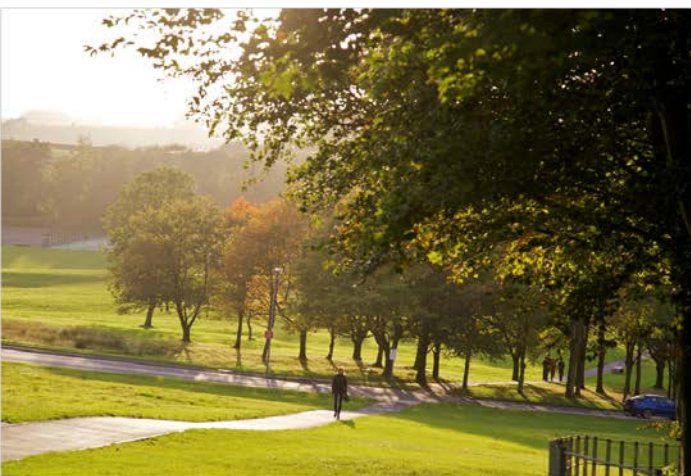# Fifth Implicit Learning Seminar
Lancaster, June 23-25, 2016

Organisation

Organizing committee: Patrick Rebuschat, Padraic Monaghan, Kirsty Dunn, Rebecca Frost

Student volunteers: James Brand, Katharina Braungart, Christian Kliesch, Chloe Newbury, Christine Schoetensack, John Shaw, Jose Luis Moreno Vega

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URL: http://www.lancaster.ac.uk/implicit-learning-seminar

Program Committee

We are very grateful to the members of our Program Committee for their abstract reviews:

- Ben Ambridge
- Sible Andringa
- Blair Armstrong
- Panos Athanasopoulos
- Colin Bannard
- Laura Batterink
- Julie Bertels
- Cylcia Bolibaugh
- Silke Brandt
- Carel ten Cate
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- Bert Timmermans
- Katie Twomey
- Janne von Koss Torkildsen
- John Williams

Sponsorship

Important information

Location

- The conference will take place in the Lancaster University Management School (building 52 on campus map, https://www.lancaster.ac.uk/maps/campus.pdf).
- Keynotes and paper presentations will take place in Lecture Theatre 1.
- Poster presentations will take place in the Hub area, i.e. the large social space adjacent to Lecture Theatre 1.

Registration

- The registration desk is located in the Hub area.
- The desk will be staffed between 8:30 and 9:00 on Thursday, Friday, and Saturday as well as during coffee breaks.

Coffee breaks, lunch, and reception

- Coffee breaks (Thursday, Friday, Saturday), the evening reception (Thursday), and lunches (Thursday and Friday) will take place in the Hub area.
- Lunches on Thursday and Friday are included in the registration fee but participants need to make their own arrangements for Saturday. There are many options on campus, and our volunteers are happy to point you in the right direction on the day. You will also find a campus catering map in your delegate pack.

Best Poster Prize

- We are pleased to announce that John Benjamins is sponsoring prizes for the three best posters of the conference. Each award provides a book voucher with which the recipient can purchase titles from the John Benjamins catalogue (https://benjamins.com/) and a one-year subscription (electronic) to one of John Benjamins' journals.
- Posters will be judged by our invited speakers, who will rate each poster based on (i) the quality of the study, (ii) its originality in relation to the field, and (iii) the quality of the presentation.
    - First prize: 100 GBP book voucher plus one-year journal subscription
    - Second prize: 75 GBP book voucher plus one-year journal subscription
    - Third prize: 50 GBP book voucher plus one-year journal subscription

Travel information

- For detailed travel information, please visit http://www.lancaster.ac.uk/contact-and-getting-here/
- Local taxi services can be reached on the following numbers: +44 (0)1524 32090; +44 (0)1524 35666; and +44 (0)1524 848848.
- Visitor car parking is available on campus 24/7 and is free after 6pm. If you are visiting the campus during the day then parking charges apply. These can be purchased from

any of the eleven pay and display machines across campus at a cost of 2 GBP for two hours. Chip and pin card payment facilities are available at several machines. Alternatively, all-day visitor scratch cards are available from the cashiers' desk in University House priced at 5 GBP each.

- Bus service from town to the university: The bus station is situated on Damside Street in city center. Buses (services 2, 2A, 3, 4, X4, 42) leave for the University every five minutes on weekdays and most services also stop at Common Garden Street. Additionally, the 3A and X4 bus services run every 30 minutes between the Railway Station and the University (Monday to Saturday daytimes; hourly on Sunday afternoons and evenings).
- Bus service from campus to town: All buses drop off and collect passengers in the Underpass, situated underneath Alexandra Square. Additionally, services 3 and 4 serve the southern perimeter road around Alexandra Park. There are also bus stops directly outside the Sports Centre on the main drive.

Internet access

- To access the Visitor Wi-Fi network, simply select the "LU-Visitor" network, then follow the registration screens.
- Visitor Wi-Fi access will last for 24 hours. For longer access, you will need to register again.
- For support on the day, please see one of our volunteers.

Social events

- Thursday, June 23: Evening reception
    - o The reception will take place in the Hub between 17.30 and 20.00.
    - o Warm food (buffet) and drinks will be served.
    - o The reception is included in the registration fee.
- Friday, June 24: Conference dinner
    - o This year's conference dinner will be hosted at The Sun Café Restaurant from 19.00. The restaurant is located at 25 Sun Street, Lancaster LA1 1EW.
    - o The conference dinner is not included in the registration fee. Advance booking is required via the Online Store.
- Saturday, June 25: Excursion to Ambleside
    - o We are organizing an excursion to Ambleside in the Lake District for those who would like to finish off their visit with a bit of adventure. The excursion departs from the University underpass. Volunteers will walk from the conference venue to the underpass at 13.20.
    - o On arrival in Ambleside, we will walk to the summit of Loughrigg Fell offering views of the Langdale Pikes, Fairfield Horseshoe (pictured on page 11), and Lake Windermere. There will be a small amount of time following this to look around the historical town of Ambleside before the bus returns to Lancaster in the early evening.
    - o The excursion is included in the registration fee but there is a limited number of spaces (50) and registration via the Online Store is required.

Food and drink on campus and in town

- Below is a list of favorites, based on an informal survey of Lancaster linguistics staff and students.
- Options on campus (selection):

o	Café 21	Nice vegetarian, vegan, and gluten-free food, with great views. Service can be slow at busy times.
o	Pizzetta Republic	Good restaurant for those who like pizza, late opening times. Good for coffee, too.
o	Grizedale Café Bar	Famous for Stone Willy's pizzas and hot wraps as well as dinky dipping hot donuts with a choice of sprinkles and sauces.
o	Sultan of Lancaster	Indian restaurant and takeaway, serves a variety of curries, chicken and wraps. Late opening times.
o	The Deli	Popular deli salad bar with fresh, homemade tartlets, a selection of meats and cheeses as well as hot roast sandwiches and filled focaccias.
o	The Lounge	Restaurant on campus close to the university guest rooms. Good food, though service can be slow if busy. Also good place for a sit-down coffee.
o	The Mill at Fylde College	A great choice of fresh toasties and sandwiches or for something more filling, try the burgers and burritos. They serve "Primal Feast burgers, with two to choose from weekly including camel, alpaca, elk and kangaroo." Open for dinner, too.
o	The Trough of Bowland	Traditional homemade pie served with potatoes and vegetables from 12.00. Open for dinner, too.
o	Trevor at Furness College	Freshly ground coffee, whole-leaf brew tea and a variety of cakes with gluten-free options.
o	Wibbly Wobbly Burger	Good burger place, not on the campus map, simply follow directions to Grizedale College. Open till late.

- Options in Lancaster town centre:
    - For restaurants, phone numbers are provided below. Reservations are recommended, especially for larger groups.

o	1725	Nice Tapas restaurant. Serves dinner until 21.30 (though open for drinks until 23.00). (Market Street, 01524-66898)
o	Full House Noodle Bar	Chinese, Malaysian. Very casual. Just walk through the shop and go upstairs. Shuts at 21.00. (21 Common Garden St, 01524-842888)
o	Kashish	Good Indian restaurant. Bring your own alcohol (which can be purchased at nearby Sainsbury's supermarket...). Open till 23.00. (32 Parliament Street, 01524-388 222)
o	Priory Hall	Serves excellent coffee from local, award-winning roastery (Atkinson's). Nice cakes, too. Shuts at 17.00. (10 China Street)
o	Sun Café	Very nice restaurant, Mediterranean cuisine. They also run Sun Pizza, a good pizza restaurant in the same street. (25 Sun Street, 01524-846252)
o	The Borough	Nice pub in town, has its own brewery. Serves food till 21.00, drinks till 23.30. (3 Dalton Square, 01524-64170)
o	The Tap House	Artisan brews and niche wines, good for drinks (open till midnight). (Gage Street, 01524-842232)

Family days out in and around Lancaster

- Things to do in Lancaster:
  o Williamson Park – Lancaster's favorite park offers beautiful panoramic views of Lancaster and its surrounding area. The Ashton memorial, butterfly house, mini beasts (meet the new arrival of Lancaster's meerkats) and bird attractions make an entertaining visit.
  o Lancaster Castle – Take a tour of Lancaster's most historic building dating back to Roman times; owned (and recently visited) by Her Majesty the Queen.
  o The River Lune – Take a stroll along the River Lune. The pathway between Lancaster and Caton offers some interesting features on and around the river.
  o The Zone soft play – Found in central Lancaster, this offers play areas for babies, toddlers and juniors including sensory features, wall puzzles, bouldering wall and aerial slide.
  o Morecambe beach and promenade – Take the train or bus to our nearest seaside town. This long stretch of beach is ideal for sandcastles providing the English summer weather is kind to us.

- If you have your own transport:
  o Old Holly Farm – Located on the A6, 5.5 miles from the University, this farm offers the opportunity to meet their baby lambs, chicks and calves alongside other farmyard animals as well as an indoor play area, café and farm shop.
  o The Pudding House, Wallings Farm – Located close to the A6, 5.5 miles from the University, the Pudding House boasts homemade, fresh food including the best ice-cream sundaes to be found. Choose from a wide range of flavors, and visit the farm animals. N.B. Don't panic if you don't have transport; we have our very own Wallings farm ice-cream shop on campus (Alexandra Square)!

- A little further afield:
  o Liverpool and Manchester can be reached within 1-1.5 hours by rail from Lancaster. Here you can visit a fantastic selection of museums, theatres, shops and parks.
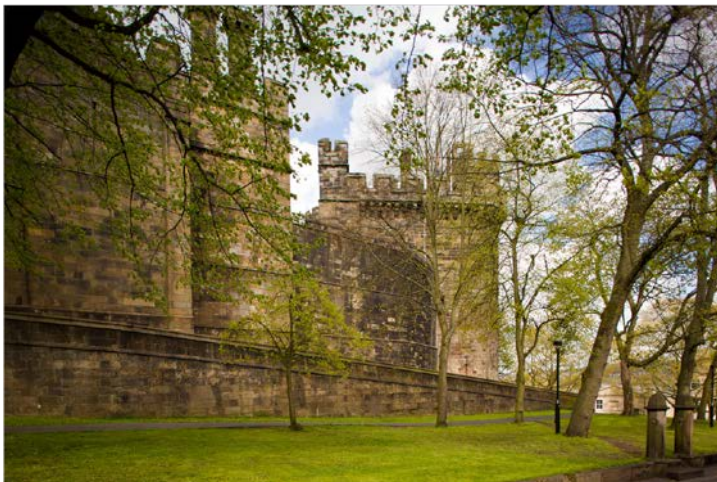
Lancaster Castle (left) and The Ashton Memorial (right)

Schedule

8.30 to 9.00   Registration

9.00 to 10.00   **Opening remarks, followed by Keynote: Morten Christiansen**
Implicit-statistical learning: A tale of two literatures

10.00 to 10.20 Dagmar Divjak, Petar Milin, and Harald Baayen
Do implicit sequence learning abilities underpin language processing? A view from naïve discriminative learning

10.20 to 10.40 Karolina Janacsek, Andrea Kóbor, Ádám Takács, and Deszo Nemeth
One-year retention of implicit sequential memory

10.40 to 11.00 Branislav Savic, René Müri, and Beat Meier
Modulating implicit task sequence learning and consolidation with prefrontal cortex transcranial direct current stimulation (tDCS)

11.00 to 11.30 Coffee break

11.30 to 11.50 Deszo Nemeth, Brigitta Tóth, Ádám Takács, Zsófia Zavecz, Andrea Kóbor, and Karolina Janacsek
Competitive networks underlying implicit learning: Evidence from a functional connectivity study

11.50 to 12.10 Laura Batterink and Ken Paller
Tracking sensitivity to stimulus sequence structure with a neural measure during learning

12.10 to 12.30 Guillaume Thierry, Si Jing Tan, Emma Jones, and Cécile Barbet
Does implicit learning go deeper than explicit learning?

12.30 to 14.30 Lunch break and Poster Session 1 (lunch included in registration fee)
Please see page 11 for list of poster presentations.

14.30 to 14.50 Monika Derda, Borysław Paulewicz, and Michał Wierzchoń
The interplay between attention load and awareness in the artificial grammar learning task

14.50 to 15.10 John Williams, Michelle Sheehan, and Albertyna Paciorek
Linguistic naturalness and semi-artificial language learning

15.10 to 15.30   Noam Siegelman, Louisa Bogaerts, and Ram Frost
What determines visual statistical learning performance? Insights from information theory

15.30 to 15.50   Arnaud Rey, Frédéric Lavigne, Fabien Mathy, and Joël Fagot
Beyond transitional probabilities: Learning XOR in non-human primates

15.50 to 16.30   Coffee break

16.30 to 17.30   **Keynote: Carel ten Cate**
The auditory rule learning abilities of birds

17.30 to 20.00   Reception

Friday, June 24, 2016

8.30 to 9.00   Registration

9.00 to 10.00   **Keynote: Linda Smith**
Infant statistical word-referent learning at scale

10.00 to 10.20   Jessica Hall, Amanda Owen Van Horne, and Thomas Farmer
Distributional learning ability in typically developing children

10.20 to 10.40   James Hutson, Shekeila Palmer, and Sven Mattys
Speech segmentation by statistical learning in young, middle-aged, and older adults

10.40 to 11.00   Rebecca Frost, Padraic Monaghan, and Morten Christiansen
High-frequency words can assist language acquisition

11.00 to 11.30   Coffee break

11.30 to 11.50   Limor Raviv and Inbal Arnon
Language evolution in the lab: The case of child learners

11.50 to 12.10   Alexis Black and Carla Hudson Kam
Prior knowledge and individual differences impact statistical learning

12.10 to 12.30   Sarah Bernolet, Paul Boon, Miet De Letter, and Robert Hartsuiker
Influence of implicit statistical learning of syntax and explicit memory for sentence structures on syntactic choices

12.30 to 14.30   Lunch break and Poster Session 2 (lunch is included in the registration fee)
Please see page 12 for list of poster presentations.

14.30 to 14.50   Sengottuvel Kuppuraj, Rao Prema, and Dorothy Bishop
No trade-off between declarative and procedural memory in children with specific language impairment

14.50 to 15.10   Sylwia Macinska and Tjeerd Jellema
Implicit learning of social and non-social information

15.10 to 15.30   Aline Godfroid, Jieun Ahn, Patrick Rebuschat, and Zoltan Dienes
What you see (during training) is what you get (at test): Triangulating process and product

15.30 to 15.50   Maja Curcic, Sible Andringa, and Folkert Kuiken
Explicit and implicit learning from reliable and unreliable input

15.50 to 16.30   Coffee break

16.30 to 17.30   **Announcement of Best Poster Prize, sponsored by John Benjamins, followed by: Themed Discussion: Elena Lieven and Zoltan Dienes**

19.00 onwards   Conference Dinner at The Sun Café Restaurant (advance booking required)

Saturday, June 25, 2016

8.30 to 9.00   Registration

9.00 to 10.00   **Keynote: Axel Cleeremans**
Unconscious associative learning with conscious cues

10.00 to 10.20   Kara Morgan-Short, Kate Brill-Schuetz, and Alexander Demos
Complex second language training leads to development of implicit and explicit second language knowledge

10.20 to 10.40   Evgeniya Gavrilova, Sofya Belova, and Galina Kharlashina
The incidental linguistic information processing, focus of attention and individual differences in verbal reasoning ability

10.40 to 11.00   Patricia Brooks and Vera Kempe
Individual differences in L2 learning: Effects of statistical learning, nonverbal intelligence, and high entropy input

11.00 to 11.30   Coffee break

11.30 to 11.50   Fenna Poletiek
Hearing true speech helps to learn a centre-embedded hierarchical structure

11.50 to 12.45   **Ram Frost**
                  Towards a theory of statistical learning individual capacity, **followed by:**
                  General discussion and closing remarks

13.20 onward   Excursion to Ambleside (sign-up required)

View from the summit of Loughrigg Fell

Poster presentations

1. Ali Al-Hoorie: *Implicit attitudes and L2 achievement*

2. Natalia Andriyanova: *Implicit learning as the reason of repeated errors*

3. Sofya Belova, Galina Kharlashina, and Eugenia Gavrilova: *Implicit learning of form-meaning connections: development of measure for Russian native speakers*

4. Louisa Bogaerts, Ana Franco, Benoit Favre, and Arnaud Rey: *Speech onset latencies as an online measure of regularity extraction*

5. Cylcia Bolibaugh and Patrick Rebuschat: *Differential roles for implicit and explicit knowledge in adult distributional learning*

6. Arielle Borovsky and Inbal Arnon: *Children use multiword frequency in real-time sentence comprehension*

7. Katharina Braungart, Birgit Öttl, Detmar Meurers, and Barbara Kaup: *Does semantic information facilitate grammar learning?*

8. Henry Brice and Ram Frost: *Statistical learning and L2 learning: Improving reliability and predictive validity*

9. Josie Briscoe and Sven Mattys: *Mapping the statistical learning of artificial speech segments using the click detection paradigm in children*

10. Helen Brown, Lydia Gunning, and Elizabeth Wonnacott: *Do shared distributional contexts aid learning of Italian gender classes in 7-year-old children?*

11. Andrei Costea, Razvan Jurchis, and Adrian Opre: *Influencing cognitive control over judgment knowledge with subliminal priming*

12. Davide Crepaldi, Daniel Casasanto, Andrea Nadalini, and Roberto Bottini: *Subliminal semantic processing is based on implicit learning*

13. Sible Andringa and Maja Curcic: *Is the visual world eye-tracking technique suitable for studying implicit learning? A validation study*

14. Nadiia Denhovska: *Frequency, animacy and working memory effects in the incidental learning of L2 grammar*

15. Piera Filippi and Sabine Laaha: *The effect of word position and prosody in a word learning task: a study on school-age children*

16. Malgorzata Forys-Nogala, Grzegorz Krajewski, Theodoros Marinis, and Ewa Haman: *Exploring the effects of implicit and explicit training on the formation of implicit and explicit representations of L2 grammar: A study on the semantics of English articles.*

17. Rebecca Frost, Michelle Peter, Samantha Durrant, Amy Bidgood, Caroline Rowland, Padraic Monaghan, and Morten Christiansen: *How do infants use nonadjacent dependencies during language acquisition?*

18. Andreea Geambasu, Michelle Spierings, Carel ten Cate, and Clara Levelt: *The effects of task-specific variables on artificial grammar-learning and generalization*

19. Wibke Hachmann and Sascha Schroeder: *Sublexical chunking in an artificial orthography*

20. Erin Isbilen, Stewart McCauley, Evan Kidd, and Morten Christiansen: *Testing implicit-statistical learning implicitly*

21. Ivan Ivanchei: *Affective consequences of implicit knowledge application*

22. Matthew Jones: *Language learners introduce iconicity implicitly in a model of language change*

23. Shani Kahta and Rachel Schiff: *The deficit in SL among adults with dyslexia is domain general*

24. Nina Kazanina and Sarah von Grebmer zu Wolfsthurn: *Are phonemes implicated in speech perception? An EEG study*

Session 2: Friday, June 24, 2016

1. Ferenc Kemény and Beat Meier: *Learning correlated sequences: Not even explicit learning of abstract modality sequences*

2. Almara Kulieva and Maria Kuvaldina: *Influence of conscious priming on Sense of Agency*

3. Hernan Labbe Grunberg and Judith Rispens: *Automatic, unconscious, implicit learning of morphology-based associations in Dutch*

4. Martyn Lloyd-Kelly, Fernand Gobet, and Peter Lane: *Be-Bop-A-Lula: A CHREST model of infant word segmentation*

5. Ágnes Lukács, Gyula Demeter, Mihály Racsmány, István Valálik, and Ferenc Kemény: *Different forms of skill learning in Parkinson's disease*

6. Beat Meier: *Implicit learning of a sequence of body movements*

7. Jelena Mirkovic, Marissa Yee, and Emma Hayiou-Thomas: *Developmental differences in memory systems supporting grammar learning from multiple cues*

8. Nadezhda Moroshkina and Anatoliy Karpov: *Implicit learning under social influence*

9. Nadezhda Moroshkina, Anastasia Mikhailova, and Valeria Gershkovich: *Implicit vs explicit motor sequence learning under pressure*

10. Irina Ovchinnikova and Nadezhda Moroshkina: *Learning global configurations in a visual search task*

11. Maud Pélissier, Jennifer Krzonowski, and Emmanuel Ferragne: *Effect of implicit training on the processing of morphosyntactic violations by French learners of English: An ERP and behavioural study*

12. Diana Pili-Moss: *Child and adult incidental learning of linking rules and case marking: A pilot study*

13. Limor Raviv and Inbal Arnon: *Developmental differences in children's statistical learning abilities*

14. Estibaliz San Antón, Sofia Jobbé-Duval, Remy Schmitz, Axel Cleeremans, and Arnaud Destrebecqz: *The role of visuospatial working memory in implicit and explicit sequence learning*

15. Rachel Schiff, Shani Kahta, and Ayelet Sasson: *Performance of children with developmental dyslexia on high and low TE artificial grammar learning task*

16. Xenia Schmalz, Claudio Mulatti, and Reno Job: *What is the role of statistical learning in reading? On the role of letter distribution statistics*

17. Christine Schoetensack, Padraic Monaghan, and Patrick Rebuschat: *Individual differences in implicit-statistical learning: Evidence from the cross-situational learning paradigm*

18. Lauren Slone and Josh de Leeuw: *Modeling the factors underlying adults' confidence judgments in a visual statistical learning task*

19. Janne von Koss Torkildsen, Joanne Arciuli, Christiane Haukedal, and Ona Wie: *Intact visual statistical learning in children with cochlear implants*

20. Anthony Trotter, Padraic Monaghan, and Rebecca Frost: *Natural language cues and the acquisition of artificial grammars.*

21. Anna Vaskevich and Roy Luria: *The role of statistical learning in general improvement*

22. Stefan Walter and Beat Meier: *Implicit probabilistic sequence learning: Correlated streams and sequence length matter*

23. Daniel Wiechmann, Elma Kerz, and Dennis Terhorst: *Awareness, inhibition and the acquisition of L2 morphology under incidental conditions*

24. Merel van Witteloostuijn, Jimena Tena Davalos, Imme Lammertink, Paul Boersma, Frank Wijnen, and Judith Rispens: *The relation between implicit learning and spelling ability in adults: An individual differences approach*

Keynote abstracts

Thursday, June 23, 2016

Morten Christiansen (Cornell University, Aarhus University, and Haskins Laboratories): *Implicit-statistical learning: A tale of two literatures*

Although implicit learning and statistical learning both can be construed as uncovering the structure of the input from its distributional properties, the relevant research has largely been published in separate literatures and with surprisingly little cross-polination between them. This has resulted in apparently opposing perspectives on the computations involved in learning, pitting chunk-based learning against probabilistic learning. In this paper, I argue for a unification of the two approaches to learning under the heading of "implicit statistical learning" and trace its long historical pedigree going back nearly a century. Building on basic insights from the memory literature, I will sketch a framework for statistically-based chunking that may provide a unified computational basis for understanding implicit statistical learning.

Carel ten Cate (Leiden University): *The auditory rule learning abilities of birds*

The abilities of non-human animals to learn and abstract grammatical rules may provide a window on the origin of human rule grammatical learning abilities – an area of controversies. A central question in this debate is whether the computational and learning mechanisms that guide learning about language structure are special and specific to language or humans. This question can only be answered by examining the rule learning abilities of other species and exploring the similarities and differences. In our work we address this issue by studies on birds, using the artificial grammar paradigm. I will present an overview of this work and relate our findings to those in other species and those obtained in humans.

Friday, June 24, 2016

Linda Smith (Indiana University): *Infant statistical word-referent learning at scale*

Infants break into word learning by mapping heard names to scenes. The unsolved problem is how infants determine the referents for unknown words from the inherently ambiguous information within a single scene. Proposed solutions to this problem have focused on how individuals learn from single events, from a series of events over short temporal scales (4 to 10 minutes) or from random selections of naming events in the wild. None of this may be relevant to word-learning at scale. Evidence on the frequency distributions of objects and words in infant environments suggests a new conceptualization of the learning problem, and new forms of statistical learning.

Axel Cleeremans (Université Libre de Bruxelles): *Unconscious associative learning with conscious cues*

Despite extensive research, the very existence of unconscious learning in humans remains much debated. Skepticism arises chiefly from the difficulty in assessing the level of awareness of the complex associations learned in classical implicit learning paradigms. Here, we show that even simple associations between color and motion direction in random dot kinematograms can be learned unconsciously. On each trial, participants had to report the motion direction of a patch of coloured dots, but unbeknownst to the participants, two out of three possible colors were always associated with a given direction/response, while one was uninformative. We confirmed the lack of awareness of the predictive value of the color-motion associations by using a combination of several recognition and generation tasks administered after the main experiment. In addition, we show that trial-by-trial feedback is necessary for learning to take place, and that both the stimulus-response (motor) and stimulus-stimulus (perceptual) associations were learned. In conclusion, we demonstrate that simple associations between supraliminal stimulus features can be learned in the absence of awareness of the predictive relationships that exist between consciously available cues and subsequent responses, so providing a novel framework to study unconscious learning.

Paper abstracts

Dagmar Divjak[1], Petar Milin[2], and Harald Baayen[2] (University of Sheffield[1], University of Tübingen[2]): *Do implicit sequence learning abilities underpin language processing? A view from naive discriminative learning*

While previous research has established that individual differences in implicit learning relate to the ability to use sentence context to predict the upcoming word (Misyak & Christensen 2007; Conway et al. 2009; Kidd 2012), we investigate this question at the level of the word-form: we look at whether individual differences in implicit learning relate to the ability to use sentence context to predict the form of a word and thereby speed up reading. For this we use data on Russian near synonyms meaning TRY that show differences in the tense, aspect and mood (TAM) marking they prefer.
We analyze data from two tasks: (1) to measure implicit learning ability we used a variant of the serial reaction time task (SRT; Willingham & Goedert-Eshmann 1999) which assesses improvements to immediate memory span for statistically-consistent, structured sequences; (2) to capture language processing abilities we used data from a word-by-word self-paced reading paradigm without placeholders (SPR). Our subjects were 39 (17 male, 22 female) adult native speakers of Russian, aged between 18 and 31.

To obtain a measure of implicit learning ability, he SRT data was analysed using a Linear Mixed Effects model, with trial order as covariate and participants as random factor. The statistically justified by-participant adjustments for intercept and slope were used as indicators of implicit learning ability in the Generalized Additive Mixed Modelling (GAMM) analysis of target verb RTs from our SPR data. In addition, the GAMM included a range of discrimination-based predictors of TAM learnability, which were obtained using the Naive Discriminative Learner (NDL; Baayen et al. 2011). We focus in particular on orthographic cues (in this case 3-letter sequences) and semantic cues (i.e., TAM marking).

Crucially, the results of our analysis reveal that participants who showed the strongest positive change across trials in the SRT task also exhibited a major behavioural change in the SPR experiment. In particular, the more they adapted or learned in the SRT task, the more their RTs in the SPR experiment were affected by the NDL activations for given TAM markers. Furthermore, our model visualizes the time-sensitive difference in contributions made by bottom-up (orthographic) and top- down (TAM) cues to target verbs in on-line sentence processing. In sum, our results show that the NDL framework captures accurately how subtle differences in implicit learning ability and contextual experience co-determine the speed with which sentences are read and processed on an individual basis.

Karolina Janacsek[1,2], Andrea Kóbor[2], Ádám Takács[1], and Dezso Nemeth[1,2] (Eötvös Loránd University[1], Hungarian Academy of Sciences[2]): *One-year retention of implicit sequential memory*

Implicit sequence learning underlies the efficient processing of sequential regularities in our environment and it is therefore crucial in many day-to-day activities. It is acquired gradually;

however, only limited information is available about its long-term retention. The aim of the present study was to investigate the short- and long-term retention of the implicitly acquired sequential knowledge using a carefully controlled experimental design, testing both resistance to forgetting and resistance to interference. Healthy young adults (N = 29) performed the Alternating Serial Reaction Time (ASRT) task, which separately measures the sequence- specific and general skill component of the learning. Three sessions were administered in the experiment: a learning phase, 24-hour and one-year retention phases. We found evidence for retained sequential knowledge after 24-hour delay. Moreover, results showed retention of sequence-specific knowledge even after the one-year period, indicated by similar performance as well as similar level of resistance to interference during the second and third sessions. In contrast, general skills decreased over the one-year period. The degree of sequence-specific retention for one year was not associated with the frontal-lobe mediated working memory and executive functions suggesting the independence of automatic and controlled processes. In sum, these results highlight the long-term persistence of the implicitly acquired sequential memories even without further practice.

Branislav Savic[1], René Müri[1,2], and Beat Meier[1] (University of Bern[1], Bern University Hospital[2]): *Modulating implicit task sequence learning and consolidation with prefrontal cortex transcranial direct current stimulation (tDCS)*

With the task sequence learning paradigm (TSL), implicit sequence learning can be measured without the involvement of a motor sequence. Moreover, by repeating the TSL in two sessions consolidation can be measured. The aim of this study was to disentangle the role of the dorso-lateral prefrontal cortex (DLPFC) for implicit sequence learning and consolidation. In the first of two experiments, participants received transcranial direct current stimulation (tDCS) above the left or the right DLPFC and fifteen minutes later they started the TSL. After 24 hours, participants re-performed the TSL but without tDCS. The second experiment was identical to the first one except that tDCS started simultaneously with the TSL. The results of the first experiment showed that in both sessions implicit sequence-specific learning was present and it was not modulated by tDCS. Comparing session one to session two showed that tDCS did not modulate consolidation. The results of the second experiment showed that in both sessions implicit sequence-specific learning was present and it was not modulated by tDCS. Additionally, tDCS did not modulate consolidation. In conclusion tDCS above the DLPFC, applied before the TSL and also simultaneously to the TSL, does not modulate implicit sequence-specific learning and consolidation.

Dezso Nemeth[1,2], Brigitta Tóth[2,3], Ádám Takács[1], Zsófia Zavecz[1,2], Andrea Kóbor[2], and Karolina Janacsek[1,2], (Eötvös Loránd University[1], Hungarian Academy of Sciences, Budapest[2], Boston University[3]): *Competitive networks underlying implicit learning: Evidence from a functional connectivity study*

Human learning depends on multiple cognitive systems related to dissociable brain structures. These systems interact not only in cooperative but sometimes competitive ways in optimizing performance. Previous studies showed that manipulations reducing the engagement of frontal lobe-mediated explicit, attentional processes can lead to improved performance in striatum- related procedural learning. The present study aimed to

investigate 1) the functional connectivity (FC) networks which promote successful implicit sequence memory formation 2) and the dynamical changes of network connectivity as a function of time during learning. Young adults (N = 28) performed the Alternating Serial Reaction Time (ASRT) task while 128 channel EEG recording was performed. ASRT can measure general skill and sequence- specific learning. Phase synchronization in 7 frequency bands was used to quantify FC between cortical regions during the first, second, and third part of the learning task. Sequence- specific learning performance was associated with an increase of FC in the posterior brain regions exclusively mediated by fast brain oscillations (beta) together with a decrease of FC in the frontal network driven by slow oscillations (theta, delta). In line, a prominent decline of FC in slow oscillatory networks together with an increase of FC in fast oscillatory network was observed as a function of time elapse. Our results indicate that implicit learning processes are provided by fast oscillation in posterior cortices while frontal slow rhythms linked with attentional monitoring. In conclusion, a dynamic antagonist relationship between the brain networks of automatic and controlled processes may serve a hallmark of implicit sequence learning.

Laura Batterink and Ken Paller (Northwestern University): *Tracking sensitivity to stimulus sequence structure with a neural measure during learning*

Statistical learning refers to the process of becoming sensitive to statistical structure in the environment and contributes to a range of cognitive functions. Most previous statistical learning studies have assessed statistical learning through post-learning tasks, examining the consequences of such learning rather than the learning process itself. In the present study, we used an online frequency-based EEG measure to assess statistical learning as it occurred. This measure, referred to as the statistical learning index (SLI), reflects enhancement in neural oscillatory activity at the frequency of the hidden underlying stimulus structure. Participants were exposed to streams of repeating nonsense words ("structured" condition) and of randomly concatenated syllables ("random" condition). After exposure, statistical learning was assessed offline using both a familiarity-based rating task and a reaction-time- based performance task. The SLI revealed enhanced EEG phase-locking at the underlying word frequency relative to the raw syllable frequency during exposure to the structured stream, providing evidence of robust statistical learning. Both post-learning behavioral tasks also demonstrated significant learning. Performance on the two tasks was significantly correlated, reflecting a common contribution   from explicit knowledge, with the performance-based task revealing an additional contribution from implicit memory. In contrast, the SLI did not significantly correlate with degree of explicit knowledge. We suggest that statistical learning per se may be conceptualized as the online statistical computations that occur during exposure to structured input, which occur as an automatic and obligatory response to input. These computations may then variably lead to explicit encoding of the stimulus structure into long-term memory, a secondary process dissociable from statistical learning itself. These results implicate online sensitivity to statistical structure at a basic processing level as an important but often overlooked aspect of statistical learning.

Guillaume Thierry, Si Jing Tan, Emma Jones, and Cécile Barbet (Bangor University): *Does implicit learning go deeper than explicit learning?*

A substantial number of studies in the domain of learning have focussed on characterizing the complexity of patterns that can be acquired implicitly and on comparing performance between implicit and explicit learning contexts. The cognitive representation levels that differentiate these two main learning contexts remain however unknown. Here, we set out to compare the efficacy of learning the rule underlying a new card game implicitly as opposed to explicitly, and we attempted a comparative neurophysiological evaluation of learning efficiency using event-related brain potentials. Participants had no prior knowledge of the card game and were instructed to indicate whether or not combinations of cars presented to them were legal or illegal. Half of the participants went through a staircase procedure whilst only receiving visual feedback on their performance. The other half received explicit instruction regarding the card game rule and were guided through 20 correct trials before judging other card combinations belonging to a sequence from one of the participants in the implicit group without feedback. Implicit learners exited the staircase procedure with an overall average accuracy of 75%, whereas explicit learners had a mean accuracy of 91%, meaning that both groups reached high levels of accuracy by the end of the training phase. Participants were then presented with an oddball paradigm in which legal card combinations only occurred 15% of the time, so as to elicit a P300-type ERP response relative to the frequent illegal card combinations. Legal combinations elicited a P3b effect (peaking at around 600 ms after stimulus presentation) of similar magnitude in both implicit and explicit learners. Surprisingly however, relative to illegal combinations, legal combinations induced a negative drift of ERPs peaking at around 400 ms –highly reminiscent of the classical N400– entirely absent in explicit learners. Beyond showing comparable performance in the two learning contexts over a brief exposure period, these results suggest that implicit learning leads to deeper encoding of underlying rules, a process resembling semantic integration in the domain of language.

Monika Derda[1], Borysław Paulewicz[1,2], and Michał Wierzchoń[1] (Jagiellonian University[1], University of Social Sciences and Humanities, Katowice[2]): *The interplay between attention load and awareness in the artificial grammar learning task*

Implicit learning is often assumed to be an automatic and effortless process. However, some artificial grammar learning and sequence learning studies using dual tasks seem to suggest that attention is essential for implicit learning to occur. It has been shown that secondary tasks engage attentional resources and therefore may bias performance on the primary task. Still, it remains unclear, whether in such case the conscious or unconscious knowledge component is affected.

To address this question, we designed an experiment with two groups (experimental and control) that differed in presence of the secondary task (Random Number Generation, RGN) administered simultaneously with the acquisition phase the Artificial Grammar Learning procedure - acquisition and classification material was adapted from Dienes & Scott (2005). Moreover, during every decision on string regularity in the test phase participants were asked to rate their awareness of the rules according to which the strings were generated using confidence rating scale (CR, where '1' is "I am guessing"; '2' - "I am not confident"; '3'- "I am quite confident"; and '4' - "I am very confident").

The mixed logistic (generalized linear with binomial distribution) model with Group and Rating as predictors was fitted to analyse the data from 53 participants. It was found that the RNG did significantly influence the sequence classification accuracy in the AGL task. Importantly, introduction of the RNG task had also an impact on the correlation between accuracy and confidence in the classification decisions: confidence ratings were significantly correlated with accuracy in the experimental group and they were even more strongly associated with accuracy in the control group. The accuracy at the lowest rating did not differ significantly from the chance level, neither in the experimental, nor in control group.

Under assumptions that the lowest ratings are associated with the implicit (unconscious) knowledge component and that the strength of the ratings-accuracy correlation is a measure of the level of knowledge consciousness, this results are consistent with the hypothesis that additional task selectively influenced the conscious knowledge component. Nonsignificant difference between the chance level and the average accuracy at the lowest rating level in both groups suggests that the implicit (i.e. unconscious) knowledge is not as important as previously thought for impaired performance in AGL task with limited attention resources.

John Williams[1], Michelle Sheehan[2], Albertyna Paciorek[3], and Dimitrios Alikaniotis[1] (University of Cambridge[1], Anglia Ruskin University[2], Pedagogical University of Krakow[3]): *Linguistic naturalness and semi-artificial language learning*

Is implicit language learning an unconstrained process that allows any regularity to be assimilated, or are some regularities more likely to be learned than others? If so, do learning biases derive from general cognition, or knowledge of universal properties of language? One way of investigating these issues experimentally is to compare the relative implicit learnability of different semi-artificial linguistic systems. Here we focus on alignment as a potential universal constraint on language learning. Whereas previous studies have examined a preference for aligned, or 'harmonic', word order patterns (Culbertson & Newport, 2015; Culbertson, Smolensky, & Legendre, 2012) here we investigated alignment between two seemingly unrelated aspects of morpho-syntax – subject-verb agreement and case marking – with respect to whether they follow an ergative or nominative pattern (the ergative pattern in verb agreement means that the verb agrees with the object in transitive sentences but the subject in intransitive sentences). Most of the world's languages show alignment between these two systems. For example, in Italian and German both case and agreement follow the nominative pattern, and in Basque both follow the ergative pattern. Non-alignment is rarer, with the combination of nominative agreement and ergative case being vanishingly rare. But typological facts can only be suggestive of differences in learnability and do not necessarily reveal the existence of constraints on the learning process, linguistic or cognitive.

The current study tests whether alignment between case and verbal agreement influences learnability of semi-artificial languages. The languages consist of English lexemes and invented morphological case/agreement markers (e.g. ku-mechanics pa- car repaired-o, pa-mechanics ne-party danced-i). One language, exhibited the vanishingly rare nominative case/ergative agreement pattern (the "NOM-ERG" language), whilst the other language exhibited the more widely attested ergative case/ergative agreement pattern (the "ERG-

ERG" language). The question was whether acquisition of the ergative verb agreement pattern, that is common to both languages, would be affected by whether it is aligned with the case system (in the ERG-ERG language) or not (in the NOM-ERG language). All participants were monolingual English speakers, who are therefore familiar only with a weakly nominative system. Separate groups of participants were trained on the respective languages in a short-term memory task that involved immediate and slightly delayed recall of the grammatical morphemes in transitive and intransitive sentences.

Experiment 1 showed that participants who remained unaware of the ergative agreement pattern nevertheless showed worse short-term memory for the grammatical morphemes during training for the non-aligned NOM-ERG language. This was despite similar performance on a production post-test for the two languages.

Experiment 2 replicated this result, and also showed that when the task encouraged rule discovery there was no difference in recall performance between the two languages. The results suggest that the NOM-ERG configuration was harder to assimilate than the ERG-ERG configuration. As a preliminary investigation of possible cognitive explanation of the results simple recurrent network connectionist simulations were run using a simple form-level encoding of the input. These showed that both languages were equally learnable. We consider alternative linguistic accounts of the bias towards alignment.

Noam Siegelman[1], Louisa Bogaerts[1,2], and Ram Frost[1] (Hebrew University of Jerusalem[1], Aix-Marseille University[2], CNRS Marseille[3]): *What determines visual statistical learning performance? Insights from information theory*

In order to extract the statistical structure underlying a continuous sensory input, the individual elements constituting the stream have to be encoded and their transitional probabilities (TPs) should be learnt. This suggests that variance in statistical learning (SL) performance reflects efficiency in encoding representations as well as efficiency in detecting their distributional properties (Frost et al., 2015). However, a recent study suggests that the encoding of visual shapes and the computation of their TPs are not independent processes, one preceding and feeding into the other. Rather, these two processes display substantial interaction: Sensitivity to extent of the TPs of elements in the stream is modulated by their exposure duration (ED), and susceptibility to ED of elements is modulated by the their predictability (Bogaerts et al., 2016).

Here, we entertain the theoretical hypothesis that one unifying construct – the extent of information per time unit – can account for this counter-intuitive pattern of performance. Operationally, we quantify the "rate of information" in a visual stream by multiplying the extent of predictability of shapes in the stream (calculated using Markov entropy), by the number of shapes presented per second. This theoretical approach blurs the distinction between constraints related to encoding of events (e.g., ED) and constraints related to learning their regularities (e.g., TPs between elements), merging them into one processing principle. It also conforms with recent neurobiological evidence regarding differential sensitivity of neurons to levels of entropy (Nastase et al., 2014; Tobia et al., 2012).

How should we go about empirically testing this theoretical approach? First, rate of information typically affects performance in a logarithmic function (e.g., Miller, 1956). Second, the theory predicts identical SL performance with different combinations of ED and TPs as long as the rate of information is identical. Using a range of experimental conditions we examined whether SL performance is indeed best predicted by the unified measure of extent of information per time unit. We discuss the theoretical and methodological implications of the findings, and argue that measuring the extent of information per time unit in the stream has the promise of providing a unifying framework for understanding the computations underlying different implicit learning tasks.

Arnaud Rey[1,2], Frédéric Lavigne[1,3], Fabien Mathy[1,3], and Joël Fagot[1,2] (CNRS Marseille[1], Aix-Marseille University[2], Université de Nice Sophia Antipolis[3]): *Beyond transitional probabilities: Learning XOR in non-human primates*

Extracting the regularities of our environment is one of our core cognitive abilities. One way of studying this ability and of avoiding the presence of any bias due to language experience is to test species that do not use language. To study the online dynamics of regularity extraction, previous work have used a method combining the artificial language paradigm (Saffran, Aslin, & Newport, 1996) and the serial response time task (Nissen & Bullemer, 1987) with a group of Guinea baboons (Papio papio) in a new automatic experimental device (Minier, Fagot, & Rey, 2015; see also Franco & Destrebecqz, 2012 ; Fagot & Bonté, 2010).

Participating monkeys had to track and touch on a screen a moving target that could appear on one of the nine possible positions defined by a 3 x 3 matrix. They were trained to produce sequences of nine-touch responses on each trial before receiving reward. After a phase during which each touch of the nine-touch trial sequence was random, three word-like patterns were introduced. These patterns were strings of three fixed locations (e.g., 5-8-2, 4- 7-3, 1-9-6) and were concatenated in a random order to form a sequence of nine locations.

Results showed that response times on the second and third position of a triplet decreased progressively with exposure to these regularities. It was also found that RTs on the third position decreased faster than RTs on the second position of a triplet. This difference on the second and third positions cannot be accounted for by the mere acquisition of transitional probabilities (TP) since the TP from position 1 to 2 was the same as the TP from position 2 to 3.

To further investigate this issue, monkeys were tested on a serial version of the XOR problem. Using the same paradigm as Minier et al. (2015), monkeys were exposed to the four following triplets: 1-2-4, 7-2-9, 1-8-9 and 7-8-4. These precise sequences where chosen because TPs between the different positions were perfectly matched. Indeed, the first and second positions of each triplet taken alone do not predict the next position, because they are not systematically followed by a given position (e.g., 7 can be followed by 2 or 8, and 2 can be followed by 4 or 9). Similarly, the third position of a triplet cannot be learned if the monkeys only take into account of the immediate information provided by the second position (i.e., 4 or 9 can indeed be preceded either by 2 or 8). The only way to predict the

third position of a triplet is to go beyond TPs and to consider the mutual information provided by the first and second positions taken together (i.e., if the sequence starts by 7 followed by 2, then 9 will appear systematically). Results showed that RTs on the second position of a triplet did not decrease with exposure to the regular sequences while RTs on the third position did. Monkeys therefore managed to learn the XOR configuration by coding the regularities beyond transitional probabilities.

Friday, June 24, 2016

Jessica Hall, Amanda Owen Van Horne, and Thomas Farmer (University of Iowa): *Distributional learning ability in typically developing children*

People are sensitive to statistical regularities present in language from a very young age. These statistical regularities are present at many levels: adjacent, non-adjacent, and distributional/categorical. Studies often focus on the first two types, but successful language learners are ultimately able to function at the level of categorical information. A previous study by Reeder, Newport, and Aslin (2013) established that adults could use distributional information in an artificial language to form new grammatical categories after a short exposure. In the Sparse experiment of this study (Experiment 3 in the paper), certain combinations of words are never heard, and thus utilization of co-occurrence frequencies alone does not allow for success in the task. However, the overlap in how words in the categories distribute can be used as a clue to category membership. Successful participants must discover the categories of the language to successfully identify grammatical sentences in the language that they have not heard before. Here, we adapt the experiment to determine if children can also show category development from distributional information in novel linguistic input. We tested 27 typically developing monolingual children ages 7-9. We adapted the artificial grammar learning task from Reeder et al (2013) in three ways, using 1) a child-friendly training that included videos, a one-back task, and child-directed speech, 2) a yes/no button task as well as a continuous analog scale for graded data on grammaticality judgment, 3) only the training used in the Sparse experiment, as this requires category formation for success. Following a brief exposure to the artificial language, participants rated sentences as sounding like or unlike sentences heard during training. Critical test sentences fit the grammar of the language but were not heard during training. Successful formation of grammatical-like categories should result in higher ratings for these sentences. We measured success by comparing ratings for novel grammatical sentences to ratings of ungrammatical sentences. A linear mixed effects model with random subject and item intercepts revealed that ratings were higher for novel than ungrammatical sentences both when participants used the visual analog scale, t(31.38)= -4.05, p<.001, and when they used the binary button press, t(31.22)= -3.31, p<.01. Ratings for novel items did not differ from those for familiar items on the visual analog scale, t(27.72)= 0.71, p=.48, and the binary button press, t(27.37)= 0.86, p=.40. A separate model showed that binary button press rating predicted visual analog scale rating, t(1564.2)=48.54, p<.0001. These data replicate the findings of Reeder et al. (2013) with typically developing children using a shorter exposure and binary and analog scale measures. We conclude from these findings that children are capable of forming grammatical categories from only distributional information after a brief exposure to novel linguistic input. Future work will involve

exploring individual differences in task performance to determine how distributional learning ability relates to real language learning ability.

James Hutson, Shekeila Palmer, and Sven Mattys (University of York): *Speech segmentation by statistical learning in young, middle-aged, and older adults*

The purpose of this study was to investigate the age-related stability vs. decline of key word-learning mechanisms and to establish the extent to which age-related trade-offs take place with cognitive resources. It is well established that young adult, in addition to infants as young as 8 months, are sensitive to distributional segmentation cues present in continuous artificial speech even after relatively brief exposure duration. What is less clear is the effect of aging on such sensitivity. With the documented decline of executive functions, information processing, memory processes, and in neural plasticity, older adults may demonstrate a degraded capacity for extracting and maintaining statistical information presented over short periods of time. Alternatively, the presumed implicit/automatic nature of statistical learning (SL) may signify that the process is less vulnerable to age-related decline generally evident in more effortful, explicit processes.

In this study, we considered the interplay between SL and other cognitive processes in young (20-30y), middle-aged (40-50y), and older adults (60-80y). Participants were asked to identify 'words' in a continuous artificial speech stream consisting of two three-syllable and two four-syllable nonwords presented in a random sequence. The stream was played at a normal or slow rate, and with or without an additional cognitive load (a concurrent 2-back visual task). The rate contrast was meant to test whether greater reliance on rehearsal, which is believed to be promoted by slow speech, helped or hindered SL in older individuals. The cognitive load task was included as a test of the automaticity of SL. Successful segmentation of the speech stream was established in a test phase in which individuals completed 2- alternative-choice trials involving statistical words (items contained in the language), part-words (items straddling word boundaries in the stream), and nonwords (items constructed from the streams' syllables in novel sequences).

The results showed that SL is remarkably robust across the lifespan with older adults demonstrating a level of performance equivalent to the other age groups despite showing a different pattern of performance in many of the cognitive tasks. SL was affected by cognitive load but not by the rate in which the artificial speech was presented and this pattern was relatively stable across the three age groups. Across all age groups, digit span and updating were strong predictors of SL performance. The results suggest that SL draws upon a combination of core implicit mechanisms that are relatively stable across the lifespan, and cognitive resources that show an age-related decline.

Rebecca Frost[1], Padraic Monaghan[1], and Morten Christiansen[2] (Lancaster University[1], Cornell University[2]): *High-frequency words can assist language acquisition*

Learners can extract transitional information from speech and use it to infer word boundaries and linguistic regularities. Critically, studies suggest that statistical language learning may benefit from the presence of high-frequency marker words (Bortfeld et al.,

2005) that may act as anchors around which speech segmentation can occur, while also assisting with grammatical categorisation (Monaghan & Christiansen, 2010).

To address these claims, we familiarised adults with a continuous stream of artificial speech comprising repetitions of 8 bisyllabic target words, and compared learning to the same language but with high-frequency monosyllabic marker words preceding target words. Critically, marker words distinguished target words into two distributionally-defined categories, which were otherwise unidentifiable. Participants completed a 2AFC test of segmentation, and a similarity judgement categorisation test containing word-pairs from the same versus different grammatical categories. We then tested transfer to a cross-situational word-action/object learning task, where target word categories were either consistent or inconsistent with the action/object distinction. This was then followed by a vocabulary test, which assessed whether participants had learnt the names of the actions and objects.

Participants in both training conditions segmented the speech stream better than chance, but only the marker word condition demonstrated evidence of categorisation on the transfer task. Data from the vocabulary task provided further evidence that categorisation was influenced by high frequency words: vocabulary learning for the marker word condition was significantly better for participants receiving consistent, rather than inconsistent, word-action/object pairings. Findings indicate that high-frequency marker words may assist grammatical categorisation at the point at which speech segmentation is just being learnt.

Limor Raviv and Inbal Arnon (Hebrew University of Jerusalem): *Language evolution in the lab: The case of child learners*

Usage based theories suggest that the kinds of structures we observe in languages arise from general biases and constraints on individual human capacities (Tomasello, 2009). Important to Language Evolution, these theories suggest that the cultural transmission of language over thousands of generations (through a repeated cycle of observation, imitation and induction) can lead to the emergence of linguistic structure as a cumulative byproduct of speakers' weak individual tendencies (Kirby, Griffiths, & Smith, 2014). Computational iterated learning models (ILM) simulating cultural transmission show that weak biases become amplified and fixated over time, creating strong linguistic universals without the need to assume strong innate biases (Reali & Griffiths, 2009). Importantly, ILM studies with adults show that randomly constructed artificial languages become significantly more structured and easier to learn over the course of multiple iterations Kirby, Cornish, & Smith, 2008).

However, to date there is no published study showing the emergence of linguistic structure over time with children. The lack of evidence from child learners is a problematic gap in the literature, as children are the most prototypical learners in the actual process of linguistic transmission, and may differ from adults in their language acquisition skills and general cognitive biases (Birdsong, 2009; Hudson Kam & Newport, 2005). Crucially, adult participants may rely on their extensive and explicit knowledge of language when learning an artificial language, undermining the overall validity of such studies (Cornish, Tamariz, & Kirby, 2009).

We address this problem by conducting a large-scale study of iterated language learning in both children and adults, using an original, child-friendly paradigm. Results show that despite making more mistakes overall, children's languages became more learnable over time just like adults', exhibiting the same trends and pace of change in learnability. Even though we found no significant increase in linguistic structure for children, significantly consistent mapping between meanings and signals emerged in child languages on many occasions, with children creating similar structure as reported in [4]. This provides the first demonstration that cultural transmission affects children and adults similarly, with both age groups guided by the same learnability biases.

Alexis Black and Carla Hudson Kam (University of British Columbia): *Prior knowledge and individual differences impact statistical learning*

Statistical learning is often seen as general (species, modality, and age independent), despite increasing evidence of its being constrained1. In this study, we ask whether auditory perceptual skills, defined as specific language experience, general linguistic skill, or musical skill are involved in statistical learning.

Methods: 154 English-speaking college students (111 female; age 17-40) listened to an artificial language comprised of either native English sounds (NL: n=39), a mixture of English and non-English sounds (SNL: n=43), or non-English sounds (NNL: n=73). All 3 languages were constructed from 12 syllables produced by a trained phonetician. Syllables were organized into trisyllabic chunks with a 1.0 transitional probability between syllables (words). After familiarization, participants completed a 56-item 2AFC task, in which they were tested on their ability to distinguish words and non-words (trisyllabic sequences that contained novel syllable sequences or spanned word boundaries). Finally, participants also completed a language and music background questionnaire. Linguistic skill was operationalized as Monolingual, Bilingual, or Multilingual; participants rated their musical skill on a scale from 0-4 (0 = no musical background; 4 = professional- level skill on at least one instrument).

Results: Participants successfully distinguished words from non-words in all Language conditions (all ps<.001). A linear regression model examined the influence of Language, Multilingualism, Musical skill, Age, and Gender on Word-choice proportion. It revealed that participants hearing less familiar sounds performed worse than those hearing more familiar sounds (SNL: ß=-.048, p=.035, d=0.36; NNL: ß =-.100, p<.001, d=0.82), that increasing age led to a decrease in performance (ß =-.004, p=.024, d=0.38), but no significant effects of Musical skill, Multilingualism, or Gender. The overall model fit was adjusted R2=0.17. Closer inspection of the age effect revealed an interaction with Language type: only Non-Native condition participants showed declining performance by age. Taken together, these results suggest that SL is more dependent on prior domain-specific experience than has been frequently assumed, and general auditory skills are at least somewhat independent. Furthermore, the negative impact of age in the Non-Native condition echoes previous findings: non-native sound perception becomes harder with age, and this impacts other aspects of language learning.

Sarah Bernolet[1], Paul Boon[2], Miet de Letter[2], Robert Hartsuiker[1] (Ghent University[1], Ghent University Hospital[2]): *Influences of implicit-statistical learning of syntax and explicit memory for sentence structures on syntactic choices*

If speakers have the choice between two equivalent syntactic structures for expressing the same message (e.g., The burglar hands a book to the nun [PO dative]/hands the nun a book [DO dative]), they will often choose the most recently processed alternative. This effect of syntactic priming is stronger when the new sentence requires the use of the same verb that was used in the prime sentence (hand-hand) than when different verbs have to be used (give-hand). It has been suggested that this lexical enhancement of syntactic priming might be an effect of explicit memory: the repeated head verb acts as a retrieval cue that gives access to the explicit memory of the prime sentence's surface structure (Chang, Dell & Bock, 2006). The basic priming effect, on the other hand, is assumed to be a side effect of the implicit-statistical learning of sentence structures. In order to investigate the hypothesis that the lexical boost to syntactic priming (but not syntactic priming itself) is caused by explicit memory processes, we compared the production of dative sentences by patients with anterograde amnesia and 2 groups of control speakers (one matched for age and one younger student group) in repeated and different verb conditions. Participants described pictures of dative actions in five different sessions (4 weeks in between sessions). Before each target picture, they heard and repeated a prime sentence (DO-dative, PO-dative, or transitive baseline) and one unrelated filler sentence. The dative verbs for the target sentences varied in their relative bias towards both datives. After each target picture, participants' memory of the prime sentence was assessed by means of a probe recognition task.

The patients showed severely impaired memory for the syntactic structure of the prime sentence: When the probe was semantically identical, but syntactically different from the prime sentence, the patients correctly rejected the probes in only 36% of the cases. Nevertheless, as in a study by Ferreira, Bock, Cohen, & Wilson (2008), all groups showed significant syntactic priming (patients and age-matched controls 15% priming; students 12% priming), indicating that sentence structures do not need to be explicitly remembered in order to cause syntactic priming. The lexical boost to syntactic priming was negligible in all groups, presumably because of the filler separating prime and target. Interestingly, the patients showed a significant effect of target verb bias in the baseline condition: here, the odds for a PO dative response decreased together with the target verbs' bias towards this response (left panel Figure). In the other groups this effect was less pronounced and not significant. We suggest that this stronger effect of verb bias in the patients is a result of a smaller influence of explicit memory processes.

Sengottuvel Kuppuraj[1], Rao Prema[1], and Dorothy Bishop[2] (All India Institute of Speech and Hearing[1], University of Oxford[2]): *No trade-off between declarative and procedural memory in children with specific language impairment*

Background: There is growing evidence that children with specific language impairment (SLI) have impairments of procedural memory. The declarative compensatory hypothesis predicts that an intact declarative system compensates for attenuated procedural memory

in these children. Accordingly, we predicted a trade-off between these memory systems in children with SLI.

Methods: Thirty children aged 8-13 years with SLI were compared with 30 matched typically- developing (TD) controls. We administered a serial response time task to test motor procedural learning. We also used two non-verbal declarative tasks that differed at the level of encoding (incidental vs. intentional) and retrieval (recognition vs. recall) to consider how far these factors could account for past inconsistencies in findings. Retrieval was examined after 10 minutes and 60 minutes of encoding on both declarative tasks.

Results: In agreement with previous research, we found deficient performance on the procedural learning task. Contrary to prediction, accuracy in declarative learning was impaired in children with SLI on both incidental and intentional tasks. Furthermore, in contrast to the declarative compensatory hypothesis, we found a positive relation between procedural and declarative skills in children with SLI. The findings are discussed in relation to a Generalized Context Model which advocates single mechanism exemplar-based learning of procedural and declarative information. The implications for teaching language to children with SLI will be discussed.

Sylwia Macinska and Tjeerd Jellema (University of Hull): *Implicit learning of social and non-social Information*

The ability to automatically detect complex regularities or contingencies in one's environment is a fundamental aspect of human cognition. This ability is often referred to as implicit learning, i.e. learning without intent or awareness. Although automatic and seemingly effortless, implicit learning plays a significant role in guiding and structuring our perceptions and behaviour. This is especially true during social interactions, where an implicit interpretation of accumulating social cues can be vital for modulating one's social response appropriately to the current situation. In the current study a novel implicit learning paradigm was used to assess differences in implicit memory formation of social and non-social information in individuals with low and high number of autistic traits, as assessed by the Autism Quotient (AQ) questionnaire. Participants were required to watch videos of two actors, whose facial expressions and gaze directions changed dynamically (social condition) and of two geometric objects, of which the colour and an internal shape changed dynamically (non-social condition). Both conditions displayed hidden contingencies that could be learned implicitly and were matched on difficulty and number of cues. In the social condition, specific combinations of facial expression and gaze direction were used to portray the actor as having either a positive or negative disposition towards the observer. In non-social condition, the combination of colour and internal movement was used to predict the shape of the object as either a square or a circle. It was hypothesised that individuals high in autistic traits would show a diminished ability to implicitly learn the positive and dispositions of the actors, while their performance in the non-social learning condition would be comparable to those individuals low number in autistic traits. The results suggested that implicit learning had occurred, with participants responses biased in accordance to the implicitly learned contingencies. As predicted, in the social condition this learning positively correlated with the AQ scores, with individuals high in autistic traits exhibiting less learning than those low in autistic traits. No difference in implicit learning

was found in non-social condition with both groups performing equally well. This pattern of results may give interesting insight into why individuals with ASD may be impaired in their use of social cues to modulate their behaviour. Future work will aim at extending this study to individuals with ASD to see if the pattern can be extrapolated to that clinical population.

Aline Godfroid[1], Jieun Ahn[1], Patrick Rebuschat[2], and Zoltan Dienes[3] (Michigan State University[1], Lancaster University[2], University of Sussex[3]): *What you see (during training) is what you get (at test): Triangulating process and product measures of awareness*

A growing body of work has investigated the acquisition of grammar under incidental exposure conditions. To understand the role of awareness in the acquisition process, it is important to distinguish between the process and the product of learning (Leow, 2015); that is, between implicit/explicit processing and implicit/explicit knowledge. In this study, we compare a process measure of awareness (eye movements) and two product measures (retrospective verbal reports and source attributions) to investigate whether learning unfolds differently in aware and unaware learners. To our knowledge, this is the first study to systematically compare these three measures of awareness.

Twenty-seven native English speakers were exposed to an artificial language that featured English words and German syntax (see Rebuschat and Williams, 2012). Participants' eye movements were recorded throughout the experiment. During the exposure phase, participants read 120 sentences and judged their semantic plausibility. At test, participants then judged the grammaticality of 60 novel sentences, only half of which followed the artificial language grammar. They indicated the basis of their grammaticality judgment (guess, intuition, recollection, or rule) after each sentence (Dienes and Scott, 2005) and were asked to verbalize any rule knowledge in retrospective reports following the test.

Overall accuracy on the grammaticality judgment test was at chance. However, given that the retrospective verbal reports indicated the presence of conscious knowledge, we reanalyzed the training and test data as a function of awareness. We found that learning, as reflected in grammaticality judgment performance, did take place and that it was restricted to conscious knowledge of specific syntactic patterns. Knowledge development could be traced to changes in eye-movement patterns during training, notably an increase in regressions (revisits of the critical verb) over time (compare Godfroid, Loewen, Jung, Park, Gass, & Ellis, 2015). Eye movements did not link with source attributions, but rather reflected the finding that judgments based on guess or intuition were slower than those attributed to recollection or rule. We discuss the benefits of triangulating multiple awareness measures, including eye-movement recordings, in artificial language studies and identify possible eye-movement markers of implicit knowledge as interesting metrics for future research.

Maja Curcic, Sible Andringa, and Folkert Kuiken (University of Amsterdam): *Explicit and implicit learning from reliable and unreliable input*

A number of studies investigated the possibility of learning L2 grammar implicitly, without awareness, and the results so far have been mixed. Whereas a number of studies found no learning without awareness at the level of understanding, others did find evidence of

learning even in the absence of learners' ability to verbalize what they had learned, which can arguably be taken as evidence of implicit learning (e.g. Rogers, Revesz, Rebuschat, 2005; Williams, 2005). Very few studies employed more natural input where learners were not aware that they were learning a non-existing language. The goal of the present study was to investigate whether learners were able to implicitly learn a determiner-noun agreement structure from two different input types: reliable and unreliable input. A more natural miniature language was used, where both lexicon and the target structure were novel to learners, and learners believed that they were learning a real language.

Fifty adult Dutch native speakers received brief, auditory exposure to a new language based on Fijian, which consisted of 20 nouns, 6 adjectives and 3 intransitive verbs. It also featured a determiner-noun agreement structure: masculine determiner lep preceded nouns ending in –uk (lep ganeuk), whereas feminine determiner ris preceded nouns ending in –is (ris maramis). The reliable input group received input that contained the target pattern without any exceptions, whereas for the unreliable input group, 4 out of 20 nouns in the input were exceptions: lep preceded nouns ending in –is and ris preceded nouns ending in –uk. During the exposure, learners looked at images and listened to phrases and sentences describing the images. They were encouraged to learn the language but were never told what to focus on. After the exposure, participants' knowledge of the target pattern was measured by means of two grammaticality judgment tasks – one with novel and one with familiar nouns. After the tests, retrospective verbal reports were used to find out if learners showed any awareness of the target structure, and if so, at which stage of the experiment they developed awareness.

Results showed that learners differed substantially in the success with which they acquired the target pattern as well as in whether and at what stage they became aware of pattern. The results indicate that only learners who were aware of the pattern could generalize it to novel items. However, evidence has been found for pattern learning without awareness as well. Namely, both aware and unaware learners showed pattern knowledge on familiar items, since they overgeneralized the pattern to the exceptions, meaning that they responded against what they had heard in the input. As for input reliability, we found that exceptions in the input disturbed pattern learning for both unaware and aware learners. However, this effect was more pronounced for learners who had explicit knowledge.

Thus, this study provides some evidence of implicit learning, but more importantly, it offers a potentially fruitful paradigm for investigating early stages of implicit learning: a paradigm that does not necessarily require learners to generalize a pattern to novel items, but allows them to demonstrate implicit learning on already encountered items.

Saturday, June 25, 2016

Kara Morgan-Short, Kate Brill-Schuetz, and Alexander Demos (University of Illinois, Chicago): *Complex second language training leads to development of implicit and explicit second language knowledge*

Previous research has explored the efficacy of different types of second language (L2) training in fostering adult L2 development (e.g., Norris & Ortega, 2000; Morgan-Short et al.,

2012). However, relatively little attention has been paid to the type of input (e.g., simple or complex) provided during training or the type of knowledge that develops from training. Research examining the learning of complex systems and stimuli in non-linguistic domains (e.g., Berry & Broadbent, 1984; Reber, 1967) suggests that training can lead to successful learning that results in implicit knowledge. Whether training with complex linguistic stimuli results in implicit knowledge development for L2, however, is a question that remains open. The current study addressed this question by exploring how complex L2 input affects adult L2 development in terms of both overall learning and the type of knowledge developed. Participants (*N* = 31) were trained on Brocanto2 (Morgan-Short et al., 2012), which is a meaningful and fully productive artificial L2. During training, participants received 80 meaningful exemplars of Brocanto2 that were complex, i.e., sentences that consisted of five word categories, and 20 meaningful exemplars of Brocanto2 that were simple, i.e., sentences that consisted of only three word categories. Thus, complexity was operationalized as input containing a large number of components, i.e., L2 word categories, and relationships between them (adapted from Bulté & Housen, 2012). After training, participants completed a grammaticality judgment task (GJT) that contained both novel complex and simple items that were either violations or correct instantiations of three underlying grammar rules in Brocanto2. After participants made their judgment for each stimulus sentence, they were also asked to report the source to which they attributed their judgment, i.e., guess, intuition, memory or rule (Rebuschat & Williams, 2012). Participants did not perform significantly above chance overall on the GJT, but they did exhibit above-chance level performance for complex GJT items. In regards to knowledge development, results showed evidence of above-chance level performance intuition and rule knowledge for the complex GJT items, which suggests that learners developed both implicit and explicit knowledge of the underlying grammatical rules. This pattern of performance exhibits characteristics of context-dependency, a feature of knowledge resulting from implicit learning (e.g., Frensch, 1998). This conclusion is supported by the fact that implicit knowledge was evidenced in the source attribution data, although some explicit knowledge was also evidenced. Overall, the results show that implicit L2 knowledge can develop when learners are provided with complex L2 input. Moreover, the study provides preliminary data related to how the qualities of the L2 input provided to learners may affect the type of L2 knowledge that a learner develops.

Evgeniya Gavrilova, Sofya Belova, and Galina Kharlashina (Moscow State University of Psychology and Education): *The incidental linguistic information processing, focus of attention and individual differences in verbal reasoning ability*

The present study was aimed at clarifying the relationship between verbal reasoning ability and performance on free recall and word generation tasks after incidental exposure to linguistic stimuli. The incidental linguistic processing is considered to be dominant and comparatively effortless in everyday life but it also has enormous implication for verbal problem solving as a source of multiple cues relevant for new decisions. Although verbal intelligence relies on explicit cognitive strategies and focused attention it is worth clarifying whether it captures and incorporates incidentally processed linguistic input in subsequent tasks.

Method. The sample consisted of 44 Russian L1 students (mean age 19.09, SD 1.36, 77% females). There were 3 stages in the procedure. At the first stage participants were exposed to pairs of words. Each pair could consist of two common nouns, two city names, or a city name and a common noun. The participants' focus of attention was directed to meaning of words. They had to decide whether a city name was present in each pair. Therefore city names were considered to be focal stimuli, whereas common nouns were considered to be peripheral stimuli. Along with that each pair could be rhymed or not, but this linguistic aspect was processed incidentally. Thus three parameters of stimuli were controlled: attention (focal vs peripheral), rhyme (rhymed vs unrhymed), position (paired with focal stimulus vs paired with peripheral stimulus). At the second stage the participants were asked to produce as many rhymes as they could to 8 new words in 10 minutes. The stimuli presented earlier could be used as well. At the third stage participants had to retrieve all words presented in the first task (word pairs) in 3 minutes. The verbal reasoning ability was measured by a newly constructed performance measure which consisted of anagram solving and conceptual generalization items.

Results. The highest rate of free recall was revealed for focal rhymed stimuli paired with peripheral stimuli (F=7.33, p<0.01), whereas peripheral rhymed stimuli paired with peripheral stimuli had the highest rate of use in word generation task (F=55.915, p<0.000). The verbal reasoning ability significantly correlated with focal rhymed stimuli recall (r=0.3, p<0.05) but was unrelated to recall of any other type of stimuli. The inverse pattern was obtained for word generation data. The verbal reasoning ability significantly correlated with generation of peripheral rhymed stimuli paired with peripheral stimuli (r=0.3, p<0.05) but was unrelated to generation of any other type of stimuli.

Conclusion. We discuss our findings in terms of differential involvement of focus of attention in incidental linguistic processing with respect to verbal reasoning ability. Although incidentally processed stimuli had no advantage in deliberate free recall, they were more effectively used by participants with high verbal reasoning ability in subsequent cognitive tasks. That implies that verbal intelligence benefits from operating by differential foci of attention while incidental language processing. This research was supported by the "Grant of President of RF for young PhD scientists" (contract № is 14.W01.6523-MK) and the Grant № 15-36-01348a2 of Russian Humanitarian Scientific Fund.

Patricia Brooks[1] and Vera Kempe[2] (College of Staten Island, CUNY[1], Abertay University[2])
Individual differences in L2 learning: *Effects of statistical learning, nonverbal intelligence, and high entropy input*

Foreign language (L2) learning outcomes may depend on the structure of the input as well as the cognitive abilities of learners. This study tested whether less predictable (high entropy) input might facilitate learning and generalization of L2 morphology, while evaluating contributions of implicit statistical learning ability and non-verbal intelligence to learning outcomes. Over three sessions, adults (N=54) were exposed to a miniature Russian case-marking paradigm consisting of two gender categories and four cases (nominative, dative, genitive, and instrumental), with either a balanced or skewed distribution of word tokens in the training input. Participants engaged in question-answer dialogues and were tested on their comprehension of case marking, their ability to inflect both familiar and

novel nouns for case, and vocabulary recall. Implicit statistical learning was assessed using an auditory artificial grammar learning task (Misyak & Christiansen, 2012), which tested participants' ability to distinguish grammatical from ungrammatical strings of nonce syllables after brief auditory exposure to a representative set of grammatical strings. Non-verbal intelligence was assessed using the Culture Fair Intelligence Test (Cattell & Cattell, 1973), which required visual-spatial pattern completion under time pressure.

In line with the view that decreasing the predictability of the input by increasing the variability of lexical items promotes pattern learning (Gómez, 2002; Matthews & Bannard, 2010), the high entropy, balanced word token distribution was associated with higher accuracy in generalizing case-marking suffixes to new vocabulary, but only in the initial test session. The observed results run counter to the claim that learners acquire grammatical constructions more readily when the input is skewed to favor specific items (Casenhiser & Goldberg, 2005; Goldberg, Casenhiser, & Sethuraman, 2004).

The transient effect of the input manipulation contrasted with the more sustained impact of individual differences in implicit statistical learning and non-verbal intelligence on L2 morphology learning across the three sessions. Implicit statistical learning ability predicted both comprehension and production of case marking for trained items, whereas non-verbal intelligence also predicted generalization of case-marking suffixes to new vocabulary. This pattern of individual differences largely replicates an earlier study (Brooks & Kempe, 2013), wherein implicit statistical learning ability was tied to item-based learning of case-marking suffixes for trained items, but not to generalization of the suffixes to new vocabulary or to incidental vocabulary recall. In the current study, the impact of implicit statistical learning extended to case comprehension; that is, participants with stronger statistical learning abilities were more efficient in extracting the correlations between specific Russian prepositions and case-marking suffixes and three distinct semantic representations, coinciding with the direction of movement of a protagonist in relation to a target object. The lack of a relationship between implicit statistical learning and incidental vocabulary recall might be taken as support for the procedural/declarative model (Ullman, 2004), which posits separable learning mechanisms for grammar and vocabulary acquisition. Taken together, the findings underscore the critical role of form-based pattern extraction in L2 morphology acquisition, and the robustness of individual differences in aptitude in the face of variable (high vs. low entropy) input.

Fenna Poletiek (Leiden University): *Hearing true speech helps learning a language with center-embedded structure*

A major theoretical debate in language acquisition research regards the learnability of center-embedded (CE) grammars (A^nB^n grammars, typically generating strings as $A_1[A_2B_2]B_1$, $A_1[A_2[A_3B_3]B_2]B_1$ etc.). These structures are difficult because the embedded clause pushes apart the subject-verb dependent words. Consider the sentence *The girl the dog has bitten, cries*. Poletiek and Lai (2012) argue that semantic biases, modeled statistically as distributional biases, might help learning implicitly (i.e. by mere exposure) complex center embedded structures, in natural language. That is, hearing *girl cries* ways more often than *dog cries*, simply because dogs don't cry in the real world, cues the learner to associate girl

with cry rather than dog with cry, when he comes across these two subject-nouns and the verb 'cry' in one sentence.

I will present a study in which we investigated the facilitating effect of distributional biases in simple AB adjacencies (subject-verb pairs) during the acquisition of a CE artificial grammar. After a pre-training in which AB-biases were established, participants (*n*=48) were randomly assigned to one of three groups receiving complex training strings with either a) AB distributional biases *matching* the CE structure (e.g., $A_aA_bB_bB_a$, A_aB_a being highly frequent (dog barks) and A_aB_b infrequent (dog cries)), b) AB-biases *mismatching* the CE structure (e.g., $A_aA_bB_aB_b$), or c) AB-biases unrelated (*neutral)* to the CE structure (e.g., $A_aA_bB_cB_d$). Groups were compared on how much of the CE grammar was learned. The *match* group outperformed the *mismatch* and *neutral* group. Results suggest that children learn complex grammatical structures by listening to caregivers' speech that truly reflects frequency biases of the objects and events in the world, they speak about.

Ram Frost (Hebrew University of Jerusalem): *Towards a theory of statistical learning individual capacity*

In recent years there is growing interest in tracking individual performance in statistical learning (SL) tasks. The main motivation for this line of research is to confirm that language learning involves a process of assimilating the statistical properties of a linguistic environment. Following this aim, a series of studies have shown that individual performance in artificial grammar learning (AGL), visual, and auditory SL predict linguistic capacities such as L1 and L2 reading skills, syntax comprehension, sentence processing, semantic and phonological lexical access, speech perception, etc.

This research is characterized by the following prototypical experimental approach: A SL or AGL task that has been shown to produce above chance performance in the group level is selected, and imported into the study as is or with minor modifications. Individual performance in the task is registered for each participant, along with his/her performance in a given linguistic domain. Finally, the participants' SL scores are used as predictors of their linguistic test scores.

Underlying the logic of this experimental strategy are three critical preliminary presuppositions. First, since there is no agreed taxonomy of possible types of SL, it is treated by default as a unified theoretical construct, a general capacity for picking up regularities. Second, and relatedly, the tasks which are selected for the study from the arsenal of tasks employed in this domain, are naturally assumed to equally represent a good operational proxy of this unified theoretical construct, so that the selection of one specific task for the study is not a matter of deep theoretical concerns. Third, the performance score of the test phase in the task is naturally assumed to be a valid and reliable measure of the operational proxy, and therefore, a valid and reliable measure of the postulated capacity for picking up regularities.

We will argue that these three critical presuppositions are subject to important theoretical and empirical concerns. We outline possible directions for advancing this research program, and obtain a deeper understanding of how SL is involved in various facets of cognition.

Poster abstracts

1. Ali Al-Hoorie (Nottingham University): *Implicit attitudes and L2 achievement*

Throughout the history of the second language (L2) motivation field, attitudes and motivation have always been viewed as conscious, deliberative processes. This is reflected in the predominant use of self-report measures of popular constructs such as integrative motivation, intrinsic motivation, and the ideal L2 self. In a first attempt to expand the research agenda, Al-Hoorie (2015; Submitted) used the Implicit Association Test (IAT, Greenwald, McGhee, & Schwartz, 1998) and found that implicit attitudes toward L2 speakers were positively associated with more openness to the L2 community.

Building on that study, the present study examined whether implicit attitudes had an association with L2 achievement as well. A total of 311 Arabic L1 learners of English L2 (18–24 years old, M = 19.8, SD = 0.95) completed the implicit test. The results confirmed that the hypothesis that implicit attitudes were associated with achievement. More specifically, high-achievers scored significantly higher in the implicit test that did low-achievers, t = 2.26, p = .025, d = 0.27. Further analyses revealed that implicit attitudes were also associated positively with the L2 learning experience and negatively with ethnocentrism. The implications of these results are discussed.

2. Natalia Andriyanova (Saint Petersburg State University): *Implicit learning as the reason of repeated errors*

The current study investigated the occurrence of repeated errors. There are a lot of evidences on regularities of occurrence and repetition of errors in the learning process (Allakhverdov, 1993; VanRullen, Koch, 2003; Hajcak, Simons, 2008). It is important to show that people tend to repeat their errors not because of the individual complexity of the tasks. Some authors suggest that error repetition effect can be attributed to implicit learning of erroneous state. Humphreys, Menzies and Lake (2010) and D'Angelo and Humphreys (2015) explain repeated errors by implicit learning of an incorrect mapping from lemma to phonology for particular word. D'Angelo and Humphreys (2015) investigated whether tip-of-the-tongue (TOT) effect tends to reoccur on particular words. Authors have found that participants tend to experience TOT against test despite the fact that they were given the correct answer at study.

Humphreys, Menzies and Lake (2010) investigated repeated errors sing the SLIP procedure to study whether there is a tendency for speech errors in specific words to reoccur. In their experiments they have shown that when speakers made a phonological speech error in the study phase of the experiment, they were over four times as likely to make an error on that same item several minutes later at test. They have also shown that saying correctly a particular word during studying did not induce speakers to say that word as an error at test and that people don't tend to repeat the same errors after 48 hours. In our research we follow similar idea and try to control the complexity of the task. In our experiment we use anagrams with 6 letters presented for 10 seconds as the stimuli. At the study 20 anagrams

were presented in random order. At the test 1 immediately after the study the same 20 anagrams and 10 new anagrams were presented in random order. The second part was two days after the first part. The second part included test 2 – 20 anagrams from the study and 10 new anagrams and test 3 - 30 anagrams from the test 2 and 10 new anagrams. The results showed that at the test 1 people tend to solve worse the anagrams which they didn't solve at the study, than new anagrams. But at the test 2 there were no difference between unsolved anagrams from the study and new anagrams. At the test 3 people tend to solve worse the anagrams which they didn't solve at the test 2, than new anagrams. But there were no difference between unsolved anagrams from the study and new anagrams. Thus people don't tend to repeat the same errors after two days. Moreover they tend to make new repeated errors on the Day 2. Therefore we can conclude that people repeat their errors not because of the individual complexity of the tasks. The research is supported by RFH grant #16-36-15012.

3. Sofya Belova[1], Galina Kharlashina[2], and Eugenia Gavrilova[2] (Russian Academy of Sciences[1], Moscow State University of Psychology and Education[2]): *Implicit learning of form-meaning connections: development of measure for Russian native speakers*

Following studies of implicit learning (IL) of connections between forms and meanings (Williams, 2005; Leung, Williams, 2011, 2012; Paciorek, Williams, 2015) three modifications of relevant measure for Russian native speakers were developed as a part of ongoing project aimed at clarifying the relationship between individual differences in incidental L2 learning and cognitive abilities. In linguistic typology Russian is a synthetic language with highly inflectional morphology, free word order, specific phonologic features. Due to this specificity compared to English, a major L1 present in IL studies so far, consistent comparisons may shed light on L1 as a factor of IL of L2. All the three measures were aimed to induce IL of animacy as an aspect of meaning of artificial words. Accuracy and RTs were registered. Split-half reliabilities, signal detection measures (d', C) were calculated. The measures were different with respect to artificial word class, tasks at the learning and testing phases.

Artificial adverbs meaning "near" and "far" were used in the first measure (N=199, mean age 11.52, SD 1.3, 55% males). Meaning judgments and forced choice were used at the learning and testing phases, respectively. Post-experimental interview revealed extremely low level of awareness with respect to performance on a test as a whole, meanwhile the effect of IL was not revealed. These findings could be explained either by young age and age heterogeneity of the sample, specificity of adverbs as a world class as they may have remote association with animacy of nouns, orientation of meaning judgment on a single word form instead of a whole sentence. Artificial adjectives meaning "near" and "far" were used in the second measure (N=29, mean age 27.9, SD 8.19, 21% males). Plausibility judgments and forced choice were used at the learning and testing phases, respectively. Level of awareness with respect to performance on a test as a whole and source attributions (guess, intuition, rule) were assessed in post-experimental interview. The aware participants (N=9) displayed significant effect of learning (M=0.59, SD=0.21). The accuracy of unaware participants was not different from chance, although accuracy distribution had a slight right skewness, especially for unaware participants who indicated intuition as an attribution source (N=12, M=0.51, SD=0.12). In the third modification artificial adjectives meaning "big" and "small"

were used (N=42, mean age 19.09, SD 1.36, 23% males) and the learning phase was prolonged.

Plausibility judgments, grammaticality judgment test, awareness assessment and source attributions were applied. The effect of IL was not revealed because of liberal bias in GJT. To conclude, multiple factors should be taken into account to validation of an IL linguistic measure. To measure IL of form-meaning connection in Russian native speakers, adjectives as a word class and plausibility judgments at the learning phase, forced choice as a task format at the testing phase, and, presumably, a longer learning phase seem to be beneficial for IL to occur. This research was supported by the Grant № 15-36-01348a2 of Russian Humanitarian Scientific Fund and the "Grant of President of RF for young PhD scientists" (contract № is 14.W01.6523-MK).

4. Louisa Bogaerts[1,2], Ana Franco[3], Benoit Favre[1,2], and Arnaud Rey[1,2] (Aix-Marseille University[1], CNRS Marseille[2], Université Libre de Bruxelles[3]): *Speech onset latencies as an online measure of regularity extraction*

Statistical learning (SL) - the ability to extract the distributional properties of continuous sensory input across time and space - is the basis of a wide range of cognitive processes including language acquisition. In spite of the growing interest in SL, little is known about the temporal dynamics of regularity extraction. Classical SL tasks are not suited to study the time course or trajectory of learning, as they provide only an offline measure of learning. A classical typical SL task consist of a familiarization phase in which a continuous stream of information with particular statistical contingencies is presented, immediately followed by a two-forced-choice task. The score on such tests reflects the mean success rate of identifying regular patterns over foils and captures only information concerning the total amount of learning.

We will argue that online learning measures yield a much richer objective quantification of individual efficiency in extracting regularities and may provide significant theoretical advances in understanding the cognitive underpinnings of SL. In this research project, we therefore aimed to develop an online measure of verbal SL to supplement the existing offline testing methods. More specifically, we tested in a set of experiments whether the naming of visual items (i.e., letters or pictures) presented within a continuous stream (i.e., the familiarization phase in the classical setup) is altered by the presence of regularities. Our data suggest that, indeed, speech onset latencies are sensitive to online statistical computations (i.e., shorter onsets with increased predictability, for example for the second and third items of a repeated triplet), thus providing an online measure of SL. However, the effect is present only under experimental conditions that promote the production of anticipations and is modulated by both the number of and the nature of the regularities to be extracted. We found that when a relatively large number of regularities are present in the material, participants manage to extract some but not all the regularities, hinting that regularity extraction is subject to substantial working memory constraints. The methodological and theoretical implications of our findings will be discussed.

5. Cylcia Bolibaugh[1] and Patrick Rebuschat[2] (University of York[1], Lancaster University[2]): *Differential roles for implicit and explicit knowledge in adult distributional learning*

A number of recent studies have demonstrated that adults exposed to an artificial language can derive abstract categories on the basis of distributional information in the input alone (e.g. Reeder et al 2013). However, findings also suggest (e.g. Mintz 2002, 2014) that learning is often driven by endorsement of distributionally supported strings rather than reliable rejection of non-conforming strings. This pattern of results mirrors observations from natural and artificial second language learning studies in which adults incidentally exposed to linguistic regularities develop knowledge of attested patterns and are able to generalise these to novel grammatical instances but do not discriminate ungrammatical items at levels above chance. On the basis of these and similar findings, it has been proposed that implicit second language knowledge results in similarity based prototype effects whilst categorical discrimination requires explicit knowledge.

Although most experiments investigating distributional learning in adults are meant to simulate the implicit inductive mechanisms assumed to operate in infants and children, it is presently unclear what type of knowledge results from adult distributional learning, and how the conscious status of this knowledge interacts with grammaticality. In the present study, we investigate the extent to which distributional learning in incidental conditions results in implicit and explicit knowledge, and further distinguish the contribution of each to transfer (generalisation) and rejection (discrimination) of novel distributionally consistent and distributionally atypical strings.

Subjects (n=32) were incidentally exposed to auditory strings of pseudowords generated by a (Q)AXB(R) grammar. In an auditory exposure condition, adults (n=16) passively listened to the language. In a semantic referent condition, participants (n=16) listened to the language while viewing line drawn illustrations of scenes in which the AXB elements were mapped to agents, actions and objects. Thus the auditory condition provided only distributional information based on the patterning of the words in sentences, whilst participants in the semantic condition benefitted from a correlated cue to word class category structure. All participants were then asked to rate trained and novel sentences based on their confidence that the strings were part of the language they had been exposed to. After each rating, participants additionally reported the source of their decision, whether recollection, rule, intuition or guess.

Findings suggest that distributional learning in adults relies on explicit memory based processes which bias learners to generalise more widely than the statistical evidence warrants, and rule based knowledge appears to be necessary to appropriately restrict generalisations. A secondary cue not only changes the overall distribution of the type of knowledge which is generated, in that it enables more rule-based judgments, but also promotes discrimination (as seen in reliable rejection of ungrammatical strings). Where the stimulus environment enables greater confidence in the systematicity of the underlying structure (via correlated semantic cues), learners more readily formulate rules and concomitantly more accurately restrict their generalisations.

6. Arielle Borovsky[1] and Inbal Arnon[2] (Florida State University[1], Hebrew University of Jerusalem[2]): *Children use multiword frequency in real-time sentence comprehension*

Children can use the distributional frequency of language to support learning in a wide range of tasks from word segmentation to learning grammatical relations (Romberg & Saffran, 2010). Children can also use distributional information in multiword sequences to support language production: word production accuracy increases in frequent frames (Bannard & Matthews, 2008; Arnon & Clark, 2011). Similarly, language comprehension in young children may also be facilitated by combinatorial information (Borovsky, Elman, Fernald, 2012). However, it is not clear if this comprehension pattern is driven by simple lexical associations summed between individual word pairs across a sequence (e.g., like verb-object associations between eats and banana) or by the combinatorial frequency of the entire sequence (e.g., The monkey eats a banana). We focus on children's sensitivity to multiword frequency to ask (a) if children utilize such knowledge in online word recognition, and (b) if they are capable of rapidly forming novel multiword associations. We test these alternate accounts in a set of two visual- world eye-tracking studies with 36 5-to-8-year-old children. In Experiment 1, we first ask if children are sensitive to phrase frequency by comparing fixations towards objects in highly frequent verb phrases (throw the ball) to objects appearing in less frequent phrases (throw the book). We then tested whether the effect of frequency is driven by the lexical association of the verb with the object or by the entire phrase frequency by contrasting object looking in the above frequency conditions to looks towards the same object in a modified sentence frame that has similar verb-object frequency but differs in phrase frequency (throw your ball/book). Preliminary results suggest that children were sensitive to the frequency of the verb-object association (β = 0.48, $\chi2$ = 4.03, p = .045), but were not influenced by modifications to the sentence frame (β = 0.06, $\chi2$ = 0.07, p = .27). While this result alone suggests that multi-word frequency may not support word-recognition in children, it is possible that the differences between the frames (e.g., throw your ball vs. throw the ball) were too subtle to drive a strong looking time effect. Therefore, we carried out a training study that precisely controlled for multiword frequency by manipulating multiword relations between agents, actions, and objects via short stories. Crucially, children learned a novel combinatory event (monkey-rides-car) and other lexical associations such that the summed frequencies for an alternative verb-object relation, rides-bus, were more frequent than the chunk frequency. Children's eye-movements were tracked as they heard previously trained multiword phrases whilst viewing an array where looks to the combinatory target (e.g. CAR) was contrasted with the lexically associated target (e.g. BUS). Children were sensitive to the novel chunk and generated anticipatory fixations towards the target item before it was spoken (β = 1.67 $\chi2$ = 55.7, p < .0001). The findings suggest that children can use multiword information to support real-time sentence comprehension, though the effects may be subtle in natural language processing.

7. Katharina Braungart[1,2], Birgit Öttl[1], Detmar Meurers[1], and Barbara Kaup[1] (University of Tübingen[1], Lancaster University[2]): *Does semantic information facilitate grammar learning?*

In a globalizing world, the question of how we should teach foreign languages is more crucial than ever. In this context, the interplay between meaning and grammar is of particular interest as it has implications for language learning in all instructed settings, from the classroom to computer-based language learning environments.

There are a few studies addressing this issue by investigating the impact of semantic information on the acquisition of morphology/syntax with artificial languages (e.g. Fedor, Varga & Szathmáry, 2012, Poletiek & Lai, 2012). The authors generally argue for a semantic benefit, yet further research is needed, especially using natural languages.

Existing research mainly focused on the connection between the meaning of vocabulary and grammar. For the present experiment, we used the semantics of whole sentences instead. We thereby aimed at imitating a more realistic language learning in a lab setting. We investigated the hypothesis that rules are acquired more easily when semantic information is available during the learning phase.

Participants (n = 40) learned the morphosyntactic rules of Latin sentences in a rule search paradigm, either with or without semantic information. The semantic information was implemented by the simultaneous presentation of the sentence meanings in form of matching pictures. The learning performance was assessed by a grammaticality judgment task combined with a metalinguistic knowledge test. Participants in the with-semantics group showed better learning outcomes than those in the without-semantics group. This finding suggests that semantic information facilitated the learning of the morphosyntactic rules. However, further research is needed to assess the extent to which this finding can be explained by means of a multi-media benefit. In principle it seems possible that the relatively high performance in the with-semantics group reflects the fact that these participants had available verbal and pictorial information whereas the without- semantics group only had available verbal information.

8. Henry Brice and Ram Frost (Hebrew University of Jerusalem): *Statistical learning and L2 learning: Improving reliability and predictive validity*

Statistical learning (SL), the ability to extract regularities from sensory input, has been tied to language processing and acquisition (Saffran, Aslin, & Newport, 1996). From an individual difference perspective, performance in visual SL tasks has been shown to predict reading acquisition ability in both L1 (e.g., Arciuli & Simpson, 2012) and L2 (Frost et al., 2013). Correlations, however, are often small, since most SL tasks are not structured to reliably tap individual differences. To better understand the relation of SL ability and second language learning, we have developed psychometrically reliable non-linguistic visual and auditory SL tasks, that include both online and offline measures. These tasks were tested for reliability on a cohort of undergraduate students at the Hebrew University. We present evidence of the improved psychometric parameters of these tasks (test-retest correlation and Cronbach-Alpha of internal consistency) as compared to previous tasks.

To test the predictive validity of the new SL measures we tracked an additional cohort of overseas students learning Hebrew as a second language during a full academic semester. Participants were tested with the new visual and auditory SL tasks, and their performance in SL was then correlated with their achievements in the Hebrew proficiency exams taken as part of the language course. These included reading, oral production and listening comprehension measures. The results show significant correlations between the visual SL measure and the Hebrew learning measures, controlled for IQ and working memory abilities. Performance in the auditory SL task, however, did not correlate with any of the

language measures. This study extends both the internal and the external validity of previous findings tying visual SL to L2 learning, but raises questions regarding what auditory SL tasks tap.

9. Josie Briscoe[1] and Sven Mattys[2] (University of Bristol[1], University of York[2]): *Mapping the statistical learning of artificial speech segments using the Click Detection paradigm in children*

Classic paradigms with infants and adults captured artificial language learning as a product of exposure to unfamiliar speech streams with high and low transitional probability segments. Yet, the scarcity of research with older children has yet to probe the complexity of learning processes and their interface with developing language in detail. Here, we used a click detection paradigm (Gomez et al., 2010) as a window into the nature and course of probabilistic learning from artificial speech over two four minute periods separated by a short pause of approximately 1 minute. By adapting the click detection paradigm for use with young children, learning was indexed during their focussed 'listening out' for clicks that had been embedded into a speech stream, although exposure to speech was incidental. Children aged 5 – 6 years showed learning indexed through their slowed response to clicks located within high probability and low probability speech segments over time. Children demonstrated a marked slowing of clicks located within high probability segments over approximately 2-4 minutes of a 4 minute exposure period. After a short pause, children's click detection latencies returned to near baseline at the beginning of a second 4-min exposure period, but 'rebounded' quickly towards slower response latencies for the clicks located within high probability segments. Children subsequently demonstrated above-chance recognition of exposed speech segments in a 2AFC recognition test. The recognition test compared the exposed tri-syllabic segments with either 'part-words' that shared either one or two syllables with the target segment, or nonwords. Unlike adults, children's performance did not further discriminate exposed tri-syllabic speech segments more reliably when contrasted with decoys that were trisyllabic 'nonwords', as compared to 'part-word' decoys that overlapped with the target segment. In summary, learning of transitional probability segments was observed indirectly in young children, using a click detection paradigm. By observing responses to embedded auditory stimuli, it was noteworthy that learning appeared non-linear across the entire exposure period but showed a 'rebound' effect after imposition of a short delay. The fragility of the learning profile, alongside a robust response to a temporal pause, were reminiscent of procedural learning observed in children on nonverbal tasks (e.g. Serial Reaction Time task; Lum et al., 2014). Implications of these findings will be discussed through their relation to statistical learning from artificial speech.

10. Helen Brown[1], Lydia Gunning[1], and Elizabeth Wonnacott[3] (Warwick University[1], University College London[2]): *Do shared distributional contexts aid learning of Italian gender classes in 7-year-old children?*

Language learning involves forming generalizations over classes of words. One example is the ability to acquire gender classes. Artificial language learning experiments in adults have shown generalization based on shared distributional contexts (e.g., Mintz, Wang, & Li, 2014). Do shared distributional contexts aid in child learning of an L2? We explored whether

7-year-olds could acquire gender classes via distributional learning using input from a real language (Italian) with two gender classes. Monolingual English speaking children heard singular and plural definite noun phrases of four types:

masculine singular: il noun[masculine] +o (e.g. il letto, the bed)
masculine plural: i noun[masculine] +i (e.g. i letti, the beds)
feminine singular: la noun[feminine] +a (e.g. la balena, the whale)
feminine plural: le noun[feminine] +e (e.g. le balene, the whales)

Nouns were inanimate with no semantic cues to gender. Children were exposed to input in 5 sessions through a computerized word-learning game; hear a noun phrase (e.g. il letto) and identify the correct picture from a choice of two. They completed comprehension and production tests, including trained and untrained nouns, in sessions 3 and 5. Two between-subject conditions manipulated type-frequency: high-type- frequency (6m/6f nouns) versus low-type-frequency (2m/2f nouns). We predicted greater generalization following high-type-frequency due to greater lexical variability in each gender class (cf. Wonnacott, Boyd, Thomson, & Goldberg, 2012).

Children showed strong item-level learning, reaching 86% accuracy in the final day's training. A speeded comprehension task provided evidence that children processed the gender marking of the determiners and used them to predict the upcoming noun, suggesting relatively automatized item-level processing. However, children showed little evidence of generalization when tested with new items; (1) They could not correctly extend newly taught words from the singular to the plural with correct gender marking (or vice versa); (2) They did not distinguish novel items with valid determiner and vowel combinations (i.e. same gender/number markings) from invalid counterparts with incorrect gender (la letto, il letta)/number (i letto, il letti) markings.

The predicted benefit of high-type-frequency was not observed. Instead, there was some evidence for a benefit of low-type-frequency, which was particularly seen in the learning of number markings. This suggests that higher input variability may actually hinder generalization, at least in the early stages of learning, presumably due to the greater complexity of the input. Ongoing experiments explore this interaction between complexity and variability, and further investigate the role of prediction in learning using visual world eye-tracking.

11. Andrei Costea, Razvan Jurchis, and Adrian Opre (Babeș-Bolyai University): *Influencing cognitive control over judgment knowledge with subliminal priming*

The implicit phenomena are very complex and difficult to separate because they often interact with each other. In this study we investigate whether cognitive control over the judgment knowledge acquired from an implicit learning task can be influenced by subliminal priming. Probabilistic serial reaction time task (SRTT) with a second order conditioning pattern is used in the acquisition phase. Process dissociation procedure is applied in the test phase. In inclusion task, participants respond to 12 triplets with no subliminal priming. In exclusion task, the subliminal priming is present. The subjects encounter 36 triplets out of which: 12 contain primes that are inconsistent with acquisition pattern (i.e., consistent with

the exclusion instructions), 12 contain primes that are consistent with the acquisition pattern, and 12 contain no subliminal primes. The primes consist in spatial locations, identical with stimuli exposed in SRTT. Each prime appears after the second element of the triplet, before the participant's generation response. Thus, in the exclusion task, we expect that participants will demonstrate higher cognitive control over trials that contain primes inconsistent with the acquisition pattern, when compared to trials with consistent or no subliminal primes. We are now engaged in the data collection process.

12. Davide Crepaldi[1], Daniel Casasanto[2], Andrea Nadalini[1], and Roberto Bottini[3] (SISSA[1], University of Chicago[2], University of Trento[3]): *Subliminal semantic processing is based on implicit learning*

Time is metaphorically arranged on either the horizontal or the sagittal axis in space [1,2]. However, whereas the sagittal metaphor comes up very often in language (e.g., "a bright future IN FRONT of you"), the lateral one does not. This implies that the sagittal time-space association could be captured, at least in principle, through statistical learning based on language use, i.e., we learn that future–related words tend to populate the same sentences as front–related words. On the contrary, more complex semantic representations would be required to get the link between past/future and left/right. Based on these considerations, we set out to test the hypothesis that higher–level semantic relationships would require conscious processing for being activated, whereas lower–level ones would be processed out of awareness [3].

We run two semantic priming experiments with the same material. Primes were two spatial words related to the lateral axis (right, left) and two spatial words related to the sagittal axis (front, back). Targets were four temporal words referring to the past (e.g., previous) and four temporal words referring to the future (e.g., next). Participants were engaged in a go/no go task that required them to respond only to either past–related or future–related target words. In the first experiment, primes were clearly visible, whereas in the second experiment they were masked from participants' awareness (as assessed through a d-prime analysis).

When primes were visible, congruent trials were faster than incongruent ones, with no sign of a Congruency–by–Axis interaction, i.e., priming was equivalent along the horizontal and sagittal axes. Masked primes, instead, yielded a significant Congruency–by–Axis interaction, reflecting faster congruent than incongruent trials only along the sagittal axis. No sign of masked semantic priming was observed for trials that were congruent/incongruent along the horizontal axis.

These data shed light onto what kind of semantic information can be processed outside awareness. When people read word forms consciously, they activate related word forms AND the semantic information associated with them. Thus, right primes tomorrow as the word right activates the mental representation of rightward space, which is in turn associated with future times. Yet, when words remain outside of awareness, information processing seems to be dominated by relationships coded in language use. Unconscious semantic processing may thus be limited to knowledge emerging from statistical learning of

word–to–word relationships, whereas awareness may be necessary for higher–level semantic information to be activated.

13. Sible Andringa and Maja Curcic (University of Amsterdam): *Is visual world eye-tracking technique suitable for studying implicit learning? A validation study*

In recent years, psycholinguists have increasingly turned to online processing measures— most notably measures of self-paced reading and listening, event-related brain potentials (ERPs), eye-tracking, and functional magnetic resonance imaging (fMRI)—to investigate the nature of language processing in native speakers and in L2 learners. It has been suggested that such studies provide evidence that L2 learners have learned particular L2 structures up to a point that little or no conscious effort is required to process them (Godfroid & Winke 2015; Morgan-Short, Faretta-Stutenberg, & Bartlett-Hsu, 2015). Therefore, these measures can be interesting for implicit learning research; they assess language processing ability at millisecond precision under conditions that do not readily allow for conscious reflection.

The visual world eye-tracking technique is an interesting case in point. Using this technique, L2 learners have been shown to predict upcoming information in much the same way as native speakers can (e.g., Lew-Williams & Fernald, 2010; Dussias, et al 2013). Such prediction occurs within a few hundred milliseconds, which suggests automatic and potentially implicit processing. An advantage of the technique is that it does not require ungrammatical items to assess learners' knowledge, which have been claimed to trigger awareness and to affect the learning processes. As such, the visual world eye-tracking technique could lend itself well to the study of implicit learning, if at least it can be shown that the predictions made by learners are based on implicit, unaware processes.

This study was designed to investigate to what extent prediction in language processing is implicit. A within- participant design was used to learn how awareness affects eye-movement behavior in a visual world paradigm. Twenty native and twenty advanced non-native speakers of Spanish were tested on their ability to process differential object marking (DOM), a rule of Spanish according to which direct objects are marked for animacy. In every target trial, learners saw two images on the screen and heard a Spanish transitive sentence. Their task was to choose the correct image. Learners who could process DOM online were expected to look at the correct image after hearing the animacy marker, but before hearing the noun. In the first stage of the experiment, learners were only instructed to choose the correct image and were not made aware of the target structure; in the second phase, they were made aware of DOM by means of brief instruction.

Neither native speakers, nor non-native speakers demonstrated evidence of online processing in the first stage of the experiment. In the second phase, however, when participants were aware, both groups did show DOM- based prediction. These results suggest that prediction in language is potentially the result of conscious and perhaps even strategic processes. This casts past research findings in a different light and points to the necessity of extensive debriefing after testing to find out to what extent participants were aware of their own processing.

14. Nadiia Denhovska (University of Central Lancashire): *Frequency, animacy and working memory effects in the incidental learning of L2 grammar*

Previous research on implicit learning of grammar and on grammatical knowledge acquisition under incidental learning conditions has focused mainly on receptive knowledge acquisition of a natural language already familiar to learners, and of artificial grammars. It has been demonstrated that some learning is possible under such learning conditions (Lee, 2002; Williams, 2005; Leung & Williams, 2011; Rebuschat & Williams, 2012). However, it still remains unclear to what extent adults can acquire receptive and productive knowledge of grammar in a natural language via incidental exposure and, if so, what factors contribute to successful L2 grammar acquisition.

In an experiment, 60 adult native English speakers with no previous knowledge of a Slavic language or advanced knowledge of a language with grammatical gender were presented with noun-adjective agreement patterns as a function of gender and case in Russian containing animate (denoting animals-epicenes) and inanimate head nouns (denoting objects) under an explicit learning condition and two incidental learning conditions. We manipulated token frequency in the incidental learning conditions: participants were exposed to the stimuli under a high token frequency and a low token frequency condition. Participants in the incidental learning conditions read for meaning Russian sentences containing agreement in masculine and feminine genders, four cases (nominative, genitive, instrumental, dative), and two animacy levels and viewed semantically corresponding pictures presented on a computer screen, whereas in the explicit learning condition they were provided with metalinguistic explanations about the agreement rule. Response times and accuracy in comprehension and production post-tests were used to investigate the level of receptive and productive knowledge retention. We also measured participants' working memory capacity using Operation and Reading Span tasks (Unsworth et al., 2005).

The data were analyzed using Generalized Linear Mixed Models. There was no significant difference in comprehension accuracy between the incidental learning conditions, however in production participants in the high token frequency condition performed significantly better than in the low token frequency condition. Participants in this condition also relied significantly on WM in comprehension ($r = .51$, $p = .02$) and production ($r = .47$, $p = .04$). But there was no significant effect of animacy either in production or in comprehension.

The results will be discussed in the light of how frequency, working memory and animacy may impact the acquisition of receptive and productive knowledge of a grammar rule through incidental exposure, and how the correlation with working memory may provide insight into the activation of either explicit or implicit knowledge when performing a task.

15. Piera Filippi[1] and Sabine Laaha[2] (Vrije Universiteit Brussel[1], University of Vienna[2]): *The effect of word position and prosody in a word learning task: A study on school-age children*

The acquisition of language includes multiple distinct sub-processes such as: i) identify word-like units within the speech stream and store their acoustic representation in memory, ii) induce the intended visual referent, i.e., map the identified words to an exemplar of the

intended visual referent, and iii) link the linguistic unit and the referent in a correct word-meaning pair. Numerous studies have addressed each of these processes separately (Morgan et al., 1987; Samelson & Smith, 1998; Shukla et al., 2011). Building on the outcomes of these different strands of investigation, the present research examines how cognitive constraints and perceptual salience of the speech signal favor these three processes simultaneously. Specifically, our study investigates the role of statistical learning, recency effect and prosody in a cross-situational word-meaning mapping task. 8-9 year-old participants (n = 56) viewed photographs belonging to one of three semantic categories while hearing a four-word utterance containing a target word. Four between-subjects conditions were tested. In the control condition, all words had the same pitch (~ 210 Hz) and, across trials, the position of the target word was varied systematically within each utterance. The only cue to word-meaning mapping was the co-occurrence of target words and referents. This statistical cue was present in all conditions. In condition 2, the target word was varied systematically within each utterance across trials, and was sounded at a pitch one octave higher than all the other words of the utterance (interval typical of infant-directed speech). In condition 3, the target word always occurred at the end of the utterance, and was sounded at the same fundamental frequency as all the other words of the utterance. Finally, in condition 4, the target word always occurred at the end of the utterance, and was sounded at a pitch one octave higher than all the other words of the utterance. Pairwise contrasts between each condition and the control condition revealed that performance in this word-learning task was significantly higher than that observed with simple co-occurrence only for condition 4. This finding suggests that, for school-age children, the combination of a recency effect with a perceptual cue (pitch enhancement) facilitates word learning within a cross- situational mapping task. We discuss the relevance of memory and perceptual constraints for language acquisition.

16. Malgorzata Forys-Nogala[1], Grzegorz Krajewski[1], Theodoros Marinis[2], and Ewa Haman[1] (University of Warsaw[2], University of Reading[2]): *Exploring the effects of implicit and explicit training on the formation of implicit and explicit representations of L2 grammar: A study on the semantics of English articles*

The aim of the present study is to examine the influence of implicit and explicit training on the formation of implicit and explicit representations of L2 grammar. Specifically, the main research question pursued here is if implicit L2 knowledge can only be developed through frequency-based implicit or statistical learning or if its growth can also be fostered by explicit representations. It is hypothesized that the explicit meaning-embedded instructions on the use of English articles may act upon the development of the implicit knowledge of the target rules.

Intermediate L2 English learners were flooded with representative exemplars of the use of English articles (a structure which is not present in their L1). Following online and offline pretests and language background questionnaires, the participants were randomly assigned to one of three experimental groups. The training in each group incorporated the timed presentation of a set of conversation extracts illustrating the use of English articles in four different semantic contexts. The contexts differed in terms of the features of definiteness and specificity encoded by articles (e.g. Ionin et al., 2004). The crucial difference between the training conditions lay in the comment that appeared below each extract. In the first

(explicit) group, the comments elucidated the use of articles based on the hearer's and speaker's knowledge of the target NP moderated by the article. The second group (implicit) considered the same extracts focusing on the politeness of the interlocutors. This condition did not include any explicit reference to either article forms or semantics. Finally, the third (semi- implicit) group received background on the hearer's and speaker's knowledge relating to the target phrase, however, the comment made no overt linkage to the use of articles. This condition was introduced into the study due to well-established evidence that articles being non-salient grammatical structures are not easily acquired by mere exposure by adult L2 learners (cf. N. Ellis, 2006). To maintain participants' attention, all the dialogues were followed by control questions. Overall, the training session took approximately 40 minutes. Two pre- and posttests - a self-paced reading task and an untimed multiple choice task - were used to assess the growth of implicit and explicit knowledge, respectively. The self-paced task was selected to investigate participants' online sensitivity to article substitution. Reaction times were collected at the critical segment, which contained the violation, and two post critical segments. The offline multiple choice task contained choice attributions - guess, rule, intuition or memory (Dienes & Scott, 2005) and filler items to mask its real purpose.

The aim of the paper is to present the results of this still in-progress study (the data is going to be gathered from approximately 75 participants), and discuss their possible contributions to the implicit/ explicit interface debate (cf. R. Ellis et al., 2009).

17. Rebecca Frost[1], Michelle Peter[2], Samantha Durrant[2], Amy Bidgood[2], Caroline Rowland[2], Padraic Monaghan[1,] and Morten Christiansen[3] (Lancaster University[1], University of Liverpool[2], Cornell University[3]): *How do infants use nonadjacent dependencies during language acquisition?*

Language learners must identify words and rules from continuous speech. Substantial evidence from language acquisition research indicates that implicit statistical computations could play an important part in these tasks, with findings demonstrating that 15-18-month-olds can use distributional information to help discover nonadjacent relations between words in pre-segmented speech (e.g. Gomez, 2002). However, infants' capacity to identify statistically defined words and rules has been shown to be contingent in part on additional cues contained within the speech, such as pauses between words (Marchetto & Bonatti, 2013).

Marchetto and Bonnatti (2014; 2013) showed that 12 -and 18-month-olds could use nonadjacent transitional probabilities to identify words from continuous speech, and could identify the rules these words contained when speech was segmented. However, segmentation was assessed using words and previously unheard non-words, where non-words were scrambled words that retained no trained statistics, limiting the competition between the two items. Rule learning was assessed using non-words and rule-words, in which a trained dependency was intervened by another trained syllable. This overlap between rule-words and trained words could have restricted performance. By permitting rule-words to include novel syllables, Frost & Monaghan (2016) demonstrated that adults can use nonadjacencies for both segmenting words and generalising the rules they contain. Thus, we revised test items to provide more robust assessments of segmentation and

generalisation, to investigate more closely infants' capacity for generalising nonadjacent dependencies. This allowed us to explore whether the simultaneity of these processes noted in adults can be seen in 16-month-olds.

We familiarised 16-month-olds to a continuous stream of artificial speech for 15 minutes using an incidental learning paradigm (e.g. Gomez, Bootzin & Nadel, 2006), then examined their knowledge of words and structural rules. Words and rules were defined by nonadjacent dependencies; there were no other cues within the language that could guide learning. Infants completed head-turn-preference tasks of segmentation and generalisation. The segmentation task contained eight words (e.g. bamuso, lifodu) and eight part-words, which straddled word boundaries (e.g. solifo). The generalisation task contained eight part-words and eight rule-words - featuring a trained dependency, intervened by a novel syllable (e.g. baveso). Gaze direction and duration was measured using video-recording and eye-tracking.

Linear mixed effects analysis indicates that 16-month-olds could use nonadjacent dependencies to identify individual words in continuous speech, and could distinguish words from close statistical competitors – building on Marchetto & Bonatti's (2013) demonstration that infants can use nonadjacencies to distinguish between words and unheard strings. Results indicate the powerful nature of these computations in infant learners. There was no evidence that infants could generalise the rules these words contained. While it is possible that generalisation performance may have been impeded by task difficulty, results support the suggestion that these processes have different developmental trajectories.

18. Andreea Geambasu, Michelle Spierings, Carel ten Cate, and Clara Levelt (Leiden University): *The effects of task-specific variables on artificial grammar-learning and generalization*

Extraction and generalization of rules is one of the bedrocks of language acquisition. Understanding the conditions under which simple rule learning can occur and to what extent learning is implicit or explicit is essential for understanding the fundamentals of language acquisition. Inconsistency in experimental methodology used to show rule learning indicates that it is of interest to explore the precise conditions influencing learning and generalization. To this end, we conducted four auditory Artificial Grammar Learning (AGL) experiments with 12 conditions (n=192) using XYX/XXY grammars. In Experiments 1-3, ten participant groups received passive familiarization with one of the two grammars and were tested with a Yes/No paradigm. In Experiment 4, two groups were exposed to one of the two grammars via reinforced training until criterion and were tested in a Go-Left/Go-Right task. Across these four experiments, we manipulated vagueness of instructions, input variety, presence or absence of feedback, and types of testing items.

In Experiment 1, instructions were "undirected," not directing attention to the underlying structure. Participants indicated whether the test items were part of the same "language" or "group" as in the listening phase. To study the effect of variety in the input, participants were further divided into groups exposed to either 3 or 15 triplets, for a total of 45 trials in both cases. Test items consisted of a consistent and inconsistent grammar, each made up of

either familiar or novel syllables, constituting "undirected" testing in which test items could not direct participants to what they should be attending to. In Experiment 2, instructions were "directed," indicating that the exposure sounds followed a certain "pattern," and that they should indicate whether test items followed that same pattern. Here too participants heard 3 or 15 triplets during familiarization, and testing was "undirected," consisting of both familiar and unfamiliar sounds. In Experiment 3, we now used "directed" testing, meaning only novel test sounds were used (directing participants' attention away from processing at the sound level). Finally, in Experiment 4, participants learned the grammars, without instruction, in a reinforced Go-Left/Go-Right task. In the test, they continued (without feedback) with categorizing the test items as either a Left sound or a Right sound, where each grammar corresponded with one of the sides.

Our results show that participants were able to apply the rule to test items composed of previously heard sounds, independently of our experimental manipulations, discriminating the two grammars significantly above chance in all conditions. However, they were not able to generalize the rule to novel sounds if they were not somehow "directed," either through directed instruction, directed testing, or feedback training. Notably, variety in number of exposure triplets during familiarization did not affect generalization, with no significant difference in performance between participants exposed to 3 or 15 triplets. It thus seems that in order to generalize simple rules beyond their surface form, participants require their attention to be directed in some way. These results have implications for the design of future AGL experiments and for theories of implicit vs. explicit AGL.

19. Wibke Hachmann and Sascha Schroeder (Max Planck Institute for Human Development, Berlin): *Sublexical chunking in an artificial orthography*

This study was designed to investigate the time course of artificial written language acquisition in adults. Particularly, we try to assess the process of chunking letters into words during learning to read a largely regular orthography. Like children usually do, our adult participants learn a new written code for known spoken words. Participants learn to read medium frequent 5-7 letter words that are written in arbitrarily assigned letters of a completely foreign alphabetic language. In this laboratory condensed version of written language acquisition, they learn the new script over three sessions, each spaced one week.

During training, we manipulate the sublexical and the lexical level. On the sublexical level, some of the grapheme-phoneme correspondences (gpc) are altered such that for four language sounds, the letter coding is different from the native language (e.g. sh is made of one new letter instead of a multigraph, and z is made of ts). These gpc-changes correspond to two easy (reduction to monograph) and two difficult (introducing new multigraph) new rules. On the lexical level, we manipulated the frequency of occurrence, in that half of the words appear twice as often as the other words. After each training block, participants also fulfill two transfer tasks in the new script: a lexical decision task to track their newly acquired word level reading, and a pseudoword reading task to assess segmentation and transfer of sublexical grapheme-phoneme correspondence rules.

The time course of acquisition follows the development from letter level segmentation through interactions with rule extraction and the chunking of sublexical units to whole word

reading. Word naming latencies during training vary as a function of rule complexity, frequency of occurrence and of time, which also corresponds to the sublexical effects visible in the pseudoword reading transfer task. The lexical decision task incorporates a full type frequency x word length x gpc-change design, and hence also shows transfer effects of frequency, rule extraction and word length on the lexical level as they develop over all three sessions.

20. Erin Isbilen[1], Stewart McCauley[1], Evan Kidd[2], and Morten Christiansen[1] (Cornell University[1], Australian National University[2]): *Testing implicit-statistical learning implicitly*

Statistical learning is typically construed as the implicit learning of distributional regularities, with little or no explicit awareness of the underlying statistical patterns. Yet, tests of such statistical learning most often involve an explicit response in which participants have to translate their implicit statistical knowledge into an overt button press in a two-alternative forced-choice (2AFC) task or a graded similarity/familiarity rating. It seems likely that asking learners to make explicit judgments based on implicitly learned associations might fail to capture subtle nuances and individual differences in statistical learning. We therefore developed a novel paradigm to test statistical learning implicitly by repurposing a standard serial recall task from the memory literature.

Recent theoretical and empirical research has suggested that basic abilities for chunking may subserve many aspects of language (Christiansen & Chater, in press; McCauley & Christiansen, 2015). Here, we take advantage of the general ability for chunking in a non-word repetition (NWR) task as an implicit measure of statistical learning. The rationale is that if participants are sensitive to the statistical regularities in the input, they should chunk coherent statistical patterns into larger units, which should facilitate recall.

In the experiment, participants listened to continuous stream of syllables from the seminal Saffran, Aslin, and Newport (1996) statistical learning study, with only transitional probabilities between the syllables as cues to boundaries between six trisyllabic words. After exposure, participants completed two tasks that measured their sensitivity to the words in the input stream: a standard 2AFC task and our novel NWR paradigm, allowing for a direct comparison between these two different measures of learning. In the NWR paradigm, participants were asked to recall strings of six syllables from the training corpus. Critically, experimental items were constructed such that they contained two-word combinations from the training input, and control items contained the same six syllables presented in a random configuration. Our prediction is that participants' ability to chunk the input stream into discreet words will result in more accurate recall of experimental items. Scoring is done on a syllable-by-syllable basis, thereby providing a means by which to measure sensitivity to the statistics of both whole words and part-words.

Our preliminary results indicate that participants were significantly more accurate at recalling the strings of syllables that were comprised of words from the training corpus than recalling strings of the same syllables presented in random configuration, confirming our hypothesis that participants' sensitivity to the statistical patterns in the input can be measured in terms of their ability to chunk subsequent input in a NWR task. The performance on the 2AFC task only approached significance. The combined initial results

thus suggest that the NWR task is more a sensitive measure of statistical learning than the standard 2AFC task. A further advantage of our novel paradigm is that it aligns with previous work suggesting that NWR provides a general measure of people's current level of linguistic exposure (Jones, in press), while offering an implicit means of testing implicit statistical learning based on general learning and memory mechanisms.

21. Ivan Ivanchei (Saint Petersburg State University): *Affective consequences of implicit knowledge application*

People like objects that have the same structure as previously seen objects. It occurs even if they do not consciously know anything about this structure – the so called structural mere exposure effect (SMEE, Gordon & Holyoak, 1983). The aim of this study was to investigate the sources of this feeling of pleasantness. In classical SMEE studies, subjects liked grammatical stimuli more just observing them. I wanted to know how decisions about stimuli change their evaluation. In recognition studies, it was shown, that people like stimuli less if they misclassify them as previously seen or unseen, suggesting presence of some internal feedback mechanism (Chetverikov, 2014). Can we find the same internal feedback mechanism in implicit learning?

The classical artificial grammar learning paradigm was used, but instead of letter strings I used nested geometrical shapes as in study by Pothos & Bailey (2000). In the first experiment (N = 10), simple implicit learning effect was observed. After being presented with rule-governed ("grammatical") geometrical combinations, subjects classified new stimuli as grammatical or not with above-chance accuracy, t(9) = 4.12, p = 0.003.

In the second experiment (N = 10), SMEE was observed. In the test phase, subjects rated grammatical stimuli as more pleasant than ungrammatical, t(9) = 3.17, p = 0.011. In the third experiment (N = 30), participants performed two tasks at the test phase: classified stimuli as grammatical or not and evaluated their pleasantness. The order of two tasks varied from trial to trial. Again, implicit learning and SMEE were observed. Interestingly, SMEE was observed only when pleasantness evaluation was the first action subjects performed with a stimulus, t(29) = 2.33, p = 0.027. When they had to evaluate it after classifying as grammatical or not SMEE disappeared, t(29) = 0.66, p = 0.515. No evidences for any internal feedback were found; pleasantness of correctly and incorrectly classified strings did not differ for subjects, t(29) = 0.82, p = 0.418.

In sum, implicit learning and SMEE were observed. SMEE disappears after stimulus classification, which can be explained within fluency attribution approach. No evidences for the internal feedback mechanism in implicit learning were found. The possible explanation is that fluency attribution is the only source of SMEE. The other alternative is the study design (trial-based instead of block). Research was supported by RFH grant #16-36-15013.

22. Matthew Jones (University College London): *Language learners introduce iconicity implicitly in a model of language change*

Iconicity – i.e. non---arbitrary correspondence between form and meaning – is familiar to Anglophones from onomatopoeia (bang, splash, meow etc.). However, many non---Indo

European languages are much richer in iconicity. Spoken languages like Japanese have extensive sound---symbolic lexica of words that speakers perceive as enacting the properties or events they describe. Moreover, signed languages are extremely rich in iconicity (see Perniss, Thompson, & Vigliocco, 2010, for a review of iconicity in natural language). There is evidence that iconic forms in natural language reflect advantages these forms enjoy in processing and acquisition (Perniss & Vigliocco, 2014): effectively biases on the part of language learners. Languages change over time and language learners' biases constrain this change. If learners acquire iconic forms more easily than non---iconic competitors, or if learners are biased towards mislearning forms in iconic ways, then iconicity will be maintained in language by cultural evolution (cf. Kirby, Cornish, & Smith, 2008).

To test this possibility we chose two forms of spoken iconicity: sound---shape iconicity, and duration of motion iconicity. Sound shape iconicity is a cross---linguistic phenomenon whereby some words (e.g. kiki) are perceived as fitting spiky shapes, and others (e.g. bouba) as fitting round shapes (Ramachandran & Hubbard, 2001). Duration of motion iconicity is the tendency of sound---symbolic languages like Siwu and to express repetition or extended duration by repetition or elongation of syllables (Perniss et al., 2010; e.g. in Japanese, goro means "heavy object rolling", gorogoro means "heavy object rolling repeatedly"). Following Kirby, Cornish, and Smith (2008) we ran two experiments in the iterated learning paradigm: a model of cultural transmission and evolution. The experiments were structured like the children's game of Broken Telephone. A first participant in each diffusion chain was taught an initial "language" of names for video stimuli showing round and spiky shapes moving for different durations. This participant   was tested and his/her responses were taught to a second participant, whose output went to a third, and so on. In total, each chain had ten generations (i.e. participants) and each experiment had six chains. The two experiments differed only in the names' modality: in Experiment 1 they were written, in Experiment 2, spoken.

In both experiments, we found that participants spontaneously introduced iconicity for both shape and duration of motion to an iconically neutral initial language, without conscious awareness of having done so. This, we argue, provides evidence that biases towards iconic forms – which are perhaps due to advantages they enjoy in acquisition - introduces pressure towards iconicity in the cultural evolution of vocabulary, explaining iconicity's widespread presence in natural language.

23. Shani Kahta and Rachel Schiff (Bar-Ilan University): *The deficit in SL among adults with dyslexia is domain general*

It has been recently suggested that individuals with DD are deficient in SL, and that this deficit accounts for some of their difficulties in acquiring fluent reading and writing skills. However, the paucity of research leaves the nature of this deficit unclear. In particular, the question of whether this deficit is specific to linguistic stimuli or whether it is domain general, and the deficit will show regardless of the type of the stimuli. Thus, the aim of the current study was to explore the nature of the SL deficit using a classic AGL task. Sixty five adults participated in two experiments, 33 in the DD group, and 32 in the control group. The stimuli for the linguistic task were letter sequences, and the stimuli for the non-linguistic

task were shape strings. Findings showed that all participants had exceeded chance level in both types of stimuli. Nevertheless, a significant difference was found between DD and controls in both linguistic and non-linguistic tasks. These results support the SL learning deficit hypothesis of individuals with DD, and further expand it by suggesting that the deficit is domain general rather than specific to linguistic stimuli. Theoretical and clinical implications are discussed.

24. Nina Kazanina and Sarah von Grebmer zu Wolfsthurn (University of Bristol): *Are phonemes implicated in speech perception? An EEG study*

The role of phonemes in speech perception has been subject to a long-standing debate. Whereas traditionally the phoneme has been taken as a critical unit for speech perception, an opposing but also solid tradition rejects phonemes either in favour of larger units (such as syllables or demisyllables, Massaro 1975; Samuel 1989) or smaller units (allophones, Wickelgren 1976). Most recently, Hickok (2014) argued that phonemes are involved in speech production, but eliminated them from the speech perception pathway in favour of (demi-)syllables. The present study uses statistical learning in an artificial language learning task to elucidate whether phonemes are implicated in speech perception.

Participants listened to two audio streams consisting of trisyllabic nonwords of an artificial language through headphones during training while their EEG brain activity is recorded (e.g. padeeloogomeefenakeezoo…; the stream was devoid of any intonation cues, pauses, etc; Saffran, Aslin, & Newport, 1996). Each stream contained either a phoneme- level or syllable-level statistical regularity as in Bonatti, Pena, Nespor, & Mehler (2005). The syllable stream contained 4 words each made up of 3 syllables, resulting in the transitional probability of 1.0 for within-word syllables and 0.33 for syllable pairs that spanned word boundaries. The phoneme stream contained 3 word families, each family consisting of 4 words formed on the basis of a tri-consonantal 'root' (e.g. the root p_d_l yielded a family padilu, podalo, podeli, pudole). In the phoneme stream the transitional probability was 1.0 for within-word consonant pairs and .5 for consonant pairs that spanned word boundaries. Critically, discovering such a regularity requires phoneme-level computations, i.e. ability to focus on consonants while disregarding vowels. In the testing stage participants were subjected to a 2-forced-choice behavioural task (a 'word' from the stream paired with a 'part-word') in which they chose which of two items sounded more like a word from the stream. In addition, the amplitude of the N100 ERP component was used to track statistical learning and concurrent emergence of stream segmentation during the training stage. A larger N100 amplitude to the first syllable of the word as compared to the second or third syllable is taken as an indication of statistical learning (Sanders et al., 2003).

Preliminary results from the behavioural task indicate that participants can extract statistical regularities both in the syllable- and phoneme- stream, thus replicating Bonatti et al.'s (2005) findings. Analysis of the ERP recordings is still in progress. The participants' ability to discover phoneme-level statistical regularities (in addition to syllable-level regularities), if confirmed, will provide evidence in support for the role of phonemes in speech perception and has implications for models of speech comprehension.

1. Ferenc Kemény[1] and Beat Meier[2] (University of Graz[1], University of Bern[2]): *Learning correlated sequences: Not even explicit learning of abstract modality sequences*

The nature of sequence learning is widely debated. A number of different hypotheses have been formed suggesting that the basis of learning is the repeating stimulus pattern, or the repeating response behaviour, or the pattern in effector-dependent movements. The correlated sequences hypothesis suggests that learning only takes place if at least two correlated sequences are present throughout the task. The current study tests whether different combinations of sequences contribute identically to learning. We used the Task Sequence Learning paradigm, in which participants face two dichotic decision tasks. In the Animals task they have to decide whether the presented stimulus is a mammal or a bird, and in the Plants task they have to decide between fruits and vegetables.

Participants have to respond with the same two response buttons for both tasks. The modality of stimulus presentation is also manipulated: stimuli are either visually presented colour pictures or auditorily presented words. The design of the Task Sequence Learning paradigm makes it possible to selectively manipulate the different sequences. In the current study we compare conditions in which two sequences were present. These combinations are correlated modality-response, correlated modality-task and correlated task-response sequences. Results show that implicit learning only takes place if a response sequence is present, that is, in the modality-response and task-response condition. On the other hand, no learning was observed in the case of correlated task-modality sequences. Learning in this case means an increase of reaction times when the sequence is removed. Interestingly, correlated task-modality sequences did not lead to explicit learning either: no learning was found even for those participants, who were able to report the full sequence used in the task.

The study provides evidence that not all combinations of sequences lead to implicit sequence learning, and that explicit knowledge does not necessarily support learning.

2. Almara Kulieva and Maria Kuvaldina (Saint Petersburg State University): *Influence of conscious priming on sense of agency*

Sense of agency (SoA) is the feeling that we are in control of our own actions (Chambon, Haggard, 2012). It is measured as a subjective rating of performance in the task. SoA depends on premotor fluency: the more fluent processing is, the higher the SoA ratings are. A conflict between two possible motor responses decreases premotor fluency and hence decreases SoA (Wenke et al., 2010; Sidarus et al., 2013). This conflict can be created by incompatibility of prime and target and can influence SoA despite the fact that the participants do not consciously perceive the prime (Wenke et al., 2010; Chambon, Haggard, 2012; Sidarus et al., 2013). In SoA studies the prime influences not only SoA ratings but also a decision making process. Participants choose congruent to the prime response more often (Wenke et al., 2010; Chambon, Haggard, 2012; Sidarus et al., 2013).

To investigate a conscious prime influence and to compare the effects of conscious and unconscious priming on SoA, we tested 20 participants (7 female) aged between 18 and 34 years (Mdn=21). We varied four factors: cued/free choice, compatible/incompatible/neutral prime, 17 ms/250 ms prime, prime's dependent/independent color. Participants completed 6 blocks of 48 trials. They were instructed to respond to left- or right-ward arrow targets by pressing a left or right key, respectively, after which a colored circle was presented. At the end of a trial, participants judged how much control they felt over the color of the circle, on a scale ranging from 1 to 8. Tar- gets also served as metacontrast masks for subliminal primes consisting of arrows pointing to the left or to the right.

As in Wenke et al. (2010) we got differences in RTs, error rates and choices during unconscious priming (17 ms). In compatible conditions participants had faster RTs (F(2, 18) = 29,376; p = .000), made less mistakes (F(2,18) = 7,151; p < .01) and more often chose a congruent to the prime response (F(1,19) = 21,982; p = .000). Similar results were observed for conscious prime (250 ms) condition. Compatibility of prime influenced RTs (F(1,19) = 18,639; p = .000), error rates (F(2,18) = 6,100; p < .01) and choices (F(1,19) = 21,982; p = .000). We didn't find evidence of priming (both conscious and unconscious) influence on SoA. Lack of this effect can be explained by differences between our design and designs of Wenke et al. (2010) and Sidarus et al. (2013). In our experiment unconscious and conscious priming conditions were presented in a randomized order. Participants could learn to predict the feedback circle's color during conscious prime trials and transfer this knowledge to the unconscious prime trials. Thus in our experiment predictions of response matched closely the outcome feedback. According to Moore et al. (2009) higher predictability of response produces stronger SoA. So, we suggest that high predictability neutralizes an influence of fluency and eliminates the difference between compatible and incompatible conditions. Work is supported by RFBR grant #15-06-07417a

3. Hernan Labbe Grunberg and Judith Rispens (University of Amsterdam): *Automatic, unconscious, implicit learning of morphology-based associations in Dutch*

Research on word processing studies what information becomes available to language users and when. Models of word processing have assumed a first stage of phonological parsing that leads to lexical activation and later to semantic interpretation. In contrast, it is less understood whether and when abstract morphosyntactic information becomes available for a speaker. Evidence from masked priming and ERP research indicates this type of information is processed very early (before the first 500ms) upon processing the word (Rastle & Davis, 2008; Morris & Stockall, 2012). Moreover, the model by Ullman (2001) predicts grammatical information to be handled by procedural mechanisms, which handle automatic, unconscious processes. However, whether this information is purely morphosyntactic or part of phonological-semantic correlations is still unclear (Bybee, 1995; Baayen, 2013). In order to answer this pending question, a new experimental paradigm was designed to evaluate whether Dutch native speakers were able to process morphosyntactic information early in word processing, via automatic and unconscious processing mechanisms. Fifteen participants were presented with stimuli within a masked priming paradigm after which a lexical decision task followed, where they were required to classify target words as existing Dutch words or pseudo-words. Unlike most priming experiments, there was no linguistic relation between the prime and the target word. Unbeknownst to

the participants, the answer on the lexical decision task could be predicted by the presence or absence of a past tense suffix on the preceding prime stimulus. Examples of prime stimuli are the verb bakte 'baked' or noun ruimte 'space', of which both end in the orthographic string 'te', but only the first one represents the past tense suffix. Based on the well-attested phenomenon of sequence learning (Nissen & Bullemer, 1987), we hypothesized that if participants were automatically and unconsciously processing the morphosyntactic information of the prime stimuli, their implicit learning mechanism should allow them to learn the association between presence or absence of a past tense suffix and type of response to the lexical decision task. Results showed that subjects were indeed able to learn the association between morphosyntactic information and the appropriate response, as shown by a significant decrease in response times only for trials whose targets could predicted by the regularity (z=-8.1379, p<.001). Furthermore, the short presentation time of the stimuli and the masked presentation indicated that the processing of morphological information must have occurred early in word processing, in an automatic and unconscious fashion.

4. Martyn Lloyd-Kelly[1], Fernand Gobet[1], and Peter Lane[2] (University of Liverpool, University of Hertfordshire): *Be-Bop-A-Lula: A CHREST Model of Infant Word Segmentation*

In a well-known study, Saffran et al. (1996) used a headturn preference procedure to show that 8 month old infants can discriminate between trisyllable nonsense words, e.g. "bidaku" after a 2-minute training phase. Words heard during the training phase are "familiar"; "novel" words are those not heard in the training phase (non-words) or words constructed from combinations of familiar word syllables (part-words). The data indicated that infants are sensitive to forward transitional probabilities. Several computational models have simulated aspects of this data. These include simple recurrent networks (Elman, 1991; French, Addyman, & Mareschal, 2011), connectionist autoassociators (French et al., 2011), Kohonen networks (Anderson, 1999), and PARSER (Perruchet & Vinter, 1998), a symbolic model. In these models, transition probabilities are approximated by learning mechanisms based on connectionist algorithms or the creation of chunks. Infants' ability to discriminate between words, non-words and part-words in Saffran et al.'s study are simulated by the models mentioned using various metrics. However, to our knowledge, no model has replicated the absolute times recorded.

Thus, we provide a quantitative explanation of word segmentation using time-limited cognition and chunking mechanisms that indirectly implement the learning of forward transitional probabilities. Notably, we simulate the timing data recorded by Saffran et al., rather than simply demonstrating reliable discrimination between novel and familiar words. This is done by replicating Saffran et al.'s study computationally and varying timing parameters associated with key structures of an infant's memory and auditory system. These structures are modelled using CHREST and the phonological store (Baddeley & Hitch, 1974). CHREST (Gobet et al., 2001; Gobet, Lloyd-Kelly & Lane, 2015) is a cognitive model based on chunking and implements both short and long-term memory (STM and LTM, respectively). To recognise environmental features, CHREST must first commit these features to LTM (a discrimination network) as chunks using one of two learning processes: discrimination or familiarisation. Chunks can then be retrieved from LTM by sorting

features through the network until a chunk is reached and subsequently placed into STM, whereupon the feature is said to be "recognised". LTM storage and STM retrieval take time and operate serially.

The phonological store implemented is a list structure that simulates trace decay by briefly storing one syllable from an input stream in each of its spaces. CHREST can combine the syllables present in the structure in the order they were inserted at any time before attempting to learn the resulting concatenation. We use 3 different times for discrimination, familiarisation and trace decay to produce 27 different infant "types". Each type undertakes 50 repetitions of Saffran et al.'s study and the time taken to recognise each of the test words used is recorded for each individual participant. Our data consistently simulate longer listening times for novel words than familiar words. Whilst the times are greater than those observed in Saffran et al.'s study, we make a novel finding regarding the potential rate of phonological store trace decay.

5. Ágnes Lukács[1], Gyula Demeter[1], Mihály Racsmány[1], István Valálik[2], and Ferenc Kemény[3] (Budapest University of Technology and Economics[1], St. John's Hospital, Budapest[2], University of Graz[3]): *Different forms of skill learning in Parkinson's disease*

The striatal dopaminergic dysfunction in Parkinson's disease (PD) has been associated with deficits in skill learning, but results are inconclusive so far. Motor sequence learning (especially sequence-specific learning) is found to be deficient in the majority of studies using the SRT task (Jackson, Jackson, Harrison, Henderson,& Kennard, 1995; Siegert, Taylor, Weatherall, & Abernethy, 2006). While problems with motor sequences seem to be prevalent, PD patients show intact performance on AGL tasks, suggesting that the sequencing problem may be response- or task- dependent (Reber & Squire, 1999). Acquisition of nonsequential probabilistic associations also seems to be vulnerable as evidenced by impaired probabilistic category learning performance in PD (Knowlton, Mangels, & Squire, 1996; Shohamy, Myers, Onlaor, & Gluck, 2004).

Our aim was to explore the nature of the skill learning deficit by testing different types of skill learning (sequential versus nonsequential, motor versus verbal) in the same group of Parkinson's patients. 34 patients with PD (mean age: 62.59.77 years, SD: 7.67) were compared to age-matched typical adults using 1) a Serial Reaction Time Task (SRT) testing the learning of motor sequences, 2) an Artificial Grammar Learning (AGL) task testing the extraction of regularities from auditory sequences and 3) a Weather prediction task (PCL-WP), testing probabilistic category learning in a non-sequential task.

In motor sequence learning (SRT task), the two groups did not differ in accuracy; PD patients were generally slower, and analysis of z-transformed reaction times also revealed deficient motor sequence learning in PD compared to the control group. The PD group showed no evidence of sequence learning. The PD group showed the same amount of learning on the PCL task as controls, and we observed higher rates of learning on the AGL task in PD patients than in controls. These results support and also extend previous findings suggesting that motor skill learning is vulnerable in PD, while other forms of skill learning are less prone to impairment. Results are also in line with previous assumptions that mechanisms

underlying artificial grammar learning and probabilistic categorization do not depend on the striatum (Reber & Squire, 1999).

6. Beat Meier (University of Bern): *Implicit learning of a sequence of body movements*

Typically, implicit sequence learning is tested with a visuo-motor serial reaction time task. Recently, implicit learning was also demonstrated for sequences of tasks, at least when they were correlated with an additional stream of information. Here, we investigated whether sequences of body movements can also be learned. Participants were blindfolded and seated on a hydraulic motion table. They were instructed to classify left vs. right, up vs. down, and forward vs. backward motions with left vs. right hand key presses. Thus, it was possible to include a sequence of x-, y, and z-axes movements, a sequence of left vs. right hand key presses and both. Our results indicate that sequence learning occurred specifically when both streams were correlated. Thus, even 3D motion information can be integrated into a comprehensive sequence representation.

7. Jelena Mirkovic, Marissa Yee, and Emma Hayiou-Thomas (University of York): *Developmental differences in memory systems supporting grammar learning from multiple cues*

The current study draws together research from statistical language learning and memory consolidation. Experimental studies have shown that both adults and children use phonological and distributional regularities to abstract grammatical categories, but few studies have examined the role of semantic cues in grammatical category learning. In a separate line of research, memory consolidation over wake and over sleep has been shown to play a crucial role in the abstraction of regularities across discrete memory traces, and the generalization of those regularities to new exemplars. We used an artificial language paradigm to investigate: 1. the learning of grammatical categories in children and adults from multiple regularities (semantic, phonological, distributional), and 2. the effect of short (~24h; Studies 1 and 2) and long (~1 week; Study 1) consolidation periods on the ability to abstract and generalize the learned regularities. Both issues were addressed using an implicit measure of grammatical category abstraction (generalization to new exemplars) and a self- report measure of explicit awareness of the semantic-phonological-distributional regularities.

The artificial language was designed to mimic properties of grammatical gender: Novel word- stems (e.g. mof-, mig-) were paired with different 'determiners' and 'suffixes' (tib mofeem, ked migool) to create two 'grammatical' categories. The words in each category were also associated with a semantic cue (e.g. all tib-X-eem words were paired with pictures of animals, and all ked-Y-ool with pictures of artifacts). Participants were trained on the artificial language using a word-picture matching task. The number of stems in each grammatical category was also manipulated: in Study 1, participants learned a total of 16 words (8 per category), and in Study 2 24 words (12 per category). (The exposure to each word-picture pair increased from Study 1 to Study 2 to ensure comparable levels of word learning.) Following training, participants were tested immediately, after 24hrs (both studies) and after 1 week (Study 1). The tests included a 2AFC word-picture matching task assessing word learning, and two tasks assessing generalization of grammatical regularities

to new exemplars. The generalization tasks focused on the mapping between the semantic cue and either both the determiner and the suffix, or only the suffix. Explicit awareness of the semantic, phonological and distributional regularities was assessed in all participants at the end of the final test session.

In Study 1, immediately after training both adults and children showed good levels of word learning, with adults achieving higher performance than children (M_{adults} = 98%, $M_{children}$ = 75%). However, over time, and unlike in children, there was significant forgetting.

Immediately after learning and following a 24 hour delay, adults showed good generalization of the grammatical regularities on the task involving both the determiner and the suffix cue. Children showed no evidence of generalization and there was no change over time. Adults also showed greater explicit awareness of the regularities associated with different grammatical categories. Data collection for Study 2 is ongoing. The findings will be discussed in the context of developmental differences in memory systems supporting grammar learning from multiple cues.

8. Nadezhda Moroshkina and Anatoliy Karpov (Saint Petersburg State University): *Implicit learning under social influence*

The process of hidden covariation detection was investigated in the situation where opinion of other people serves as the source of information. Many studies are devoted to the problem of social context's influence on other people opinion. However, in the majority of studies the change of individual opinion concerning concrete stimuli is investigated (for example, Bond, 2005; Bond, Smith, 1996). In given study we have tried to estimate, if it is possible to form the implicit categories under the influence of other people opinion.

The differences in implicit learning in estimation of person IQ by his/her appearance were studied dependent on the instruction type (either information about real IQ scores or information, how other participants have estimated the IQ). A total of 61 participants (34 women, 27 men) aged 18 to 25 participated in the experiment. We modified Lewicki paradigm of hidden covariation detection (Lewicki, 1986). The experiment consisted of 2 stages: learning and testing ones. On learning stage participants were presented with 20 young girl photos with an indication of their IQ. Participant's task was to remember faces of "intelligent" girls (IQ > 100). Group 1 was instructed that IQ score, written under the photo, was obtained during psychological testing. Group 2 was instructed that IQ score, written under the photo, was the result of survey of data from people who see the girl's photos for the first time. The hidden covariation between the type of haircut and IQ level was inserted in stimuli presentation, about what participants were not informed. On test stage participants were to estimate the IQ of 20 new girls, depicted on photos. Results show that people unconsciously learn the hidden covariation between the type of haircut and IQ level and apply this rule in estimation of new girls (F=39,409, p<0,001). The effect of learning was observed in both groups. Thus we received an experimental verification that other people opinion can help forming hidden perceptual categories.

9. Nadezhda Moroshkina, Anastasia Mikhailova, and Valeria Gershkovich (Saint Petersburg State University): *Implicit vs explicit motor sequence learning under pressure*

It's important for the athletes to perform under pressure without errors, i.e. during competition. Several studies have shown that implicitly learned motor skill unlike explicit learning doesn't decrement under pressure (Gabbett, Masters, 2011). Yet not all authors agree with the view (e.g. Carson, Collins, 2016). The aim of the current study was to find out, which of the learning conditions (implicit or explicit) will result in greater efficiency in under pressure situation.

40 participants (15 men) aged 18 to 33 years were asked to play a Golf computer game. Their task was to press and hold the spacebar in order to regulate the impact force of the ball for to put it in the hole. At the beginning, participants were asked to do warmup session (21 trials), followed by the first competition (80 trials) with the scoring, dependent on participant's hits. At the end of the competition participants were informed about their rating according to received scores among other participants. This rating was spurious, and was formed such as each participant could notice that he was currently taking the third place. This was followed by training session without scoring (80 trials); upon its end participants went through the second competition (80 trials). The regularity was inserted in the presentation of the holes at different distances (it was consisted of 10 holes and repeated 8 times). In addition three types of holes had differences in real and visible size, i.e. it was harder to hit them compared to other holes. There were two groups in the experiment. Participants in the implicit group haven't been informed neither about the presence of regularity nor about the differences in real and visible size of some holes. Participants in the explicit group were informed about the regularity and the holes harder to hit.

Results. To compare the effect of learning we contrasted the amount of hits in two groups in two competition sessions. For learning dynamics estimation competition sessions were split into half. The difference between groups at the initial stage of competition was not significant (implicit gr. – 59% hits, explicit gr. – 57%, p = 0,540). At the second stage of the first competition implicit group demonstrates learning effect (62% hits), whereas explicit group does not (56%) (p = 0,018). This difference increases at the beginning of the second competition session (implicit gr. – 75% hits, explicit gr. – 64%, p < 0,001), however by the end of the second competition implicit group apparently reaches the ceiling effect (74% hits) and explicit group's level of accuracy get closer to it (70% hits), (p = 0,164). Thus, preliminary results are in favor of implicit learning compared to explicit one, however the effect is observed only at the beginning of learning. To clarify the interpretation we are planning to conduct an experiment with control group, which will do the same task in conditions of random presentation of holes of different distances. The research was supported by RFBR grant # 16-06-00376.

10. Irina Ovchinnikova and Nadezhda Moroshkina (Saint Petersburg State University): *Learning global configurations in a visual search task*

Chun and Jiang (1998) showed that there is the effect of implicit learning in visual search tasks when the location of distractors associated with the target position is repeated. This study was continued by Jiang and Wagner (Jiang, Wagner, 2004), who tried to answer the question, what affects the increase the search speed goals – global configuration of

distractors or the position of the individual distractors? In our study, we tried to get closer to the answer to this question, using a modified Navon's task (Navon, 1977).

Participants were shown an abstract figure consisting of the letters "T" rotated 90 degrees. Among these letters T also were the 1 letter L rotated 90 degrees (up or down). The subjects had to find the letter L and its turn: "up" or "down" by pressing the appropriate key. 8 unique configurations were presented in a random order, 8 times each (4 times with the answer "up", 4 – "down"). In each configuration, the letter "L" was always located identically. Thus, each subject performed 64 trials (8 training series), and then charged with a 9 – critical series, in which the target's location in each configuration has changed.

The experiment involved 49 subjects (24 male, 25 female, aged 20 to 34, Me=26) that were randomly distributed in 3 groups: 2 experimental and 1 control. In the experimental group 1 (EG1) all global configuration consisted of the "T", rotated in one direction (i.e. from time to time not only the global configuration was repeated and the target location, but also the position of all local distractors). In the experimental group 2 (EG2) "T", were turned left and right randomly (i.e. global configuration and the target position from series to series was repeated, but the position of the individual distractors varied from trial to trial). In the control group (CG) the global configurations were repeated, however, the target position and the position of the distractors changed each trial.

Both experimental groups showed a gradual decrease in the RTs during the 8 series (F (7,210) = 12,809, p <.001). EG1 subjects responded significantly faster than EG2 subjects (F(1,30)=23,661, p<.001 ANOVA with rep. ms). Comparing the results of critical (9th) and last training series (8th) the interaction of groups and series factors detected (F(1,30)=10,173, p=.003 ANOVA with REP. measurements). That can tell us about global configurations learning. Also, the group who learned best (EG1) shows more appreciable negative transfer.

The subjects of the control group showed an adaptation to the task and for 8 series they showed a slight acceleration response. Our results can testify in favor of the hypothesis of learning global configuration. The results of comparison between EG1 and EG2 also show the contribution of local position of distractor to learning. However, the question remains - how much local distractors can be varied to effect was kept. The authors acknowledge Saint-Petersburg State University for a research grant 8.38.287.2014.

11. Maud Pélissier[1], Jennifer Krzonowski[2], and Emmanuel Ferragne[1] (Université Paris Diderot[1], Université Lyon[2]): *Effect of implicit training on the processing of morphosyntactic violations by French Learners of English: An ERP and behavioural study*

Implicit grammar learning with semi-artificial languages has shown that it is possible to learn novel grammatical structures implicitly and that this can lead to both explicit and implicit knowledge. Can these results be extended to natural L2 learning and to learners who already have some knowledge of the L2? In this experiment, we investigated the effect of implicit training on the processing of morphosyntactic violations whose saliency and similarity between the participants' L1 (French) and L2 (English) varied.

The experiment followed a pre-test / training / post-test paradigm. During the pre- and post-test, ERP responses were obtained from 16 participants while they judged the semantic acceptability of 432 sentences. 192 critical polar questions contained violations of past tense morphology with DID and HAD. The rest of the sentences were fillers, 120 of which contained a semantic violations. Participants also completed a short timed Grammaticality Judgment Task with confidence ratings and source attributions (Rebuschat et al. 2015). During 3 one-hour training sessions, participants heard correct polar questions and were asked to select the right answer among propositions containing semantic and critical tense violations.

In the first session, violations with DID elicited a positive peak in the 300-500ms and 500-900 ms windows. A broad negativity resembling an N400 followed violations with HAD. These effects disappeared in the post-test. Behavioural measures revealed that participants were more accurate but slower in the HAD condition. Their performance did not improve following training but their response time slowed down. Confidence ratings showed that performance was better than chance even at a medium-low level of confidence (2 on a scale of 4). Participants reported using mostly intuition but their performance was significantly different from chance only when using rule knowledge. In the semantic acceptability task, participants performed better in the post-test; but they rejected semantically correct sentences containing a morphosyntactic violation with HAD more than with DID. A debriefing questionnaire showed that only 5 participants noticed the critical morphological errors, but only two of them were able to provide explicit rules for the relevant structure.

These results show that participants are more sensitive to the L1-like violation (HAD condition) despite the superior saliency of the DID violation. It seems that learners rely on different processes for the two violations – an attention-related response with DID, probably triggered by the phonological saliency of the violation, and actual morphosyntactic processing with HAD. Though no significant effect of session was found on accuracy, the slow-down in response time and the disappearance of the positive effect suggest that participants were starting to rely less on saliency to process violations with DID. The training may have been too short for effects to appear. Although participants show some degree of implicit knowledge, they still relied on explicit knowledge successfully in the GJT. This might be due to the explicit nature of the rest of their English instruction and therefore to a habit of relying on rules.

12. Diana Pili-Moss (Lancaster University): *Child and adult incidental learning of linking rules and case marking: A pilot study*

In the last 15 years a number of studies in cognitive psychology found that child and adult incidental exposure to semi-artificial languages results not only in the learning of novel word orders but also in the learning of the linking rules relating an NP's thematic role to its syntactic position in the new construction (Boyd, Gottschalk & Goldberg, 2009; Wonnacott, Boyd, Thomson & Goldberg 2012; Wonnacott, Newport & Tanenhaus, 2008). Case morphology has a function similar to syntactic linking, as it encodes the thematic interpretation of an argument (see Rogers, Révész & Rebuschat, 2015, for a recent study investigating incidental learning of morphology in adults).

In this laboratory-based study I aimed at monitoring L2 morpho-syntactic learning in the very early stages of incidental artificial language instruction. Ten 9 year olds and ten adults (L1 English) were compared on their comprehension of the morpho-syntax of a version of Brocanto2 (Morgan-Short, 2007), a fully productive semi-artificial language. In the present study Brocanto2 has 14 vocabulary items and mirrors the morpho-syntax of Japanese showing SOV order and postpositional case markers, as exemplified in (1).

(1) Troise   neep li   neimo pleck lu   zayma yab
[Roundneep NOM square pleck ACC   horizontally   release]
'The round neep piece releases the square pleck piece horizontally'

After vocabulary training and training in a novel computer board game similar to draughts, the participants were shown game moves on the game board and simultaneously exposed to the auditory Brocanto2 sentence stimuli that described them. The exposure (144 sentences) was distributed over six blocks and delivered over three consecutive days. After each exposure block the participants played a game on the computer, which consisted in performing novel moves on the board following an auditory description in Brocanto2 (20 sentences per block).

Crucially, though the case markers were included in the exposure and game auditory stimuli, they were not presented during the vocabulary training and participants were not given hints regarding their presence in the input, their meaning or function. A continuous online measure and a forced-choice task administered at the end of the exposure and training phases were used as measures of morpho-syntactic learning.

The computer programme produced detailed reports of the learners' online gaming performance, and a comparison of the gaming performance with the corresponding auditory stimuli allowed tracking the development of the learners' comprehension of the syntactic position/thematic role linking rules across blocks. As it was not possible to extract this information on the basis of the gaming performance, a forced-choice task was deployed to specifically investigate learning of the relationship between postpositional case markers (li/lu) and the subject/object function of the nominal phrases.

13. Limor Raviv and Inbal Arnon (Hebrew University of Jerusalem): *Developmental differences in children's statistical learning abilities*

Infants, children and adults are constantly exposed to repeating patterns and regularities in their environment, and manage to learn them implicitly. This ability, often called statistical learning (SL), is postulated to be an important mechanism in language acquisition (Romberg & Saffran, 2010). Research over the past twenty years has shown that SL is present from early infancy (Saffran, Aslin & Newport, 1996) and is found in a variety of tasks and modalities (e.g., auditory, visual), raising questions about its domain generality (Conway & Christiansen, 2005; Frost, Armstrong, Siegelman & Christiansen, 2015). But although SL is well established for infants and adults, very little work has looked at SL across development. Importantly, despite its postulated role in language learning, no study has examined changes in auditory SL throughout childhood, and no work has compared children's visual and auditory SL abilities. The paucity of research leaves two important questions

unanswered. The first has to do with the developmental trajectory of SL: is SL a fully developed capacity in infancy, or does it improve with age, like other cognitive skills (e.g., memory)? Only few studies have examined SL across childhood, with conflicting results: some find age related improvement (Arciuli & Simpson, 2011), while others do not (Saffran, Newport, Aslin, Tunick & Barrueco, 1997). Interestingly, the differences seem to be, in part, modality-based. This leads to the second question: does SL have the same developmental trajectory across domains, or does age affect SL differently in different perceptual modalities? We addressed these issues by conducting a large-scale study of children's performance on matching auditory and visual SL tasks across a wide age-range (5-12y, N=230). Our results show modality-based differences in the developmental trajectory of SL abilities: while children's learning significantly improved with age in the visual domain, learning in the auditory domain did not change much across development. We examine these findings in light of previous studies and discuss their implications for modality-based differences in SL and for the role of auditory SL in language acquisition.

14. Estibaliz San Antón, Sofia Jobbé-Duval, Remy Schmitz, Axel Cleeremans, and Arnaud Destrebecqz (Université Libre de Bruxelles): *The role of visuospatial working memory in implicit and explicit sequence learning*

The serial reaction time (SRT) task is often viewed as a paradigmatic example of implicit or unconscious learning. Several reports, however, have shown that performance in that task is also based on conscious knowledge acquisition. The extent to which learning takes place consciously seems to be due to the training conditions in which participants are faced with the to-be-learned sequence of events. Destrebecqz and Cleeremans (2001) claimed that the time that elapses between the response and the onset of the next stimulus (the Response-to-Stimulus Interval or RSI) may influence the conscious nature of learning. Short RSIs, or a faster pace in the learning phase, would favor unconscious learning while slowing the pace would induce explicit learning strategies and, therefore, conscious knowledge acquisition.

Other authors have failed to replicate these results (Wilkinson & Shanks, 2004) or have shown that the role of the RSI interacts with personality traits (Norman et al, 2006). In this study, we tried to replicate Destrebecqz & Cleeremans' (2001) results and measured the potential influence of the visuospatial working memory (VWM) on performance.

Results indicate that the value of the RSI do not influence sequence learning in the SRT task or performance in subsequent inclusion, exclusion or recognition tasks. Participants acquired explicit knowledge in both fast and slow paced conditions. Interestingly, SRT, inclusion, and recognition performance correlate with VWM, but only in the slow pace condition, when participants have time to recruit VWM resources. This result suggests that VWM exerts a strong influence on the amount of sequence learning and that the RSI mostly influences the "expression" of sequence knowledge rather than learning "per se".

15. Rachel Schiff, Shani Kahta, and Ayelet Sasson (Bar-Ilan University): *Performance of children with developmental dyslexia on high and low TE artificial grammar learning task*

Graph complexity as measured by Topological Entropy (TE) has been previously shown to affect performance on artificial grammar learning tasks among typically developing children.

The aim of this study was to examine the effect of the graph complexity on implicit sequential learning among children with developmental dyslexia (DD). Our goal was to determine whether children's performance depending on the complexity level of grammar system learnt. We conducted two Artificial Grammar Learning (AGL) experiments that compared performance of children with DD with that of age and reading level matched controls (CA and RA, respectively). Experiment 1 is high TE AGL task aiming to establish implicit learning phenomena in children with DD with previously published experimental conditions. Experiment 2 is a lower TE variant of the task. Results indicated that given a high TE AGL task, similarly to the RA group, children with DD had substantial difficulty to perform the task compared to CA and RA, who exhibited intact implicit learning of the grammar. On the other hand, when tested on a lower TE grammar system, all groups performed above chance level, indicating that children with DD were able to identify rules from a given grammar system. The results indicate that children with DD are not impaired in their implicit sequential learning abilities. This study reinforces the significance of the graph complexity when experimenting with artificial grammar learning tasks particularly with participants with DD.

16. Xenia Schmalz, Claudio Mulatti, and Reno Job (University of Trento): *What is the role of statistical learning in reading? On the role of letter distribution statistics*

It is assumed (e.g., by connectionist models of reading) that statistical learning is central to reading acquisition. This assumption has been supported by recent studies showing correlations between reading ability and performance on statistical learning tasks (Arciuli & Simpson, 2012; Frost et al., 2013). However, it is unclear what specific cognitive processes underlie the causal chain from statistical learning to reading ability. Two possibilities have been discussed in the literature: First, the distributional statistics of letter or bigram frequencies may facilitate reading by leading to more specified orthographic representations. Second, statistical learning may facilitate the learning of complex grapheme-phoneme, which are not taught explicitly (e.g., in English, context-sensitive rules; "a" is pronounced as in "swan" when preceded by a "qu" or "w"). Here, we focus on the former possibility. We present a corpus analysis and data from a new study, which aim to assess the role of letter distributions in reading. The overall aim is to resolve some conflicts in the existing literature, where not all studies find an effect of letter distributions on reading. The results show that the link between bigram frequency and reading efficiency is weak to non-existent, suggesting that alternative causal pathways may be driving the correlation between statistical learning and reading.

17. Christine Schoetensack, Padraic Monaghan, and Patrick Rebuschat (Lancaster University): *Individual differences in implicit-statistical learning: Evidence from the cross-situational learning paradigm*

Research has demonstrated that infants, children, and adults can acquire novel form-meaning mappings by tracking co-occurrence statistics across multiple exposure trials (e.g., Yu & Smith, 2007; Smith & Yu, 2008). Learning outcomes have been shown to vary between individuals, both in the case of children and adults. However, to date little research has systematically attempted to identify which individual differences might be responsible for such variation, although an exploration of this question might provide insights into the

mechanisms underlying cross-situational learning and facilitate the construction of more accurate computational models. The present study directly addressed this gap by investigating the role of executive function, phonological short-term memory (PSTM), working memory (WM), declarative visual memory (DM) and reasoning ability in cross situational learning.

Thirty native speakers of English took part in the experiment. Participants first completed Monaghan et al.'s (2015) cross-situational learning task. In each trial, participants were required to match a novel sound sequence with one of two moving shapes. This task could only be accomplished successfully by tracking co-occurrences between nouns and shapes as well as verbs and motions. Participants then completed a battery of cognitive tests (non-word repetition, automated operation span, continuous visual memory, flanker, reasoning ability task). Retrospective verbal reports served as a means of recording the strategies used by participants in the cross-situational task and determining whether subjects had become aware of any rules or patterns. Results replicated previous studies showing that adults can rapidly acquire words via cross-trial statistics. Awareness of the learning target was not necessary, as aware and unaware subjects clearly showed a learning effect overall, but awareness did appear to affect the learning trajectory, with aware subjects performing above chance significantly earlier. With regards to the individual difference variables, performance on the cross-situational learning task significantly correlated with performance on the nonword repetition task (PSTM) and the visual memory measure (DM). However, a stepwise regression further indicated that only DM accounted for independent variance, with PSTM not contributing significantly in addition. Individual differences in cross-situational learning were therefore predicted by visual, rather than phonological, memory.

18. Lauren Slone and Josh de Leeuw (Indiana University): *Modeling the factors underlying adults' confidence judgments in a visual statistical learning task*

Much research has documented learners' ability to segment visual and auditory input into its component units. In typical visual and auditory statistical learning (SL) experiments, participants are familiarized to structured inputs, then asked to make judgments in a two-alternative-forced-choice task about which of two candidate units is more likely to pertain to the familiarized structure. Such research has consistently demonstrated learners' capacity for selecting statistically coherent combinations of items over less coherent combinations.

Moreover, experimental manipulations of input structure have helped to tease apart the types of statistical structures that learners are sensitive to, and possible ways learners might represent these structures in memory.1 Nevertheless, little is known about how learners leverage those representations to make likelihood judgments in SL tasks.

To examine this issue, we developed a visual SL task in which adult participants were familiarized to either scenes or sequences of shapes (between subjects) composed of two types of units: shape pairs and shape triples. Each scene/sequence consisted of five to seven shapes (e.g., five shapes = one pair + one triple). Following familiarization, participants completed 20 test trials. Each test trial presented a scene/sequence of two or three shapes and participants rated how confident they were that those shapes had co-occurred during

familiarization, on a 1-7 scale (1=very confident they did not co-occur, 4=not sure, 7=very confident they co- occurred). There were six types of test trials, designed to provide different amounts of evidence in favor of and against a high "co-occurred" rating. "Pair" and "triple" test trials presented units from familiarization and therefore provided positive evidence for a high "co-occurred" rating. In contrast, "impossible pair" and "impossible triple" test trials presented shape combinations that were never observed during familiarization, and therefore provided negative evidence for a high "co-occurred" rating. The two other test types provided mixed evidence for high ratings. For instance, "false triple" trials presented three shapes: two that had consistently co- occurred during familiarization combined with a third shape that had not consistently co- occurred with the other two.

This design will allow us to use model fitting to examine how participants weight various types of information available to them when making judgments about shape co-occurrence. Specifically, we defined model parameters that assign different weights to positive and negative evidence, and to test structures of different sizes (i.e. pairs versus triples). Preliminary data from 145 adults suggests that our rating scale is able to detect statistically significant differences in ratings of the various test types. Our next step will be to examine which model parameters best account for participants' co-occurrence judgments. We will also examine whether presentation format – scenes versus sequences – affects participants' ratings or the information used to make co-occurrence judgments. These findings should provide novel insights into the process by which adults generate judgments about candidate structures, as well as into the underlying representations formed during SL tasks, from which co-occurrence judgments are derived.

19. Janne von Koss Torkildsen[1], Joanne Arciuli[2], Christiane Haukedal[1], and Ona Wie[3] (University of Oslo[1], University of Sydney[2], Oslo University Hospital[3]): *Intact visual statistical learning in children with cochlear implants*

According to Frost et al. 2015, statistical learning involves both domain-general computational mechanisms and modality-specific encoding mechanisms. Optimal development of the domain-general mechanisms may depend on sufficient opportunities to detect sequential patterns early in life. The auditory scaffolding hypothesis proposes that sound exposure may provide crucial experiences with tracking sequential patterns in the environment, and consequently that a lack of auditory input may delay the development of domain-general sequence learning skills (Conway, Pisoni and Kronenberger, 2009). In line with this hypothesis, Conway et al. 2011 found that a group of 23 5-10 year-old deaf children with cochlear implants (CI) did not show learning in a visual serial reaction time (SRT) task. Moreover, visual sequence learning was negatively correlated with the age at which the child received their implant. Similar results were found in a study of 18 adults with varying degrees of hearing loss (Lévesque, Théoret and Champoux, 2014). This study also employed an SRT task, and found that participants with normal hearing (NH) performed significantly better than hearing impaired individuals. In the present study, we aimed to assess whether children with CI show impaired learning in a standard visual statistical learning (VSL) task. The task assessed learning of embedded triplets of images and was based on Arciuli & Simpson (2011). In addition to the VSL task, the children were tested with a comprehensive battery assessing language, nonverbal abilities and hearing.

Fifty-eight children (29 with CI (14 boys) and 29 with NH (10 boys)) between the ages of 7;0 and 12;11 participated in the experiment. (The data collection is still ongoing). There was no significant age difference between the groups (t (50.63) = -0.94, p = 0.35).The average age of implantation for the CI children was 18.34 months (SD = 11.97, range = 5-50), and was thus comparable to the sample used by Conway et al. (mean age of implantation 21.2 months, range = 10-39). The mean proportion of correctly identified triplets was 57.07 (SD 12.35) for children with CI and 58.34 (SD 16.34) for children with NH. One sample t-tests showed that VSL was significantly above chance for children with CI (t (28) = 3.08, p = 0.005) and children with NH (t (28) = 2.75, p = 0.010). There was no significant difference between the amount of VSL in the two groups (t (56) = 0.34, p = 0.74). A partial correlation between age of implantation and VSL controlling for age, did not find a significant relation (r = -.08, p = 0.68).

In sum, there was no difference in VSL between children with CI and children with NH. However, differences between results of the present study and that of Conway et al. 2011 may be due to the use of different tasks to measure sequence learning (VSL vs. SRT), the fact that children in the present study where somewhat older and thus had a longer duration of CI use, or the fact that the majority of children in the present study had bilateral implants compared to unilateral implants in the Conway et al study.

20. Anthony Trotter, Padraic Monaghan, and Rebecca Frost (Lancaster University): *Natural language cues and the acquisition of artificial grammars*

Language is composed of complex grammatical structures that learners must make sense of in order to achieve linguistic proficiency. Key questions concern how learners come to realise that these structures are present in the language input, and how they grow to understand the purpose they serve. Much research has tested learners' processing of language structures in laboratory studies by training participants on artificial languages, and examining their learning of the structures they contain. For example, prior work has shown that learners can extract transitional information from language input, and use it to identify word boundaries (e.g. Saffran et al., 1996) and grammatical regularities, such as non-adjacent dependencies (e.g. Frost & Monaghan, 2016).

However, successful acquisition of statistically defined recursive structures has proven notoriously difficult to achieve, making measuring the way that learners process them even more difficult to accomplish. Previous studies have tended to use sequences of nonsense words to determine learning of recursive structures. Natural language, in comparison, contains multiple other sources of information to support the processing of dependencies within recursive sentences. Key structural information is provided by; prosody (learners have been found to use voice pitch directional changes to indicate phrase boundaries), rhythm (pauses occur in speech at phrase boundaries), and information about semantic relationships within dependencies (e.g., knowing that dogs chase cats, and that cats meow, helps us to determine the meaning of "the cat the dog chases meows"). In a series of experimental studies, we show that the addition of explicit phonological cues - reflecting similarity across dependent elements in recursive structures - facilitates learning. We found no evidence of prosodic pitch cues promoting learning in isolation. However, rhythmic cues

did seem to support learning, and combining all three cues resulted in the best performance of all. Our results indicate that learners are able to use phonological and rhythmic information in isolation to support learning of recursive structures. In addition, we show that learners are able to combine phonological, rhythmic, and prosodic information to assist in acquisition of recursive structures.

21. Anna Vaskevich and Roy Luria (Tel Aviv University): *The role of statistical learning in general improvement*

The current investigation focused on the relationship between implicit learning of regularities and improvement in performance due to general learning. Previous studies have demonstrated that in a visual search task, observers are faster to locate targets when these are presented in repeated rather than random contexts, an effect termed contextual-cuing. Using a random mapping condition and a consistent mapping condition, in which targets and distractor-sets were paired throughout the experiment, we replicated this classic effect (Experiment 1), and conducted two experiments aimed at clarifying how contextual cuing interacts with general task improvement (i.e., learning). We used either repeated contexts only (Experiment 2) or random contexts only (Experiment 3), and found that learning curves were similar in both experiments and, surprisingly, much faster than in Experiment 1. Our results suggest that contextual-cuing does not facilitate general learning performance. Instead, an advantage for a repeated context condition seems to be observed only when it is intermixed within a random context condition. As such, we argue that the contextual-cuing effect is not a result of facilitation from repeated contexts, but rather reflects overcoming interference caused by mixing regularities with randomness. To better understand whether our results are specific to contextual cuing, or can be generally applied to other kinds of implicit learning, we conducted an additional experiment with a discrimination task. Participants were randomly assigned to either a random-sequence or structured-sequence groups, and instructed to answer as fast as possible which image (out of four possibilities) was presented. For the random-sequence group images appeared at random locations, while for the structured-sequence group images appeared according to a specific 9-elements spatial order. Again, learning curves were similar for the random-sequence and structured-sequence groups. Surprisingly, a cost in performance was observed not only when the sequence was changed from structured to random (structured-sequence group), but also when the random sequence was changed to a structured one (random-sequence group). This result suggests that implicit learning is a very strong mechanism that operates regardless of benefit to performance. Even after practicing a random version of the task, this mechanism was very quick at picking up the regularities, once introduced. In general, our results question the current view of statistical learning as a mechanism that supports general learning improvements or has an additional benefit beyond general learning. Previous conflicting results are discussed.

22. Stefan Walter and Beat Meier (University of Bern): *Implicit probabilistic sequence learning: Correlated streams and sequence length matter*

We investigated whether a pure perceptual stream is sufficient for probabilistic sequence learning to occur within a single session or whether correlated streams are necessary, whether learning is affected by the transition probability between sequence elements, and

how the sequence length influences learning. In each of three experiments, we used six horizontally arranged stimulus displays which consisted of randomly ordered bigrams xo and ox. The probability of the next possible target location out of two was either .50/.50 or .75/.25 and was marked by an underline. In Experiment 1, a left vs. right key response was required for the x of a marked bigram in the pure perceptual learning condition and a response key press corresponding to the marked bigram location (out of 6) was required in the correlated streams condition (i.e., the ring, middle, or index finger of the left and right hand, respectively). The same probabilistic 3-element sequence was used in both conditions.

Learning occurred only in the correlated streams condition. In Experiment 2, we investigated whether sequence length affected learning correlated sequences by contrasting the 3-elements sequence with a 6-elements sequence. Significant sequence learning occurred in all conditions. In Experiment 3, we removed a potential confound, that is, the sequence of hand changes. Under these conditions, learning occurred for the 3-element sequence only and transition probability did not affect the amount of learning. Together, these results indicate that correlated streams are necessary for probabilistic sequence learning within a single session and that sequence length can reduce the chances for learning to occur.

23. Daniel Wiechmann[1], Elma Kerz[2], and Dennis Terhorst[2] (University of Amsterdam[1], RWTH Aachen University[2]): *Awareness, inhibition and the acquisition of L2 morphology under incidental conditions*

While early child acquisition – approximately up to age six before the onset of formal education - is a prime example of implicit learning, it is less clear whether and to what extent adult acquisition of a second language (L2) proceeds without intention to learn and in the absence of awareness. In this study, we report on two web-based experiments that investigated to what extent L2 inflectional morphology can be acquired under incidental conditions after a minimal amount of exposure and to what extent the resulting knowledge is implicit or explicit in nature (see Rebuschat, 2013). In both experiments, we used a modification of the experimental design described in Rogers, Revesz and Rebuschat (2015), in which participants were exposed to a semi-artificial language system consisting of foreign words (Croatian nouns) embedded into participants' L1 (English). While participants were told that they were taking part in a foreign language vocabulary task, the learning target was a case-marking distinction (accusative/dative). Rather than using isolated sentences as the stimulus material during the exposure phase, we embedded the foreign words into a short story (cf. Willems, Frank, Nijhof, Hagoort & van den Bosch, 2015). To determine whether learning outcomes are affected by task demands, we decided to utilize a timed grammaticality judgment task (GJT; Experiment 1) and a timed two-alternative forced choice task (2AFC; Experiment 2). Participants were also administered a Stroop Colour-Word test (e.g. Stuss, Floden, Alexander, Levine & Katz 2001) to assess if learning outcomes were related to selective attention and inhibitory control. 200 participants were recruited through CrowdFlower (www.crowdflower.com), an online crowdsourcing platform, allowing us to investigate learning effects in a more diverse population. Performance on the timed GJT (Experiment 1) and the 2AFC task (Experiment 2) served as the measures of learning. Confidence ratings, source attributions, and retrospective verbal reports served to

distinguish implicit and explicit knowledge. Interestingly, we found that participant performance was above chance level in the 2AFC task (M = 54.2% (SD=0.5), t(99) = 8.18, p < 0.0001) but not in the GJT (M = 51.4% (SD=0.4), t(99) = 2.18, p > 0.05). The results of mixed-logit models revealed that task performance was related to inhibitory control (2AFC: $\chi2$ (1) = 4.87, p < .03; GJT: $\chi2$ (1) = 1.63, p > .05), confidence (2AFC: $\chi2$ (1) = 4.87, p < .03; GJT: $\chi2$(1) = 2.97, p > .05) and source attributions (2AFC: $\chi2$ (1) = 4.87, p < .03; GJT: $\chi2$ (1) = 4.94, p > .05).

24. Merel van Witteloostuijn[1], Jimena Tena Davalos[1], Imme Lammertink[1], Paul Boersma[1], Frank Wijnen[2], and Judith Rispens[1] (University of Amsterdam[1], Utrecht University[2]): *The relation between implicit learning and spelling ability in adults: An individual differences approach*
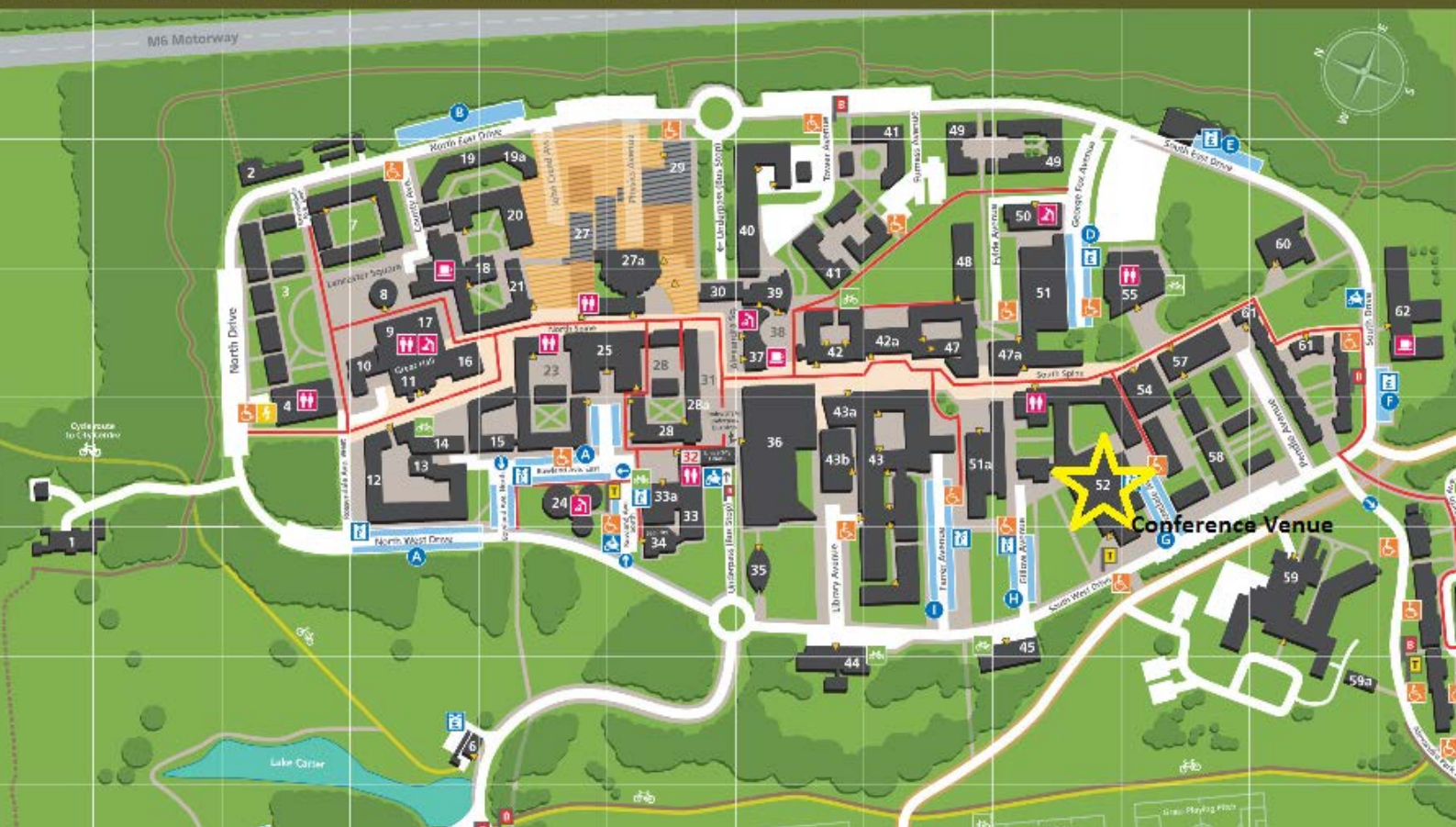
The ability to implicitly detect statistical regularities in orthography has been hypothesized to partly subserve spelling ability (Deacon, Conrad, & Pacton, 2008). The theorized relationship between implicit learning and spelling has been substantiated by findings that the degree of success in artificial orthographic rule learning correlates with English and Spanish spelling ability (Nigro et al., 2015; Steffler, 2004). Implicit non-orthographic sequence learning, as tested with an alternating serial reaction time (ASRT) task, also correlates with English spelling (Howard et al., 2006). Despite these promising findings, the link between implicit learning and spelling ability is not fully understood. Outstanding questions are 1) whether implicit learning of non-orthographic sequences, as measured by the serial reaction time (SRT) and visual statistical learning (VSL) task, is associated with spelling and 2) whether the relation between spelling and implicit non-orthographic learning is also visible in a semi-transparent orthography like Dutch.

This study addresses these issues by investigating the relation between Dutch spelling and implicit learning. We administered three implicit learning tasks in two experiments: a version of the SRT task (Nissen & Bullemer, 1987), an ASRT task, and a VSL task (Arciuli & Simpson, 2012). Twenty-five adult participants (age 18 − 55 years) performed the SRT, the ASRT and a spelling task comprising real Dutch words and nonwords. The results showed significant correlations between real word spelling and both the SRT (r = .48, p = .015) and ASRT (r = .40, p = .045). Another twenty-eight Dutch native speakers (age 21 − 35 years) completed the VSL and spelling task. The VSL results correlated significantly with spelling (both real words and nonwords, r = .53, p = .004). The outcomes of the combined studies underline the association between spelling and implicit learning. The results furthermore show that spelling ability is associated with implicit learning of sequences tested in three different paradigms, varying in complexity (first-order (SRT) versus second-order sequences (ASRT)) and nature (visuo-motoric versus visual statistical learning). Finally they confirm that this relationship also exists in a semi-transparent orthography.

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