontal gyrus. Invalidly cued suffixes activated the left inferior parietal lobe, arguably reflecting increased processing cost of their meaning. In sum, we find a rapidly activated, predominantly left-hemispheric network which underpins interaction of word accent tones with grammatical morphology.

Morphological processes and reading directions

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Studies on reading directions (e.g., Huey, 1898; Yu, Park, Gerold, & Legge, 2010) and those on lexical processes have so far developed as distinct streams of research. A consequence is that it is still not clear whether models of morphological processes proposed by horizontal reading studies can be generalized to vertical reading. Although it is commonly believed that lexical effects reflect higher-level cognitive processes, it is not unlikely that vertical reading induces a different pattern of processing. Vertical reading, for example, may motivate more holistic supra-lexical processing due to lack of horizontal eye movements.

The present study investigated (1) whether there is overall processing cost for vertical reading over horizontal reading in word recognition and (2) whether reading directions (horizontal vs. vertical alignments) modulate lexical effects in morphologically complex word recognition. To this end, a lexical decision eye-tracking experiment was conducted with vertically presented Japanese two-*kanji*-character (i.e., bimorphemic) words. The data were analyzed together with those obtained in a horizontal lexical decision experiment of Miwa, Libben, Dijkstra, and Baayen (2014). Miwa et al. (2014), based on patterns of eye movements in lexical decision experiments with horizontally presented Japanese compounds, proposed that morphological processing in Japanese is initially driven by characters (i.e., morphemes), rather than radicals (i.e., sub-morphemic components) or a whole word unit.

Linear mixed-effects regression analyses fitted to readers' response times, early and late eye fixation durations, fixation counts, and saccade amplitudes revealed that there is early

processing advantage in horizontal reading when the first morpheme is processed. More importantly for morphological processing research, although characters remained the primary processing units regardless of reading directions as predicted, lexical processes were not identical in the two alignments. Reading directions modulated frequency effects of the first character in a response time measure: facilitation in horizontal reading and inhibition in vertical reading. All in all, the results indicate that, while the character-driven pattern of morphological processing generalizes to vertical reading, different reading directions also induce qualitatively and quantitatively different linguistic processes.

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More than a noun, less than a verb: Observing the noun-verb distinction from the noun-verb continuum perspective

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Within the debate on the locus of the difference between nouns and verbs it is not clear whether this difference is the result of a distinction at the lexical-grammatical level (Shapiro & Caramazza, 2003) or at the semantic level (Vinson & Vigliocco, 2002). The main limit of both hypotheses is that they are mostly based on the difference between prototypical elements of each category.

The present research investigates the noun-verb distinction throughout the noun-verb continuum theory (Givón, 1986). Nouns and verbs are bundles of properties more than temporary stable entities or action/events. Only the prototypical members of these categories (i.e. object nouns and finite verbs) show the highest number of features which qualify them as nouns or verbs. The representation of grammatical classes in terms of prototypes permits to isolate then single morphosyntactic features and to establish the position of non-prototypical members along the continuum. What is in between nouns and verbs is a question of degree of similarity to the prototype.

In Italian, there is evidence that both in production and recognition processes (Laudanna, Gazzellini & De Martino, 2004; Laudanna, De Martino, Postiglione, 2011) non-finite verb forms (infinitives and participles) tend to behave more as nouns than as finite verb forms (indicatives, subjunctives, conditionals). This experimental research represents the first attempt to investigate the noun-verb distinction by comparing both prototypical and non-prototypical forms of nouns and verbs. At the same time it aims at

analyzing the reliability of the noun-verb continuum on a cognitive level.

In the light of the noun-verb continuum hypothesis we assume that the more a form moves away from the prototype, the more its processing is different from the processing of prototypical forms.

In a grammatical decision task, participants were asked to assign the grammatical class to the following word types: object nouns (*biscotto; biscuit*), denominal action nouns (*coltellata; stab*), deverbal action nouns (*censimento; census*), past participles with a noun homograph (*abitato; inhabited/residential area*), unambiguous past participles (*raccontato; told*), finite verbs (*taceva; he kept quiet*).

The analysis of errors and reaction times showed that the loss of nominal features and the simultaneous acquisition of verbal features (i.e. the non-prototypical forms between object nouns and finite verbs) correspond to a constant increasing in both response times and errors. Interestingly, deverbal action nouns were significantly slower than denominal action nouns. No differences were found when word forms containing both nominal and verbal features and resulting equidistant from the prototypes are compared (i.e. deverbal action nouns and past participles with a nominal homograph). These findings suggest that noun-verb distinction is not only explainable by mere action-object opposition and are in line with the noun-verb continuum assumptions: the distribution of nominal and verbal morphosyntactic features establishes the position of a word form along the continuum and drives the grammatical class assignment.

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Inflectional encoding during word production: Insights from word-picture interference paradigm with Italian verbs.

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In many languages, words sharing the same set of inflectional realizations are grouped into inflectional classes (IC) (Carstairs-McCarthy, 1994): e.g. the three Italian verbal conjugations. IC information has morphological implications, since speakers are allowed to generate all the possible forms of a word by knowing its IC. In Italian, where each word form undergoes processes of inflectional encoding, IC is crucial for the selection of the appropriate endings of words and it cannot be left unspecified.

We exploited the word-picture interference methodology (WPI) to investigate IC effects during production of verbs (Bordag & Pechmann, 2009). Italian speakers named pictures of actions as finite verbs (*esplode*, 2nd conj., present indicative, 3rd singular person, he-she-it explodes, Experiment 1) or as non-finite verbs (*esploedere*, infinitive, to explode, Experiment 2). The congruency of IC between targets and distracters was manipulated:

- in the congruent condition (CC), the distracter shared the IC with the target (*beve*, 2nd conj., present indicative, 3rd singular person, he-she-it drinks);
- in the non-congruent condition (NCC), the distracter did not share the IC with the target (*fugge*, 3rd conj., present indicative, 3rd singular person, he-she-it escapes).

A control condition with action nouns as distracters (*furto*, theft) and a neutral baseline were also included. The distracters in the three experimental conditions were matched for the main psycholinguistic variables and any semantic or formal relation between targets and distracters was avoided.

In Experiment 1, but not in Experiment 2, verb-distracters in the CC induced stronger interference than verbs in the NCC.

Different patterns of results were observed in the two experiments also when comparing noun-distracters and verb-distracters. In Experiment 1, noun-distracters induced interference when compared with verb-distracters but only in the NCC. In Experiment 2, verb-distracters induced facilitation when compared with nouns only in the CC.

These findings can be explained by assuming that the naming context (finite vs. non-finite verbs) modulates the sensitivity of the WPI task to morphological (IC) and grammatical class information. When finite forms have to be produced (Experiment 1), the naming context sets the response-relevant criterion on the grammatical class of verbs. This promotes the emergence of morphological effects (IC) which are subordinated to grammatical class: the production system, at least in highly inflected language like Italian, dictates to discriminate between various available allomorphs to choose the one that is appropriate for inflection. The activation of different morphological information in CC and in NCC can explain the different pattern of naming latencies of verb-distracters when compared with noun-distracters.

When non-finite verbs have to be produced (Experiment 2), the naming context sets the response-relevant criterion on the category of “names for actions”. Actually, infinitives, although being verbs, can be used as substantives for the name of the action denoted by verb, as in the sentence “*adoro ballare*”, (verb infinitive), I love dancing. As a consequence, effects due to verbs morphology (IC) tend to disappear and different pattern of latencies are observed between distracters from different grammatical classes.

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Conference venue: Campus “Neues Palais”

