This we think is the main obstacle to the formation of young scientists contributing and taking advantage of interdisciplinary research.

Among other aspects the most important, in our view, is the possibility to understand which are each other's experimental strengths and weaknesses; the meaning and the limitations of each other's results and their complementarities. These aspects are very difficult to acquire by reading each other's articles and/or participating occasionally in joint workshops as the danger of underestimating the experimental difficulties and overestimating the results obtained is very easy with the consequence of stopping at the "how" without asking the "why" or stopping at the "why" without asking the "how". This hypothetical interdisciplinary environment is, I think, the ideal place to form an interdisciplinary thinker because he/she will be able to continue deepening his/her specific area of interest and to provide it to the "team" without the danger to become an "amateur" scientist or engineer.

Sandini, G., G. Metta, and J. Konczak. 1997. "Human Sensori-Motor Development and Artificial Systems." Paper presented at the International Symposium on Artificial Intelligence, Robotics, and Intellectual Human Activity Support for Applications, Wakoshi, Japan.
Sandini, G. 1997. "Artificial Systems and Neuroscience" In M. Srinivasan (ed), Proceedings of the Otto and Martha Fischbeck Seminar on Active Vision, Wissenschaftskolleg zu Berlin, Berlin.
Stark, L. 1968. "Neurological Control Systems: Studies in Bioengineering". New York, Plenum Press,
Vernon, D., C. von Hofsten, and L. Fadiga. 2011, "A Roadmap for Cognitive Development in Humanoid Robots", Cognitive Systems Monographs (COSMOS), Vol. 11, Springer, Heidelberg.
D. Vernon, G. Metta, and G. Sandini, "A Survey of Artificial Cognitive Systems: Implications for the Autonomous Development of Mental Capabilities in Computational Agents", IEEE Transactions on Evolutionary Computation, special issue on Autonomous Mental Development, Vol. 11, No. 2, pp. 151-180, 2007.
Vernon, D. 2014. Artificial Cognitive Systems - A Primer, MIT Press.

Training Master Students in Cognitive Science

Franck Ramus

Département d'Études Cognitives, École Normale Supérieure, PSL Research University, EHESS, CNRS Paris, France

franck.ramus@ens.fr

Thérèse Collins

Laboratoire Psychologie de la Perception, Université Paris Descartes & CNRS, Paris, France

collins.th@gmail.com

In their target article, Rohlfing and colleagues expose the considerable challenge of educating young researchers in an interdisciplinary field, considering mostly the doctoral and postdoctoral levels. In the present article, we describe our own attempts at addressing this challenge at the master level.

In the Master program in cognitive science that was created in 2004 by Emmanuel Dupoux and Daniel Andler, and that we now jointly direct, we admit students with a Licence (3-year bachelor degree) in any discipline relevant to cognitive science (psychology, linguistics, biology, philosophy, social sciences, computer science, mathematics, and other math-intensive disciplines such as physics and engineering), and we aim, in 2 years, to turn them into students capable of carrying out a Ph.D. in cognitive science (which, in Europe, usually is a 3-year research project with few or no additional courses). Thus, we face the double challenge of training students to perform research and to do so in an interdisciplinary field. The main stumbling blocks are the sheer amount of knowledge and practical training that they need to absorb in a limited amount of time, and the heterogeneity inherent to the diverse backgrounds of the students. Here are some features of the program that have been designed to address these challenges.

The general philosophy of the program is that the first year (M1) is dedicated to both the reinforcement of each student's initial background and the opening to other disciplines and to cognitive science as such. It is our belief that, whatever students' background, they should keep specializing in it, because in order to do interdisciplinary research, it is not enough to have superficial knowledge of diverse areas, one must be at the top of the field in at least one area. Thus the M1 is divided into five majors reserved for students with the corresponding background: psychology, linguistics, neuroscience, math and modeling, philosophy and social sciences. This also ensures that M1 students can go back to a disciplinary M2 if they want or if they have to, and that students keep a disciplinary label that can be useful later when applying for jobs in institutions that remain structured according to disciplines and where it can be a huge handicap to fall in between established categories.

More specifically, the first year of the program has five components: 1) A core curriculum; 2) concentration courses; 3) introductory courses; 4) advanced courses; 5) internships. The core curriculum is meant to provide all students with a common culture and common methodological tools. This includes catch-up courses in math/statistics and in programming (for those who need it), as well as compulsory workshops on experimental design and on theoretical thinking (based on classic texts of cognitive science and on computational modelling). Concentration courses are specific to each major and only for students with the relevant background. Introductory courses are introductions to each discipline of cognitive science, reserved to students with a different background. Advanced courses go further into each of those disciplines, and are open both to students with the relevant background, and to those who have followed the corresponding introductory course. Finally, internships (on any topic of cognitive science in any appropriate laboratory) are an important part of the training, where crucial hands-on experience is acquired and where theoretical skills and knowledge can be applied.

In the second year (M2), students are deemed ripe for interdisciplinary science. The first semester is spent on courses that are all object-oriented and multidisciplinary (e.g., courses on vision, language, development, or social cognition, with content drawn from any combination of psychology, neuroscience, modeling, linguistics, philosophy and social sciences). The second semester is spent full-time on a five-month research project in a laboratory, which most often draws from several disciplines as well. Although our highly dense and structured M1 program is designed to be the best preparation for the challenges of the M2 year, we also admit some students directly into M2. They are typically medical students, engineers, or students with another relevant M1 or M2 degree, with a sufficiently strong record to be allowed to skip the M1.
In both M1 and M2, and thanks to our three partner universities and many dedicated teachers, the choice of courses and internships offered to students is very large. Thus each student has many degrees of freedom and each individual curriculum is unique. In order to help students make the best use of their freedom and to ensure that they meet the pedagogical requirements of the program, each student is assigned a personal tutor who will advise, validate, and provide as much guidance as needed.

As can be seen, this master program is a challenge in itself, not only for the faculty, but most of all for the students. The fact is that doing interdisciplinary research is not for everybody: it requires acquiring more knowledge across several disciplines, juggling with more methods, and trying to keep up with more sectors of the scientific literature than in strictly disciplinary research. Thus a stringent selection of the students allowed to enter the program is another important aspect of our general strategy.

Although our ambitions are immense, we have to admit that this master program can only partly and imperfectly meet the challenge of training young researchers in cognitive science. We do our best to further improve the program each year, based on student and teacher feedback. But we also have to be content with the idea that training continues for many years after a master degree, and indeed throughout a researcher's career.

Promote Early-Stage Interdisciplinarity Based on Mutual Respect and Trust

Maha Salem

Adaptive Systems Research Group, The University of Hertfordshire, United Kingdom

m.salem@herts.ac.uk

Rohlfing and colleagues initiate a much-needed dialogue and highlight some of the main challenges regarding the education and training of young scientists destined to work in an interdisciplinary research area. They offer two options as potential approaches to equip students with the required skills, i.e. either by exposing them to interdisciplinarity (1) at the PhD level or (2) at the postdoctoral level.

Although I am aware of many of the supposed risks and pitfalls of interdisciplinary research (e.g. as discussed by Caudill & Roberts, 2009) as well as of the challenges to satisfy peers (i.e. supervisors) of different disciplinary backgrounds, I personally argue for the first option based on my own experience. During my PhD, for which I implemented human-like communicative capabilities in the form of synchronized gesture and speech on a humanoid robot (Salem, 2012), I came to realize that, in order to model human cognitive behaviors for an artificial system, a thorough understanding of the distinct qualities and mechanisms regarding the "human side" of these skills is essential. In other words: it would have been much more difficult—if not impossible—for me to develop an appropriate speech-gesture generation framework had I not reached out to disciplines such as psychology, linguistics and neuroscience to gain insights and inspiration for my technical work.

In light of my personal experiences, I would even encourage interdisciplinarity from an earlier stage, e.g. at the Masters level. This preference is further based on the following two thoughts.

1) As Rohlfing and colleagues emphasize, the research area of Cognitive Developmental Robotics is inherently interdisciplinary; accordingly, it can and should best be approached in a way that acknowledges and embraces the multi-faceted disciplines involved and with a general willingness to transcend disciplinary boundaries as