Computational Neuroscience Search
Department of Neuroscience
Brown University

April, 2012

To the members of the search committee,

Please regard this letter as a formal application for the position of Assistant Professor in Computational Neuroscience. Details of my work and experience can be found in the materials submitted along with this letter (curriculum vitae, research and teaching statements, copies of three articles) as well as in letters of recommendation from three faculty members (arriving under separate cover).

My research focuses on the study of visual object recognition through the coordinated use of neuroimaging and computational methods grounded in machine learning and computer vision. These lines of research were established as a graduate student at Brown University, developed during my postdoctoral training at Carnegie Mellon University and are currently pursued during my appointment as a research scientist with the Center for the Neural Basis of Cognition.

I hope that both my research and my teaching interests will help recommend my application. Letters of reference from Drs. Marlene Behrmann, Michael Tarr and David Plaut will complete this application. Should you have any questions or require additional materials, please feel free to contact me at anestor@andrew.cmu.edu.

Thank you for considering my application. I look forward to hearing from you.

Sincerely,

Adrian Nestor

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Adrian Nestor
Curriculum Vitae

Personal Information

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Nationality
Romanian (US permanent resident)

Academic History

Center for the Neural Basis of Cognition / Carnegie Mellon University, Pittsburgh, PA
- Research Scientist, 2012

Carnegie Mellon University, Pittsburgh, PA
- Postdoctoral Fellow, 2009 - 2011
Psychology Dept., labs of Prof. Marlene Behrmann and Prof. David Plaut

Brown University, Providence, RI
- Ph.D. in Cognitive Science, 2004 - 2009
Thesis: ***The Featural Code of Face Perception - Three Studies of Human and Automatic Visual Face Processing***
Committee: Prof. Michael Tarr, Prof. David Sheinberg, Assist. Prof. David Badre

New Bulgarian University, Sofia, Bulgaria
- M.Sc. in Cognitive Science, 2001-2003

University of Bucharest, Bucharest, Romania
- B.A. in Philosophy, May 1997-2000

Journal Publications

Published articles

Nestor, A., Vettel, J.M. & Tarr, M.J. (accepted) Internal representations for face detection – an application of noise-based reverse correlation to BOLD responses. ***Human Brain Mapping***.

Nestor, A., Plaut, D.C. & Behrmann, M. (2011) Unraveling the distributed neural code of facial identity through spatiotemporal pattern analysis. ***Proc Natl Acad Sci USA***, 108(24), 9998-10003.

Nestor, A., Vettel, J.M. & Tarr, M.J. (2008) Task-specific codes for face recognition: how they shape the neural representation of features for detection and individuation. ***PLoS ONE***, 3(12), e3978.

Nestor, A. & Tarr, M.J. (2008) Gender recognition of human faces using color. ***Psychological Science***, 19 (12), 1242-1246.

Nestor, A. & Tarr, M.J. (2008) The segmental structure of faces and its use in gender recognition. ***Journal of Vision***. 8(7), 1-12.

Nestor, A. & Kokinov, B. (2004) Toward active vision in the Dual cognitive architecture. ***International Journal of Information Theories and Applications***, 11(1), 9-15.

Articles under review

Nestor, A., Behrmann, M. & Plaut, D.C. (under review) The neural basis of visual word form processing – a multivariate investigation. ***Cerebral Cortex***

Manuscripts in preparation

Nestor, A., Plaut, D.C. & Behrmann, M. (in prep) Face space architectures: independent component analysis accounts for the structure of human face representations.

Vettel, J.M., Nestor, A., & Tarr, M.J. (in prep) Spatiotemporal interactions during multisensory integration of audiovisual events.

Other Publications

Nestor, A. (2011) Edge detection; Saccades. In *Encyclopedia of Clinical Neuropsychology* (eds. Jeffrey S. Kreutzer, John DeLuca & Bruce Caplan), Springer-Verlag, Heidelberg.

Nestor, A. & Andonova, E. (2004) Semantic effects in speech production. *Proceedings of the 26th Annual Conference of the Cognitive Science Society*, pp. 1011-1016.

Conference Talks and Posters

Nestor, A., Plaut, D. C., & Behrmann, M. (2012) A large-scale computational investigation of face space. Poster to be presented at the annual meeting of the Vision Sciences Society, Naples, FL.

Nestor, A., Behrmann, M. & Plaut, D. C. (2011) Orthographic form processing - a multivariate investigation of its neural basis. Presentation scheduled at the annual meeting of the Society for Neuroscience (SfN), Washington, DC.

Nestor, A., Plaut, D. C., & Behrmann, M. (2011) An investigation of the neural basis of face individuation through spatiotemporal pattern analysis. Presentation at the annual meeting of the Vision Sciences Society, Naples, FL.

Nestor, A., Plaut, D. C., & Behrmann, M. (2010) Face individuation: an information-based brain mapping study. Poster presented at the annual meeting of the Society for Neuroscience (SfN), San Diego, CA.

Nestor, A., Leeds, D.D., A., Vettel, J.M. & Tarr, M.J. (2010) Neurally-derived representations for face detection. Poster presented at the 5th workshop on Statistical Analysis of Neural Data (SAND), Pittsburgh, PA.

Vettel, J.M., Nestor, A., Bird, C.W., Heller, L.M., Curran T., & Tarr, M. J. (2010). Neural integration of audio-visual environmental events. Poster presented at the annual meeting of the Cognitive Neuroscience Society, Montreal, Canada.

Nestor, A., Vettel, J.M. & Tarr, M.J. (2009) Neurally-derived codes for face detection. Presentation at 19th workshop of the Perceptual Expertise Network (PEN), Pittsburgh, PA.

Vettel, J.M., Nestor, A., Bird, C.W., Heller, L.M., Curran T., & Tarr, M. J. (2009). Investigating the interplay of time and semantics during multimodal integration. Poster presented at the 10th International Multimodal Research Forum, New York, NY.

Nestor, A., Vettel, J.M. & Tarr, M.J. (2008) Task-specific feature codes for face processing. Presentation at the annual meeting of the Vision Sciences Society, Naples, FL.

Nestor, A. & Tarr, M.J. (2008) The featural structure of faces. Poster presented at the all-hands meeting of Temporal Dynamics of Learning Center, Nashville, TN.

Nestor, A. & Tarr, M.J. (2007) Recognition of faces by fragments. Presentation at 15th workshop of the Perceptual Expertise Network (PEN), Boston, MA.

Nestor, A. & Tarr, M.J. (2007) Compositional Structure in the Visual Representation of Objects. Presentation at the National Geospatial-Intelligence Agency (NGA) Academic Research Program Symposium (NARP), Washington, DC.

Nestor, A. & Tarr, M.J. (2006) Region-based representations of faces. Poster presented at the annual meeting of the Vision Sciences Society, Sarasota, FL.

Nestor, A. & Tarr, M.J. (2006) Recognition by segments. Presentation at 12th workshop of the Perceptual Expertise Network (PEN), Sarasota, FL.

Research Support

NSF (COGNEURO); PI: Adrian Nestor (Co-PIs: M. Behrmann & D.C. Plaut); pending
A large-scale neurocomputational investigation of human face encoding and recognition

NIH (R21); PIs: M. Behrmann & A. Nestor; pending
Neural plasticity and recovery of visual functions in patients with hemispherectomy

Honors, Awards, & Fellowships

Brown University Fellowship in Computational Cognitive Science (spring 2009)
Brown University

Institute for Pure and Applied Mathematics (UCLA) Travel Award (July 2008)
'Summer School: Mathematics in Brain Imaging'

Golden Greeble Award (July 2006)
Perceptual Expertise Network Travel Award

Brown University Fellowship (Sept 2004 – May 2005)

Graduate Student Fellowship (Sept 2002 – May 2003)
New Bulgarian University

Undergraduate Scholarship (Sept 1998 – May 2002)
University of Bucharest

Professional Service

Ad-hoc journal reviewer
NeuroImage; Cerebral Cortex; Journal of Experimental Psychology: General

Journal club organizer
Object recognition (Center for the Neural Basis of Cognition, 2009-2010)

Professional group and association memberships
Society for Neuroscience (SfN)
Vision Sciences Society (VSS)
Perceptual Expertise Network (PEN) / Temporal Dynamics of Learning Center (TDLC)

Teaching Experience

Sheridan Center Teaching Consultant
Brown University (2008-2009)

Sheridan Center training in teaching methods
Brown University (2006)

Teaching Assistant
Human Cognition (Spring 2006 & Spring 2008)
Quantitative Methods in Psychology (Fall 2005 & Fall 2007)

Research Statement

Adrian Nestor

The apparent ease with which we recognize objects belies the operation of a mechanism of remarkable complexity and versatility. Clarifying the representational and processing nature of this mechanism is one of the overarching goals of object recognition as a field. My research approaches this challenge through the convergent use of neuroimaging (fMRI), computational and neuropsychological investigations. Such a diverse approach is crucial when attempting to provide a comprehensive and coherent description of the mechanism subserving object recognition. The work summarized below examines a number of key issues in face and word form recognition as well as novel approaches to the development of neuroimaging methodologies.

Computational and behavioral research of face recognition

As a special case of object recognition (Serre, Oliva & Poggio, 2007; Ullman et al, 2002), face recognition is thought to rely on a multiple-level architecture supporting representations of increasing robustness and generality (e.g. Riesenhuber et al, 2004). Extensive work has been carried out to elucidate high-level processes involved in recognition (e.g. categorization). However, lower-level processes (e.g. facial feature segmentation) have received considerably less attention despite their foundational role within the recognition system. A significant goal of my research is shedding light on these lower-level processes and on their relationship with higher-level recognition. The three projects summarized below illustrate different attempts at pursuing this goal in the context of three different research paradigms.

Nestor and Tarr (2008a) measured and modeled human performance in a feature segmentation task. While the common notion of face structure seems intuitive enough (all faces have eyes, cheeks, mouths…), it is unclear how our visual system derives this structure and how it uses it for recognition purposes. Arguing that face segmentation is a particular case of natural image segmentation, Nestor and Tarr (2008a) asked subjects to freely parse face images into features (i.e. by drawing their boundaries) and accounted for their performance with the aid of an algorithm for surface-based image segmentation. Not only did this study quantify the consistency with which we segment faces into image components, but it also established the relative use of different cues (e.g. color and texture) in this process. Furthermore, it assessed and confirmed the utility of a segmentation-based structure for higher-level processing, specifically for gender categorization. In sum, this work represents an original and promising effort in the attempt to validate and quantify our intuitive notion of facial structure with the aid of computer vision algorithms.

An interesting aspect of feature segmentation relates to the color structure of human faces and its potential use in recognition. This idea was further explored in another study (Nestor & Tarr, 2008b) by means of image classification, an influential version of reverse correlation developed for neurophysiological and psychophysical investigations of visual perception. Specifically, image classification was applied in the color domain with the goal of deriving the structure associated with facial gender separately for each color channel. Again, this study employed a twofold approach by computing objective structures through image

analysis as well as their human counterparts (behavioral estimates of internal representations). One outstanding result of this study concerns a global difference in coloration between genders: Caucasian male faces tend to be redder than female faces (see press release). Such global differences along with more fine-grained featural ones may lack obviousness yet, as we show, can be used by our visual system to accomplish its recognition goals. Thus, in contrast to our previous work on segmentation, this study establishes a set of surprising non-intuitive face characteristics and demonstrates their contribution to face representations.

Finally, Nestor, Plaut & Behrmann (in prep) explore a different approach to uncovering facial structure and its underlying representation. This work represents a large-scale investigation of a multitude of standard algorithms for automatic face recognition and their ability to account for human performance at different stages of processing. Specifically, this work explores a powerful computational strategy implemented by means of high-throughput modeling. Its current results provide evidence for the plausibility of a face encoding architecture based on independent component analysis (ICA). More generally, our investigation supports the idea of statistical independence (e.g. implemented by ICA) as a general principle of visual representation in both low-level and high-level vision.

Neuroimaging research of face and word form perception

Face and word form perception are among the most popular and prolific fields of research in neuroscience. Yet most of this research is dedicated to large-scale differences (e.g. category selectivity) or qualitative distinctions (e.g. featural versus holistic processing). In contrast, my interests focus on fine-grained recognition (e.g. face individuation or identification) and on quantitative models of neural processing. Several examples of this line of research are summarized below.

Nestor, Vettel & Tarr (2008) assessed the neural correlates of face detection and individuation (i.e. identifying faces at the individual level). To this goal, the study employed, expanded and tested an influential architecture for object recognition based on image fragments (Ullman et al, 2002; Epshtein et al, 2008). First, the study showed that optimal face detection and individuation rely on largely different sets of features. Second, it established the sensitivity of our visual system to objective feature diagnosticity measured separately for detection and individuation. Third, it mapped the correlates of detection and individuation to different cortical areas and interpreted these results in the context of the architecture mentioned above. In sum, this study represents a clear example of the power of computational models to direct and expand current research on the neuroimaging of face perception.

A pair of recent studies (Nestor, Plaut & Behrmann, 2011; Nestor, Behrmann & Plaut, under review) confirmed and extended the work above on face individuation. Moreover, these studies examined an intriguing relationship between face and word form individuation suggested by previous neuroimaging and computational results (Hasson et al, 2002; Plaut & Behrmann, 2011). The first of these studies, recently published in PNAS (see also press release), mapped the neural correlates of face individuation using a variety of multivariate techniques such as pattern classification and multivariate feature selection. This work uncovered a network of cortical regions underlying face individuation, examined its functional / domain specificity and took first steps toward characterizing this network in terms of information-based connectivity (relying on multivariate analyses). The latter of these studies (Nestor, Behrmann & Plaut, under review) took on a similar enterprise with regard to

word form perception. Of note, this study tested a critical prediction of current theories of reading. Namely, it provided a direct demonstration that different word forms lead to distinct neural patterns within the left occipitotemporal cortex. Finally, both studies found support for the idea that face and word form perception share a common processing basis and explained this result in the context of a computational model of object perception (Plaut & Behrmann, 2011).

Development of new fMRI methodology

Neuroimaging represents a relatively young field of research. As such, it is critical to identify, understand and overcome its present limitations. Relevantly here, another line of research I currently pursue aims at developing and evaluating new fMRI methods for data analysis. These methods, grounded in powerful statistical and machine learning techniques, are meant to expand our standard toolbox of analyses and to facilitate new directions of research. Of note, these methods are tested in the context of face and word recognition, that is, domains that provide a wealth of empirical data suitable for establishing the validity and utility of new methodological approaches.

For instance, Nestor, Vettel & Tarr (accepted) extended, evaluated and explored the use of noise-based image classification in connection with fMRI data. Specifically, this study aimed at reconstructing basic templates for face detection out of white noise stimuli and the responses they elicited in classical face-selective regions. The main result of this reconstruction was a simple but robust image structure highly diagnostic for face detection. Thus, not only did this study establish the applicability of reverse correlation to BOLD data but it also revealed a privileged perceptual element accounting for the response profile characteristic of face-selective regions.

Another study (Nestor, Plaut & Behrmann, 2011) proposed a powerful method of spatiotemporal multivariate mapping by bringing together two novel techniques for data analysis: spatial 'searchligh' mapping (Kriegeskorte et al, 2007) and dynamic discrimination analysis (Mourão-Miranda et al, 2008). In addition, this study championed an information-based approach to functional connectivity meant to complement traditional activation-based approaches.

Neuropsychology of object recognition

Two ongoing projects illustrate a different direction of research aimed at extending and enriching my current work on object recognition.

The first of these projects examines perceptual processing in patients who have undergone a ***surgical hemispherectomy*** procedure at an early age. The amazing ability of the neural system to cope with the high demands of visual processing even when reduced to a single hemisphere provides a unique perspective on neural plasticity and cortical reorganization. This project is a collaboration with Drs. Christina Patterson at University of Pittsburgh School of Medicine and Marlene Behrmann at Carnegie Mellon University.

Finally, a second project aims at characterizing the distortion of the perceptual 'face space' in patients with ***congenital prosopagnosia***. This project relies on a battery of novel neuroimaging and behavioral techniques in order to gain a better understanding of this well-documented yet puzzling perceptual deficit.

Future directions

My work on object recognition is the sum of several research strands embracing different research methods, strategies and paradigms. However, the underlying focus on object recognition is common to all projects described above. In my new position as an Assistant Professor I would be happy to continue these lines of research but also explore new directions of theoretical and methodological interest.

First, the combination of real-time neurofeedback and multivariate analysis of neuroimaging data provides a promising approach to the development of new therapies in the treatment of a number of neural and cognitive disorders. As a concrete example, inducing higher levels of pattern discriminability in face perception could result in significant improvements of face recognition abilities in prosopagnosia and autism.

Second, the use of adaptive stimulus sampling (Lewi et al, 2009) in connection with real-time fMRI can facilitate a more targeted and effective investigation of perceptual codes and their neural implementation. For instance, this approach could speed up the search of high-dimensional representational spaces and the assessment of their neural plausibility.

Last, my current work supports the idea of general computational principles unifying low-level and high-level visual perception (e.g. the statistical independence of visual representations). However, a major challenge for future research consists in relating multiple levels of perceptual representation. Developing a unifying computational framework around such principles (e.g. through recursive / hierarchical ICA) could yield significant advancements in the neurocomputational study of visual perception.

To conclude, my work to date has a natural continuation into several related domains of theoretical and empirical research. The potential value and effectiveness of the research approaches outlined above warrant my commitment to these future directions and motivate my enthusiasm for future work.

Teaching Statement

Adrian Nestor

Undoubtedly, teaching represents one the most critical missions of an academic career and an essential component of research on the whole. As such, I have placed significant interest, attention and dedication on improving my teaching skills and on helping improve the same set of skills in my peers. The experience acquired as a teaching assistant, guest lecturer, trainee in teaching methods as well as teaching consultant served an important part in my graduate and post-graduate training.

Thus, during my graduate studies at Brown University I served as a teaching assistant for four semesters. The profile of the courses with which I was involved (***Quantitative Methods in Psychology*** and ***Human Cognition***) was beneficial in shaping a teaching approach to large-scale introductory-level material. The responsibilities associated with this position included (but were not limited to) guest lectures, hands-on workshops, helping students with course materials as well as guiding them in selecting and addressing research proposals.

As a guest lecturer, I designed and taught classes on ***Perception*** and ***Human Cognition***. I also organized and served as a lead instructor for workshops on the basics of programming and statistical analysis (***Matlab***). This experience has been invaluable to me in that it required me to handle different types of teaching goals and materials (i.e. theoretical issues as well as concrete practical skills).

To further develop and personalize an effective teaching style, I attended a seminar on teaching methods hosted by the Sheridan Center for Teaching and Learning at Brown University. Upon completion, I volunteered to serve as a teaching consultant for the same center. In this position, I provided advice and feedback to fellow graduate students on their teaching approach and performance. This provided me with a unique opportunity to think critically about the goals and attributes of successful teaching as well as to broaden my perspective on a variety of teaching styles related to different topics, settings and types of audience.

Thus, my broad research interests along with my training provide me with the background to teach any of several introductory-level courses (***Cognitive Psychology***, ***Perception***, ***Research Methods and Experimental Design***, ***Quantitative Methods in Psychology***, ***Introduction to Neuroimaging***…) as well as more advanced courses in my specific research areas (***Object recognition***, ***fMRI methods***).

My experience so far reflects the significant interest and enthusiasm I bring to a teaching mission. My overarching goals as an instructor are to promote an understanding of scientific research as well as to cultivate critical thinking and communication skills, qualities essential within and outside an academic setting. Moreover, it is my hope that I can instill in my students the same excitement and curiosity about scientific research that motivates my own work. Last but not least, I look forward to teaching as a unique opportunity for intellectual exchanges and for intellectual development.