Review of the Thesis
Perceptual Learning – Perceptual Changes in Learning New Categories
submitted by *Alexander Enchev Gerganov*
in partial fulfillment of the requirements for the degree of Ph.D. in Psychology at the
DEPARTMENT OF COGNITIVE SCIENCE AND PSYCHOLOGY, NEW BULGARIAN UNIVERSITY

The dissertation has the following structure: 55 pp. review of literature, 20 pp. description of the new model that is to be employed in the study, 30 pp. for the two pilot experiments, 20 pp. devoted to the results and discussion of the principal idea, 15 pp. for major achievements and contributions and includes about 125 referred publications.

The major goal of the thesis was stated as: "unification between psychophysical approach (oriented to perceptual constructs) and the cognitive science approach (mainly dealing with categorization of events)". Since perceptual learning hypothesize 2 options: either feedforward neural network, or recurrent Hebbian network producing activity-dependent synaptic modifications, the author proposes an alternative, third-way of research attitude, namely, multichannel reweighting. A sophisticated mathematical model serving this approach was created and tested beforehand.

This description of future research by itself presupposes a rather ambitious attempt to not only elucidate controversial empirical data published up to date, but also to reveal a very confident and self-assured young scientist, boldly daring onto convoluted theoretical concepts. Further on, we will see substantial support to his venture. The author possesses both deep knowledge of structural and physiological intricacies of the brain mechanisms and ability to construct his own models and to implement them in action. Undoubtedly, these gains are based on a profound dwell in scientific literature. The vast amount of publications reviewed encompasses a period of 65 years and, at the same time, involves very recent papers from the last two years. The theoretical model, in author's own words is "*to bring together the two fields – the cognitive science approach to understanding complex cognitive processes like categorization which are basic for humans and the psychophysical approach which attempts to systematically study the process of perceptual learning and map it to the corresponding brain structures*". In order to achieve the above goal, a classical categorization problem – forming visual categories based on characteristic elements - is studied through the prism of perceptual learning. The main questions this research tries to unravel are: 1) What are the underlying mechanisms which determine visual categorical learning; 2) Can these mechanisms and the resulting changes in performance be simulated with a physiologically plausible computational model; 3) What are the lowest-level learning structures, involved in visual categorical learning;

4) Can categorical learning of this type indeed be considered to involve perceptual learning; 5) How does the nature of the task interact with learning; 6) Are there explicit strategies during categorical learning of simple objects and what the interaction between these strategies and perceptual learning might be.

The position specificity (i.e., translation invariance) in the visual field of categorical perceptual learning was explored. It was found that the task was quite difficult for participants who did not know the categorization principle, that is, the characteristic elements. The subjects who succeeded in learning to categorize though, always knew explicitly about this principle and used it as a strategy.

The simple mechanism of competitive learning, reinforced by the horizontal Hebbian connections, was able to extract perceptual categories that are statistically present in the input space. This was in support of empirical findings that Gestalt principles of perceptual organization could be overruled by category learning. The model suggested how even certain Gestalt principles, like continuity, could be learned as a consequence of experience with an environment including visual patterned stimulation.

For the first time the paradigm of position transfer in explicit categorical learning of simple objects was incorporated. These experiments paved the first steps towards closing the gap between understanding of lower-level vision and higher-level cognitive functions like categorical learning, generalization and even concept formation.

The consistent partial position transfer effect brought strong support for a notion that certain processes, previously considered to be positioned only in the domain of perceptual learning, could be an important hidden part of many everyday cognitive tasks. Using the position transfer paradigm for other higher-level cognitive tasks could provide new insights in the study of perception and cognition.

All in all, higher-level cognitive tasks could, and should, be explored in the same way as low-level "sensory" tasks in the domain of perceptual learning. The new model of categorical perceptual learning claims that perceptual learning might be achieved by both reweighting and changes in representations (low-level as well as mid-level). The interplay between these processes was demonstrated computationally in a clear, falsifiable model.

The experiments conducted by the author demonstrated that categorical learning of simple visual objects tends to show the same basic effects (position specificity of learning), found in typical perceptual learning tasks. This provided strong evidence that perceptual learning is not a phenomenon found only in "sensory" or "implicit" tasks but rather is an important part in categorical learning as well.

An interesting fact that the author does not hesitate to declare, is that more than 50% of the experimental subjects recruited for the study were unable to correctly perform and thus successfully conclude the pivotal tests. This attracts attention to the intricate design of the model and its valuable characteristics serving the challenging problem. Further on, the aspirant takes into account possible pitfalls, occurred in the pilot experiments, and very skilfully changes the design for the decisive ensuing tests, thus guaranteeing the consistency of the new data and proceeding boldly to accomplish the goal, as stated in the beginning. Thus, new recruits for the experiment *proper* have achieved a stunning 90 % correct performance…

By the way of these lengthy explanations and formally not obligatory in-depth deliberations, I've tried to prove the very skillful and productive intertwine between author's ideas, previous knowledge of events and facts, and the final outcome of his own products. This guarantees that the basic – even overwhelming – requirements of a Ph dissertation are exhaustingly fulfilled.

I like very much the way contributions are presented:

Theoretical:

- Gestalt principles of perceptual organization can at times be overruled by category learning;
- perceptual learning is not akin only to *sensory* or *implicit* tasks, but is an important part in categorical learning as well;
- perceptual learning is achieved by both reweighting and changing representations (low-level as well as mid-level).

Methodological:

- novel promising model of competitive learning reinforced by lateral excitatory Hebbian connections;
- the paradigm of position transfer in explicit categorical learning of simple objects;
- higher cognitive tasks explored the same way as low-level "sensory" tasks in the domain of perceptual learning.

Empirical:

- some processes, previously considered only in the domain of perceptual learning, could be an important hidden part of many everyday cognitive tasks;
- tasks like categorical learning of simple objects open new possibilities to perceptual learning research like varying the implicit degree of task

and Practical:

- the simulator invented; as I understand, it is also available for future research to other people interested!

Three publications in international scientific media (proceedings, not journals) were presented in the course of the last 8 years with the aspirant's participation. It is noteworthy that they are cited 13 times altogether by other authors. The supplied combined list of papers/citations is to gain a high praise by itself: such an approach greatly facilitates the understanding and appreciation on the side of reviewers (e.g., there exists a continuity of citing in the course of the last 5 years and counting…). I am at some unease to point, however, that these publications are pinned far away 6 years ago.

Last, but not least, I should stress upon the fact that this dissertation is (finally, following a chain of others that I have had to heavily criticize) written in quite agreeable and passable English language. Obviously the young man possesses a good command over the language.

Like an invisible ghost of a benevolent fairy godfather, we feel the omnipresent shadow of the ONE TEACHER of several generation psychologists. He has touched in his memorable manner many possible frail points so that they may emerge as impeccable concepts or undisputed facts and findings. Here comes a chance for us all to pay a tribute to him…

The summarized short version of the thesis presents a true story of the immense amount of concepts, data and conclusions, in a skilful manner and with reassurance flair. By itself it might be used as a separate reading, serving both graduate students and high professionals. Still, I would have vied for a Bulgarian version of at least this part of the story.

Thus I publicly declare my staunch support towards a decision in favour of granting the Philosophical Degree *DOCTOR* in Psychology to Alexander Gerganov as an appreciation of his valuable and self-depending research. I am convinced that his participation in the scientific developments of the New Bulgarian University will contribute towards an even higher level of international acceptance.

Reviewer:

Sofia, 5 May, 2015

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