



Exploratory Workshop Scheme

Scientific Review Group for the Humanities

ESF Exploratory Workshop on

From Numbers To Knowledge – 20 Years of Spatial-Numerical Associations

Potsdam (Germany), 10-12 September 2013

Convened by:

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ESF Exploratory Workshops

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1. Executive summary

BACKGROUND AND MOTIVATION: The ESF Exploratory Workshop on 'From Numbers To Knowledge - 20 Years Of Spatial-Numerical Associations' took place as planned on 10-12 September 2013 in Potsdam/Germany. It was motivated by the fact that it had been 20 years since the publication of a seminal scientific report on the relationship between our cognitive representation of number meanings and their systematic associations with space. The report by Dehaene, Bossini, and Giraux (1993) showed that small numbers (e.g., 1 or 2) activate the left side of space while larger numbers (e.g., 8 or 9) activate the right side of space in most Western adults. This effect has since been documented in a wide range of behaviours: The original study has been cited by over 600 follow-up publications, making it one of the landmark papers in the Cognitive Sciences.

WORKSHOP OBJECTIVES: Several seminal ideas have contributed to the impact of the original 1993 report, and the present workshop gathered a number of researchers from different disciplines to reflect upon these ideas and their relevance for those different fields. Specifically, we had invited educational scientists, neuroscientists, psychologists, roboticists, ethologists, neuropsychologists and cognitive scientists to address the following four interrelated points:

1. Theoretical implications: What does the link between number meaning and space imply for our representation of number concepts and for knowledge representation more generally? Can we develop a theoretical framework that accounts for the ubiquitous number-space associations and also makes strong novel predictions?
2. Educational implications: What is the current state of math education when it comes to spatial-numerical links? Can we use the spatial associations of numbers to develop recommendations for mathematics education and/or for more effective teaching methods?
3. Technological implications: What kind of technological devices (hardware) can be used to study or train number-space associations? Can we develop software applications that support the acquisition or rehabilitation of number knowledge?
4. Rehabilitative implications: What do studies with neuropsychological patients tell us about the possibility to activate defective knowledge representations in one domain (e.g., space) through the use of concepts from a different domain of knowledge (e.g., numbers)?

Finally, we also wanted to discuss the relevance of spatial-numerical associations in the light of forthcoming research initiatives, especially at a European level. For that purpose, the workshop delegates also received advice on European funding mechanisms from two representatives of European funding agencies. One was the European Science Foundation (ESF) which generously sponsored this workshop, the

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other was the European Commission which is about to launch its eight research framework called “Horizon 2020”.

WORKSHOP IMPLEMENTATION

Owing to contributions from all delegates both before and during the meeting, all workshop goals were achieved. A particularly valuable decision was the idea of the two organizers to set up sub-groups of experts well in advance of the meeting.

Group 1: Theory Building (Elena Rusconi, Mauro Pesenti, Samuel Shaki)

These researchers share a common theoretical interest in the role of finger representations for numerical cognition, which is a prime example of embodied numeracy. This group derives predictions from embodiment theory and develops scenarios for empirical testing, also in the context of educational and rehabilitative settings. Questions to be addressed: Which manual-numerical tasks are both diagnostic/predictive of numeracy and measurable on a tablet or smartphone? Which performance parameters should be recorded?

Group 2: Education (Dana Ganor-Stern, Maciej Haman, Korbinian Möller)

Members of this group have a strong background in educational aspects of numerical cognition and are familiar with the state of the art in developmental numerical cognition. This group determines current use of gaming for numeracy training and its limitations. Questions to be addressed: Which aspects of computer gaming best predict or improve numeracy? How much embodiment is needed for successful numeracy training?

Group 3: Rehabilitation (Luisa Girelli, Marco Zorzi, Peter Brugger)

This team has expertise in neuropsychology and hands-on experience with, as well as good access to, neuropsychological patients. This group reports how number knowledge and numerical tasks can assist in rehabilitation, for example to re-instantiate spatial representations in neglect patients or as mnemonic aid for other knowledge domains. Questions to be addressed: What specific training methods/designs can be used? How can tablet-based technology be incorporated in neuropsychological settings? What unique contribution to rehabilitation comes from an embodied approach to knowledge? What number and type of patients will be suitable and available for testing?

Group 4: Technology (Guilherme Wood, Silke Göbel, Angelo Cangelosi)

Members of this group have pre-existing links to software development companies, specific expertise in hardware and software for optimal education and rehabilitation

This team explores links with small- or medium-sized companies within the EU. They are allowed to give out general information about the research agenda. Questions to

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be addressed: Which company (or companies, if complementary) can be suitable industrial partners for an EU proposal to study embodied numerical cognition (incl. rehabilitation and education) on tablet PCs or smart phones? What is the state of the art in tablet-based math assessment and training?

We also offered to all delegates the opportunity for video-conferencing both before and after the workshop. For this offer, we wanted to utilize the flashmeeting resource (see the general info here: <http://cnm.open.ac.uk/projects/flashmeeting/>) which was free and required no software downloads.

Due to holiday constraints immediately prior to the workshop, no pre-workshop video conference took place. However, some of the delegates met in advance of the workshop during the bi-annual conference of the European Society for Cognitive Psychology in Budapest (Hungary) to agree specific goals and clarify expectations.

The local administrator Petra Köhler informed all delegates of travel arrangements, coordinated hotel bookings, venue preparation and catering, and supported the conduct of the meeting as well as the post-workshop financial procedures. The actual content of the workshop and its outcomes are described in the next two sections and are therefore not reiterated here.

2. Scientific content of the event

The first part of the scientific program was an overview presentation by Professor Mauro Pesenti on the theory of embodied cognition. He concluded that this theory seems to be a promising framework for collaborative research on the spatial-numerical associations and their implications for knowledge representation more generally. Specific ideas for experiments were discussed and critically evaluated.

The second part of the scientific program was a shared presentation by the technology group, which was delivered by Dr Wood and Professor Cangelosi. Doctor Göbel summarized the state of the art of tablet PC technology and also the currently available software programs for mathematics training in preschoolers. Professor Cangelosi highlighted the potential of cognitive robotics research for the planned network activities. In the subsequent discussion it was concluded that there is a lack of scientifically founded training software and that current tablet and smartphone technology provides a unique opportunity to train numeracy skills outside of traditional school settings. Evidence regarding basic cognitive processing of information delivered via such devices is, however, also lacking. Industrial partners, especially those in the field of multi-media learning, should be natural supporters of this kind of research.

In the afternoon we first listened to a survey of developmental research into spatial-numerical associations and their educational implications, delivered by Professor

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Moeller. One important conclusion was that the comprehension of fractions seems to be a skill with strong predictive value for further mathematics success of children. Another insight was that specific tasks differ in their training potential for numeracy development, and that the approximate number system can be trained most effectively through non-symbolic magnitude comparisons. The number-to-position task was another promising training task that should be implemented in a multi-modal learning environment for maximal benefit.

The last part of the scientific program was dedicated to a discussion of the rehabilitative potential of spatial-numerical associations, delivered in the form of a joint overview by Professors Brugger and Zorzi. Both of them, and also most of the delegates, felt that the embodied cognition approach provided a suitable framework for the rehabilitation of both developmental and acquired deficits in the numerical domain. Possible implications for dyscalculia training and rehabilitation were summarized for the benefit of delegates interested in such more applied work in future, possibly seeking the collaboration of hospitals and rehabilitation clinics.

3. Assessment of the results, contribution to the future direction of the field, outcome

The goals of the workshop were accomplished in full, leading to the following results:

- 1 Establishing new links between researchers from different European countries and from different disciplines. This was clearly accomplished, both at the workshop and during the surrounding social events (the two dinners and the concluding breakfast).
- 2 Setting up a web page. This internet-based resource hosts all workshop documents, including summaries of the presentations, researchers' profiles of current interests, photos from the workshop activities and guidance notes received from the European funding bodies. The web link is <http://cognitive-psychology.eu/esfworkshop/> (user name: Potsdam, password: H2020)
- 3 Establishing a track record of collaboration. This will assist with the applications for funding and was accomplished through the pre-workshop cooperation of the subgroups, as well as through the workshop itself, and will be continued at further meetings (such as the recent Workshop on Educational Neuroscience, Tübingen/Germany, 7/8 October 2013; and the forthcoming European Workshop on Cognitive neuropsychology, Brixen/Italy, 26-31 January 2014) and through use of the Flashmeeting Video Conferencing Tool described above.

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4 Dissemination of findings. In addition to setting up the shared web page, the two workshop conveners plan to guest-edit a special issue of a peer-reviewed international journal that focuses on the themes of the workshop. We already received abstracts from several delegates and a statement of interest from the editor of "Journal of Cognitive Psychology" to host a Special Issue on the topic of our workshop. We plan to submit a formal proposal by December and expect the Special Issue to be completed in 2014.

5 Plans for an EU level collaboration. Both the scientific discussions and the initial guidance from ESF and EU representatives, proved valuable in setting up plans for research collaborations among the delegates. To assist with this, the organizers recorded the statements of interest of all delegates at the end of the workshop, which should facilitate network-building among the participants.

CONCLUDING REMARKS

The ESF exploratory workshop has proven to be an excellent stimulator. It was unfortunate that one local colleague cancelled participation after the official deadline for changes (Schwarz), and that two colleagues fell ill and could not attend (Girelli, Crollen). Another delegate (Hartsuiker) was the only industry representative scheduled to present at the meeting and also fell ill on the last minute, so the industry cooperation was left unclear after the meeting. Finally, one small point of discontent was the fact that, on the one hand, ESF guidelines suggested that delegates were to receive food and drinks, while on the other hand the administration of ESF funds through the University of Potsdam prevented the payment of alcoholic drinks. This was resolved by asking delegates to pay for their alcoholic drinks but more explicit ESF guidance on this point might be useful in future.

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4. Final programme

Tuesday 10 September 2013

Afternoon *Arrival*

19.00 *Informal gathering (Potsdam, Lobby of Hotel am Luisenplatz)*

Wednesday 11 September 2013

07.45-09.30 Breakfast, Hotel am Luisenplatz and walk to Workshop Venue (via Park Sanssouci)

09.30-09.40 **Welcome by Convenors**
Fischer, Lindemann

09.40-10.00 **Presentation of the European Science Foundation (ESF)**
tba (Scientific Review Group for the Humanities)

10.00-10.30 **Presentation on Initial Training Networks under EU FP8**
Richter (European Commission, Brussels, Belgium)

10.30-13.00 Morning Session: Theory and Technology

10.30-10.50 **Group Presentation 1 "Embodied Numbers"**
Pesenti, Shaki, Rusconi

10.50-11.30 **Discussion of theoretical issues (Coordinator: Nuerk)**

11.30-12.00 *Coffee / Tea Break*

12.00-12.20 **Group Presentation 2 "Technology"**
Wood, Cangelosi, Göbel

12.20-13.00 **Discussion of technological challenges (Coordinator: Lindemann)**

13.00-14.00 *Catered Lunch*

14.00-15.30 Afternoon Session: Education and Rehabilitation

14.00-14.20 **Group Presentation 1 "Education"**
Hamann, Möller, Rugani, Ganor-Stern

14.20-15.00 **Discussion of edutainment requirements (Coordinator: Schilz)**

15.00-15.30 *Coffee / tea break*

15.30-15.50 **Group Presentation 2 "Rehabilitation"**
Brugger, Girelli, Zorzi

15.50-16.30 **Discussion of rehabilitation potential (Coordinator: Schuller)**

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16.30-18.00 **Follow-up activities/networking/collaboration**
Lindemann, Fischer

19.00 *Informal gathering (Potsdam, Lobby of Hotel am Luisenplatz)*

Thursday 12 September 2013

08.15-09.30 Breakfast, Hotel am Luisenplatz
End of Workshop, final coordination and departure

5. Final list of participants

1. **Martin H. FISCHER (Convenor)**
Division of Cognitive Sciences, University of Potsdam
2. **Oliver LINDEMANN (Co-Convenor)**
Division of Cognitive Sciences, University of Potsdam
3. **Milena Zic-FUCHS (ESF representative)**
Faculty of Humanities and Social Sciences, University of Zagreb
4. **Peter BRUGGER**
Department Neuropsychology, Universitäts-Spital Zürich
5. **Angelo CANGELOSI**
School of Computing and Mathematics, University of Plymouth
6. **Dana GANOR-STERN**
Department of Psychology, Achva Academic College
7. **Silke GÖBEL**
Department of Psychology, University of York
8. **Maciej HAMAN**
Faculty of Psychology, University of Warsaw
9. **Korbinian MÖLLER**
Leibniz-Institut f. Wissensmedien, Tübingen
10. **Hans-Christoph NUERK**
Department of Psychology, University of Tübingen
11. **Mauro PESENTI**
Department of Psychology, Catholic University of Louvain
12. **Bodo RICHTER**
Directorate General Education and Culture, European Commission
13. **Rosa RUGANI**
Department of Psychology, University of Padova
14. **Elena RUSCONI**
Department of Social & Health Sciences, University of Abertay
15. **Christine SCHILTZ**
Faculté des Lettres+Sciences Humaines, Université du Luxembourg
16. **Anne-Marie SCHULLER**
Faculté des Lettres+Sciences Humaines, Université du Luxembourg
17. **Samuel SHAKI**
Department of Behavioral Sciences, Ariel University
18. **Adriana WIPPERLING**

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Dezernat 1, Research Coordination, University of Potsdam

19. **Guilherme WOOD**

Department of Psychology, University of Graz

20. **Marco ZORZI**

Department of Psychology, University of Padova

6. Statistical information on participants

Age distribution

Bracket	N° participants
30-40:	5
40-50:	7
50-60	2
Undeclared	6

Gender distribution

Bracket	N° participants
Male	12
Female	8

Geographical distribution (country of affiliation)

Country	N° participants
Austria	1
Belgium	2
Switzerland	1
Germany	5
Croatia	1
Israel	2
Italy	2
Luxemburg	2
Poland	1
UK	2
USA	1

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