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FACE RECOGNITION BY MYOPIC BABY NEURAL NETWORKS

Dominique Valentin* & Hervé Abdi†
* Université de Bourgogne à Dijon † The University of Texas at Dallas

Do we need to assume that face recognition represents an innate ability to explain the fact that newborns are able to discriminate mother from stranger? Indeed if we consider that faces are highly similar, that newborns possess poor visual acuity and contrast sensitivity, and that they cannot resolve high spatial frequencies, this ability seems paradoxical. However, this paradox might come from the fact that we evaluate the complexity of the task performed by newborns through our adult experience. A less biased way of evaluating the complexity of a perceptual task is to simulate the task via an artificial neural network (Abdi, Valentin & Edelman, 1999; Abdi, Valentin, Edelman & O'Toole, 1995). The performance of such a model depends both on the learning algorithm implemented and on the number and perceptual characteristics of the stimuli on which the learning algorithm is applied. By manipulating these two factors, Valentin, Abdi, Edelman and Nijdam (1996) showed that the ability of newborns to recognize the faces of their caretakers is less paradoxical than it first seemed. In a series of simulations, they compared the ability of an autoassociative memory trained with two different learning algorithms: Hebbian vs. Widrow-Hoff.

The neural network task was to recognize an increasing number of faces presented in various perceptual conditions. The Hebbian and Widrow-Hoff learning algorithms vary in their level of complexity and, in their ability to process subtle information. Hebbian learning is an unsupervised learning algorithm based essentially on the processing of low spatial frequency information. On the other hand, Widrow-Hoff is supervised, and the small adjustments occurring during learning permit the processing of high spatial frequency information. As a consequence, the performance of these algorithms varies in opposite way when the number of encountered faces varies. When only a few faces are learned, a Hebbian trained

Correspondence should be addressed either to Hervé Abdi, School of Human Development, The University of Texas at Dallas, MS: GR4.1, Richardson, TX 75083–0688, email herve@utdallas.edu, http://.utdallas.edu/˜herve; or to Dominique Valentin. Université de Bourgogne, ESBANA, 1, Place Erasme, 21004 Dijon Cedex, France, email: Dominique.Valentin@u-bourgogne.fr.

memory can recognize the faces on which it has been trained. When the number of faces increases, the memory begins to suffer from interference, and so, begins to forget the faces it was previously able to recognize. On the contrary, the larger the number of faces, the more details are captured by the Widrow-Hoff algorithm, and the better the memory performance. Moreover, the two algorithms are differentially sensitive to perceptual information degradations. Whereas the performance of a Widrow-Hoff trained neural network is degraded by high frequency random noise and high spatial frequency filtering, theses two types of manipulations have no effect on Hebbian trained neural networks learning.

What these simulations demonstrates is that the complexity of a face recognition task and the nature of the information needed to perform this task depend on the number of faces involved. Discriminating among a small number of faces does not require a sophisticated learning mechanism nor does it require the existence of innate abilities. As an illustration, a very primitive algorithm, able to extract only low frequency information, can discriminate a face after a single exposure. The complexity of the task, however, increases with the number of encountered faces.

When the problem is to learn more than a few faces and discriminate them from other faces a more sophisticated algorithm able to "tune itself with increasing exposure to faces" is needed. This dual mechanism hypothesis is in agreement with Nelson's claims that "the mechanisms controlling face recognition may be different in the newborns than in older infants" and that "experience drives development." In addition, although the neural network framework cannot provide responses for all Nelson's unanswered questions, it might provide a tool for exploring some of the issues raised by these questions. For example, by manipulating the type of faces learned by the network, one might gain insight on the "kinds of experiences" necessary to perform different face processing tasks. Using this strategy, O'Toole, Abdi, Deffenbacher, and Bartlett (1991) demonstrated that an autoassociative memory trained with a majority of faces from a given race exhibits an "other race" effect similar to that displayed by human adults. Examination of the memory's inner workings showed that, during learning, the network had extracted a set of features that became more and more optimal for the set of faces which were learned, but less and less appropriate to discriminate between faces from another race.

References

[1] Abdi H., Valentin D., Edelman B., (1999). *Neural Networks.* Thousand Oaks (CA, USA): Sage Publications.

[2] Abdi H., Valentin D., Edelman B. & O'Toole, A.J. (1995). More about the difference between men and women: Evidence from linear networks and the principal component approach. *Perception*, **24**, 539–562.

[3] O'Toole A.J., Abdi H., Deffenbacher K. A. & Bartlett J. A. (1991) Simulating the "other race effect" as a problem in perceptual learning. *Connection Science Journal of Neural Computing, Artificial Intelligence, and Cognitive Research*, **3**, 163-178

[4] Valentin D., Abdi H., Edelman B. & Nidjam A. (1996). Connexionist "face-off": Different algorithms for different tasks. *Psychologica Belgica*, **36**, 65–92.