# Rebordering the borders created by multidisciplinary sciences: A study

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## Abstract

Emergence of "Glass ceiling" like phenomena in the minds of professionals doing research in a multidisciplinary subject needs to be studied. For an example, computational neurosciences(CNS) comprises of neurology, cognitive science, psychology, computer science, physics, mathematics, information technology, radiology, anthropology, sociology, and biology. When a specialist doing research in a multidisciplinary science like computational neuroscience, know less about other disciplines. This at times leads to tension among the members of the multidisciplinary group. This may create an environment where some members feel excluded. This may also lead to a power structure among different professionals. In case of CNS, the biological scientists feel the computational and engineering sciences may use their mathematical power to control them. On the other hand the engineering scientists feel they need to learn more about biology to understand CNS. The highly technical medical specialist such as Electro physiologists were also feeling like the biologists. As computational neurosciences gaining more importance, it is important to understand the interaction among the scientists from different disciplines and its effect on the development of discipline. The present paper is an attempt to study the dynamics of the members of the multidisciplinary group, who have done their short course on CNS.

## Introduction

Emergence of "Glass ceiling" like phenomena in the minds of professionals doing research in a multidisciplinary subjects needs to be studied. Computational neurosciences comprises of neurology, cognitive science, psychology, computer science, physics, mathematics, information technology, radiology, anthropology, sociology, and biology. When a member from a particular discipline engage in computational neuroscience research, it is difficult for him/her in dealing with the disciplines outside their own. This limitation at times may lead to tension among the members of the group. This creates an environment where group members feel, one group member have advantage over the others by over emphasizing their own discipline. This is seen as

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a power structure and will develop in to a hierarchy of disciplines within computational neuroscience.

According to Fox(1999) Science is fundamentally hierarchical. It is an institutional medium of power, marked by immense inequality in status and rewards with the valued attributes of science.

There are also studies in sociology of gender shows science is a focal case because science is an agent of power, with consequences for the present and future human condition. Science is a prototype of professional claim to "authoritative knowledge:. Science defines what is "taken for granted". (Fox, 1999)

According to Comte's theory of the hierarchy of the sciences, mankind progresses through stages. Each successive stage building on the accomplishments of its predecessors, hence, scientific knowledge passes through similar stages of development. It is different for different sciences. "Any kind of knowledge reaches the positive stage early in proportion to its generality, simplicity, and independence of other departments." Hence astronomy, develops first, followed by physics, chemistry, biology, and finally, sociology. Holistic character distinguishes biology from all the other natural sciences. Unlike physics and chemistry, which are isolating elements, biology studies the organic wholes. In the inorganic sciences, the elements known to us, than the whole which they constitute: so we must proceed from the simple to the compound. But the reverse method is necessary in the study of Man and Society; Man and Society as a whole being better known to us, and more accessible subjects of study, than the parts which constitute them. (Aron, 1968) This is true with biological systems.

**Computational Neuroscience**

Computational Neuroscience is a combination of neurology, Biology, Computer Science, Mathematics, Physics, Electrical Science, Physiology, Psychology and other related fields. Keeping the multidisciplinary nature in mind author along with specialists from Neurology, Radiology, Computer Science, Physics and Social Science and Information Technology has initiated a group to work on a multidisciplinary field called medical imaging informatics group. This group functioned as think tank group for research in multidisciplinary research for last five years. Author being the coordinator of Tele-education, and Medical Informatics project has conducted number of courses in the field of imaging informatics in medicine with the help of the multidisciplinary group. In the formative years it was a challenging task to bring all the experts from different discipline to work in a common platform. Later it has helped all the members to formulate research in the field related to and many have published in the international journals.

As per the Comte Mathematics, Physics and Chemistry are simple sciences which have structurally defined. While biology is a complex science as it is dealing with the living

organisms. Now we need to understand whether CNS is a Biological science or the physical science. Scientists describe computational neuroscience as using computer simulation as a tool for understanding brain. Some have also explained construct a model with a hypothesis and to conduct computer experiments to study the behavior similar to experiments on the biological system. It is basically using the computational approaches to understanding the biological system namely the neurological system. It has more of a simulation in many instances. The mathematical models help in understanding the neuroscience better. That will help to understand the human brain. The popular things which are used to explain this concept are the learning systems, vision, memory, stimuli-response models and so on. These are explained using experimental data from a lab setting. For an example, how a mouse learns in a vessel of water to save its life is an interesting problem. The movements of mouse are codified and plotted and it is documented as a response to a problem situation. Later, the models developed were tested in a simulated computational model. This helps the researchers to understand the response in a problem situation for a mouse. The findings are further explained by the existing theories of neurology and psychology for better understanding. In another example, the computation involved in a physical activity namely, a person picking up a cup from a table in front of him/her is studied. In this exercise, first the eyes of the person look in to the object and the brain does a computation and the information is passed on to the hand. The brain measures the distance from the hand, the angle, and the other dimensions required for picking up the cup. First the hand tries to locate with an estimated space and tries to reach it at the nearest spot which has shortest difference as possible. The interesting thing in this example is, the amount of computations the brain does before one picks up the cup using the hand. This is further simulated in a computational setting. Performing this is a complex task. These kinds of computations are discussed in Computational Neurosciences. For such experiments one has to have a thorough understanding of subjects such as neurology, psychology, physics, and other theories which are useful to understand the phenomena. During the course itself the students from the different disciplines have raised concerns about the difficulty in understanding the subjects other than their own. The biology students especially felt it is very difficult to deal with too much of mathematics. On the other hand the computer science participants could not follow the concepts of Biology and neurology. They need to do more background readings to understand the concepts. For the students of biology and medicine, it is not sufficient for them to just read the materials on mathematics but need to understand the computations. Even the person with physics background felt the mathematics was a bit heavy to follow. In addition they were also finding it difficult to understand the biological concepts. Overall all were appreciative of the computational neuroscience. However, they were feeling that other discipline is trying to control their subject. They were all feeling that they were not able to own the multidisciplinary subject. Hence, the author attempted to explore more in to the problem. He has interacted with the students

informally and tried to understand the problems faced by them. He being a social scientist - neither from biology nor from computational sciences he was accepted by all. He was working with an Information Technology institution for seven years was convincing to computer scientists and physical scientists and working presently in a public health school was acceptable to the biology and medical students. This helped them to feel the author was able to empathize with them and they come forward to explain their problems. He further went ahead with sending a set of questions through which had close ended questions with an options open ended response. The finding was clear that all were having some problem in understanding or following the subject which is not their own. This leads to alienation among them. Some of them were optimistic to learn. Some were bugged by that. This led many to stop attending the topics which are not of their own discipline. It was evident when the software exercises which are of hands on made the biologists and medical students did not follow the steps while the physics, engineering and computational students were following it easily. Some of the extreme cases of mathematical derivations for some of the models made many biology and medical students go out of reach. This made them frustrated and where seriously thinking of whether this will at all help them their research. When some software which automatically does the modeling job for them made them feel happy. Some of the anatomical topics and the other physiological concepts made the computer scientists and physical scientists very difficult to follow. This requires them to go through the basics courses of anatomy and physiology.

The research field such as computational neuroscience gaining more importance in the current world necessitates the need for studying the dynamics of interaction among the members belong to different disciplines. The present paper is an attempt to study the dynamics of interaction among members using an informal qualitative method.

**The qualitative findings**

Computational Neuroscience course was attended by participants belongs to four major disciplines. In total there were 32 participants attended the course. Author first interacted with the participants informally and sent email to all participants with the following eight questions.

1. What is your opinion about computational neurosciences?

2. Which one of the discipline describes you best?

3. Which one of the topics in computational neurosciences was difficult to you?

4. Whether anytime you felt you are not comfortable or considered when a topic been discussed?

5. If yes, whic topic?

6. At any time did you feel the subject other than yours is trying to control the CNS?

7. If yes, which subject?

8. Please give your experience of being a member of a multidisciplinary group like this?

The responses were codified and a table is generated with the following. (Table 1).

**Table 1 CNS : The dynamics of multi-disciplinary group**

| **Discipline** | **Opinion on CNS** | **Difficult CNS Topic** | **The topic which is uncomfortable when discussed** | **Subject that controls CNS other than your discipline** |
|---|---|---|---|---|
| 1. Medical Sciences | It is a combination of all three – Biological, Mathematical and Medical sciences | Mathematical topics | Mathematics | Mathematics & Computer Science |
| 2. Computa-tional Sciences | Mathematical Science / All three sciences | Biological aspects | Biological topics / No | Biology & Medicine |
| 2a Computer programmer | Medical Science | Computational aspect | Physical science | Physics |
| 3. Biological sciences | Biological science | Mathematics | Mathematics | No |
| 4. Physical sciences | Mathematical science | Biological aspects | Biological topics | Computer science |

Refer Table 1. The participants of the Computational Neuroscience course conducted by our institute attended by four major disciplines namely Medical Sciences, computational sciences, biological sciences, and physical sciences. There was a member from a sub-discipline, Computer Programmer. This can be classified under computational sciences. All participants excepting the medical discipline, were feeling computational neuroscience is a discipline which does not belong to their own discipline. In response to the question, "Which one of the topics in

computational neuroscience is difficult to you?" Many mentioned the disciplines other than their own. The members of medical science felt mathematics was difficult, while members of computational sciences felt biology was difficult, while biological sciences members felt mathematics was difficult and physical scientists felt biology was difficult. This shows the difficulties of experts working in one discipline to work for a multidisciplinary science. The above feelings are not only stated as difficult but they have also felt they were not feeling uncomfortable while discussing the topic. The pattern of the response for the topics which were uncomfortable is similar to that of the earlier question.

Further, to a question on whether subject that controls computational neurosciences other than your discipline, all mentioned excepting the biological sciences members the discipline other than their own. The typical pattern emerged is, medical scientists felt the mathematics and computer science trying to control the computational neurosciences, while, computational scientists felt biology and medicine trying to control the Computational Neuroscience, while physical scientists felt computer science trying to control the Computational Neuroscience. The possible tension between the members of the multidisciplinary research needs attention. This is further fuelled by the hierarchy of disciplines which are many at times determined by the market forces.

The cause for tension among the disciplines may be due to the hierarchy among the scientific knowledge. Unlike the Comte's hierarchy of discipline, the present day hierarchy is determined based on the market forces. This phenomena needs to be studied in detail. This hierarchy of disciplines will have an effect on the future generation. When a student is deciding his or her career, these forces will influence them while selecting a discipline for study. For an example, in India, the professionals qualified in medical discipline were high in demand compared to non-medical disciplines in a medical college setting. Similarly, engineering science was valued more than other sciences in an engineering college setting. This may be the situation in computational neuroscience, where a computer scientist and neurologist will be more preferred to other disciplines of computational neuroscience. All these factors may lead to a conflict and imbalance in the development of such disciplines. This many at times adversely affect the development of multidisciplinary subjects in the developing country like India. The market forces driven hierarchy is a dangerous sign to many of the disciplines as they are purely derived based on the demand conditions. It is high time to derive a methodology to protect the growth of multidisciplinary research in Computational Neuroscience.

The situation created by the market has to be addressed very carefully. These forces make the life difficult for many aspirants who are from less valued disciplines but passionate to contribute significantly to the discipline. This many at times lead to exclusion of such active members from

some of the developments. This necessitates an indiscriminate approach to develop such disciplines. Other important thing which emerges from these is the power structure among such professionals in the higher up of the hierarchy makes others vulnerable. In a school setting in India, the teachers who were instructing the physical education and fine arts were always excluded from the main academic activities. They were assigned a fixed sessions for a routine course. These are never been graded and considered for promotion of the students. Similar situation is found in the Engineering institutions where the humanities are taught as a requirement to pass their engineering qualifications. On the other hand, the prospective employers of the engineering graduate students always praise training of the engineering students in humanities and social sciences stating "this education makes them a good human being and a successful manager". This is even true with the basic sciences which strengthen the fundamentals of the students. Thanks to globalization and the creation of thin layer of the geographical difference. The emergence of multidisciplinary research raises questions in the minds of the present day scientists about their future. In spite of globalization, the hierarchy and power structure of disciplines remained unchanged even after two decades in India.

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