

**Short report of the EARLI Advanced Study Colloquium on “Cognitive neuroscience meets mathematics education” (Brugge, Belgium: 25/03/2009 – 28/03/2009).**

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The EARLI Advanced Study Colloquium (ASC) on “Cognitive neuroscience meets mathematics education” took place from March 25 until March 28 2009 in the Hof van Watervliet, which is located in the centre of Brugge, Belgium. Forty-three people, coming from 13 different countries and mostly constituting pairs of a senior and junior researcher from the same research unit, participated in this ASC, the organisation of which was in hands of the three active research teams within the EARLI community, namely the Centre for Instructional Psychology and Technology of the K.U.Leuven, theETH Zurich, Switzerland, and the Centre for Learning Research of the University of Turku, Finland.

The central goal of this ASC was to present and discuss empirical work situated at the intersection of cognitive neuroscience and mathematics education. As stated in the introduction by Bert De Smedt and Lieven Verschaffel, the past few years have witnessed a large number of general statements and claims about the relationship between these two fields of research, whereas actual research at the intersection of both areas of research is only emerging. With this ASC we wanted to move beyond mere theorizing or speculating about this relationship in general and to look at the emerging empirical research at the intersection of both disciplines. Researchers have begun to collaborate across disciplines, giving rise to a new interdisciplinary research field called (mathematics) educational neuroscience. All presentations at this ASC represented collaborations between educational researchers and neuroscientists, and, consequently, the audience of this ASC represented a good balance of scholars coming from both disciplines, complemented with an extremely promising group of (young) truly “interdisciplinary” researchers with a strong training in both fields (several of whom are active EARLI members). This rich and well-balanced combination of scholars with various backgrounds (in terms of nationalities, seniorities, and scientific disciplines) provided a unique opportunity to comment upon emerging empirical work at the intersection of neuroscience and mathematics education and to explore and discuss challenges and future avenues of the field.

Setting the scene for the ASC, De Smedt and Verschaffel argued in their introduction to the colloquium that this interdisciplinary field of cognitive neuroscience and mathematics education should take the shape of a two-way street, going from cognitive neuroscience to mathematics education and back to cognitive neuroscience, and so on. The lively discussions after each of the presentations at the ASC indicated that there is quite some traffic going on across this two-way street.

Three keynote speakers – all three world-leading scholars in the field – presented the latest insights and methodological approaches in the neuroscience of mathematical cognition. Dénes Szűcs’, (Centre for Neuroscience in Education at the University of Cambridge, UK) presentation about “Educational Neuroscience: linking neural representations to educational performance” focused on the role of electrophysiological measures (EEG) in educational research. In doing so, he concentrated on his work on the representation of magnitude, one of the major topics in the neuroscientific research in the domain of mathematical cognition and learning so far. The second keynote lecture entitled “Numeracy and arithmetic in the brain: the roles of development and individual differences” was given by Daniel Ansari, who has a Canada Research Chair in Developmental Cognitive Neuroscience, from the University of Western Ontario, London, Canada. In his overview of the cognitive neuroscience of arithmetic, he stressed that most of the available neuroimaging data involve – for evident reasons – adults. He argued that it is crucial to take a developmental perspective and to account for individual differences in future research and he gave some examples of ongoing research in his lab along these lines. The final keynote lecture was presented by Stanislas Dehaene, who is director of the prestigious INSERM-CEA Cognitive Neuroimaging Unit in Paris, France. He talked about “Cognitive foundations of arithmetical and geometrical intuitions”, with a strong focus on his latest fascinating neuroimaging work on geometry.

Next to these keynote lectures, the ASC included 16 empirical research papers, that were carefully selected by the conference programming committee from a set of about 30 submissions. As said before, these papers were presented by pairs of researchers from the same team, mostly comprising a senior researcher and a junior (pre-doctoral or doctoral) researcher. Nine of these 16 teams that participated at the workshop involved EARLI members<sup>1</sup>. The papers were thematically grouped into different sessions. Each paper was accompanied by a 15 minute time slot for discussion. These discussions were taken as an opportunity, not only to comment on the presented papers, but also to raise and discuss more general theoretical and methodological challenges for the emerging interdisciplinary field. Thanks to the advanced and the small-scale character of the colloquium, all senior and junior researchers and keynote speakers were very actively involved in these discussions, which were always remarkably lively and stimulating. The fact that so much time was spent to discussion was greatly appreciated by the ASC attendants (see Appendix for some exemplary e-mail reactions we received after the ASC).

The different papers covered various domains of mathematics education, comprising number processing (Brigstocke & Göbel, Hannula, Grabner & Lehtinen; Kaufmann & Vogel; Kucian &

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<sup>1</sup> As explained in our exchanges with the EARLI EC in the preparatory stage of the ASC, it would have been a mistake to select only or even almost only EARLI members for this EARLI ASC meeting, since this would have resulted in a qualitatively much weaker scientific program. By having a good mix of EARLI and non-EARLI members the “learning experience” for the participating EARLI members was much larger than if we would have allowed only EARLI members (because then we would have had much too few (technical) neuroscientific expertise among the participants).

Rotzer; Landerl & Hausenberger; Reeve & Humberstone), arithmetic (Grabner, Ansari & Stern; Rubinsten; Ram-Tsur & Mevarech), negative numbers (Varma & Schwartz), problem solving (Preusse & Wartenburger; Reiss & Obersteiner; Stavy & Babai), geometry (Griva & Vosniadou), algebra (Thomas & Yoon). They included a variety of specific methodological approaches, such as longitudinal studies (Hannula, Grabner & Lehtinen; Landerl & Hausenberger; Reeve & Humberstone), pharmacological intervention (Rubinsten), intervention studies (Grabner, Ansari & Stern; Kucian & Rotzer), studies on learning disorders (Brigstocke & Göbel; Kaufmann & Vogel; Ram-Tsur & Mevarech), next to experimental designs. These studies also used various neuroimaging techniques, like fMRI, EEG and NIRS. For a detailed program, we refer to the programme book that is enclosed to this brief report.

The collection of key-note and research papers presented at this EARLI-ASC nicely illustrated two-way interactions between cognitive neuroscience and mathematics education. The following three issues were repeatedly addressed and can be seen as a “take home” message from this ASC. Firstly, when evaluating the potential of cognitive neuroscience and designing collaborative studies, it is of crucial importance to take into account developmental issues and individual differences. Secondly, it is critical to depart from a clear theoretical framework and research question or hypothesis located in the domain of educational psychology for successfully setting up joint research projects. These joint projects should take advantage of the large knowledge base of learning sciences research to design new studies and to interpret (neural) data. Thirdly, the study of learning environments should become an essential focus of research. This focus should not be limited to taking into account the prior educational histories of the participants involved in the ascertaining neuroimaging studies. Besides, there is a great need of intervention studies wherein the effects of different learning environments on brain activation, are studied (in combination with behavioral effects).

While these three issues have been already been addressed in the presented papers, it is clear that this interdisciplinary field is still in its infancy. However, several teams showed at the end of their presentation the steps they are taking at the moment or that they plan to take in their interdisciplinary research projects for the near future. Taking this as an indication of where the field is heading over the next few years, the future looks bright.

As a result of their very positive evaluation of the EARLI-ASC, several participants expressed their great interest in the participation of an EARLI Special Interest Group on “Cognitive Neuroscience and (Mathematics) Education”<sup>2</sup>. Therefore, we started to write out a proposal for a EARLI SIG on this topic, which we plan to submit soon. We also plan to write a state-of-the-art and/or discussion paper about the topic of our EARLI-ASC taking the fruitful discussions of the ASC as an input, which we hope to submit for publication to the EARLI journal *Educational Research Review* in

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<sup>2</sup> We emphasize that although the topic of the EARLI ASC was cognitive neuroscience and *mathematics* education, it may be more appropriate to establish an EARLI SIG on the broader topic of cognitive neuroscience and education, to stimulate exchanges and collaborations between EARLI members with interest and expertise in cognitive neuroscience in different subject-matter domains.

the coming months. To conclude, this EARLI-ASC has, in our opinion, been extremely well in time and helpful for the (EARLI) scholars who attended it., as also indicated by the large number of positive reactions that we received after the workshop (see Appendix 1 for some illustrative reactions). Not only the scientifically impressive program and the stimulating discussions contributed to this success. Thanks to the substantial grant we got from EARLI<sup>3</sup>, we could not only invite three world-leading experts as keynotes, but we were also able to organize this scientific meeting in a nice historical site in the heart of Brugge and to offer our participants nice meals (i.e., a welcome reception and two lunches) that helped to create a warm and open atmosphere, providing ground for informal talks and establishing or strengthening links between research groups. We would like to thank EARLI once again for giving us the opportunity to organise this ASC.

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<sup>3</sup> As explained in our application for the EARLI-ASC, there was also a substantial grant from the Research Foundation-Flanders as well as substantial technical support from the Department of Educational Sciences of the K.U.Leuven. Thanks to these sponsors, it was possible to pay a) the traveling and hotel costs of the three plenary speakers, b) the rent of the conference facilities and the five coffee breaks, and c) the welcome reception and the lunches, without having to ask any registration fee to the participants.

Appendix 1: Some e-mail reactions received after the EARLI-ASC

*I wanted to thank you again for the wonderful conference and for your generous and warm hospitality. I think that the conference was well organized and balanced between topics, talks and discussions and the atmosphere you and the other organizer created certainly had a tremendous impact on the conference's success. [...] Looking forward for a follow-up conference in a year or two...*

*Thank you very much for the wonderful conference in Brugge!!! I had a fantastic time, the conference was excellent, very well organised and very stimulating.*

*Thanks again for the invitation and the organization, I hugely enjoyed the conference!*

*The workshop was one of my best I've ever attended.*

*I had a fantastic time at the conference. I really appreciate you and the other organizers taking a chance on mine and Dan's research, which was somewhat out-of-step with the other presentations but I think served as useful food for thought. I was able to meet people who's papers I've long admired, to learn about research I would have otherwise missed, and perhaps most importantly, to get a sense of where the field is heading over the next few years.*

*Thank you again (and everyone else involved) for a stimulating and enjoyable colloquium in Bruges. I found it very useful.*

*Thank you so much for such a WONDERFUL workshop in Brugge. I think it was the best conference I have been to! [...] The conference was so stimulating and afforded such great intellectual interactions.*

## Appendix 2. List of participants

1. Ansari Daniel
2. Babai Reuven
3. Brigstocke Sophie
4. De Smedt Bert
5. Dehaene Stanislas
6. Dénes Szücs
7. Depestel Isabel
8. Ghesquière Pol
9. Göbel Silke
10. Grabner Roland
11. Griva Georgia
12. Hannula Minna M.
13. Holloway Ian
14. Humberstone Judi
15. Kaufmann Liane
16. Knausenberger Judith
17. Krinzinger Helga
18. Kucian Karin
19. Landerl Karin
20. Lehtinen Erno
21. Mevarech Zemira
22. Obersteiner Andreas
23. Preusse Franziska
24. Ram-Tsur Ronit
25. Reeve Robert
26. Reiss Kristina
27. Reynvoet Bert
28. Rotzer Stephanie
29. Rubinsten Orly
30. Schwartz Daniel
31. Schneider Michael
32. Stavy Ruth
33. Stern Elsbeth
34. Thomas Mike
35. Van Eimeren Lucia
36. Vandermosten Maaïke
37. Varma Sashank
38. Verschaffel Lieven
39. Vogel Stephan
40. Vosniadou Stella
41. Wartenburger Isabell
42. Willmes Klaus
43. Yoon Caroline

## Appendix 3 Book of Abstracts

[See separate book]