Temporal Dynamics of Learning Center

Research Highlights

2016

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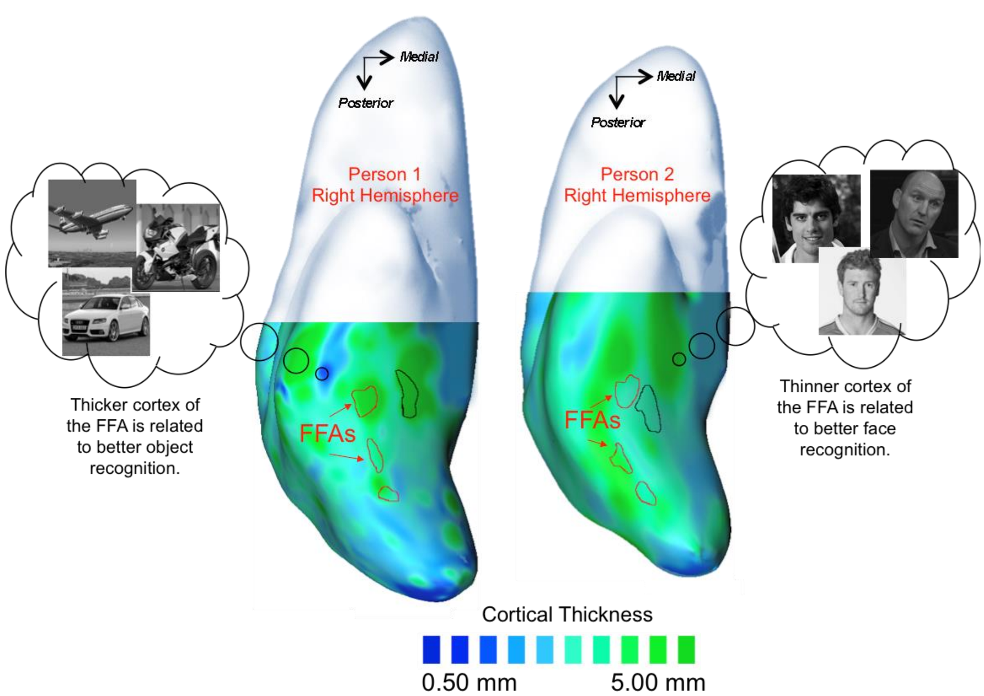
Thickness of Cortical Grey Matter Predicts Face and Object Recognition

Outcome: Sophisticated techniques allowed for segmentation of human grey matter and estimates of regional cortical thickness. Individual differences in the cortical thickness of pea-sized regions in the inferior temporal could be predicted by behavioral recognition performance on faces and objects. While subjects with a thicker cortex performed better with vehicles, those with a thinner cortex performed better with faces and living objects.

Impact/benefits: The fusiform face area (FFA) is a brain region defined by its selectivity for faces. Several studies have shown that the response of FFA to non-face objects can predict behavioral performance for these objects. However, one possible account is that experts pay more attention to objects in their domain of expertise, driving signals up. By considering brain structure rather than function, we show an effect of expertise with non-face objects in FFA that cannot be explained by differential attention to objects of expertise.

Explanation: Regional cortical thickness estimates corresponded to face-selective regions in a group of 27 men who evidenced functional expertise effects for cars in FFA. Cortical thickness was measured from high-resolution structural images, calculating the distance between the white/grey matter boundary and the grey matter/cerebral spinal fluid boundary. Right hemisphere FFA was thicker for individuals with high performance on non-living categories (vehicles). In contrast, right hemisphere FFA was thinner for individuals with high performance on faces. The results point to a domain-general role of FFA in object perception and reveal an interesting double dissociation that does not contrast faces and objects, but rather living and non-living objects.



McGugin, R.W., Van Gulick, A.E. & Gauthier, I. (2015). Cortical thickness in fusiform face area predicts face and object recognition performance. *J Cogn Neurosci.* 1-13.

Understanding the neural code that supports the individuation of similar faces

Outcome: Researchers from Carnegie Mellon University have shown that it is possible to reconstruct a novel face image based on the observer's behavioral or neural response to a very large set of homogeneous faces (Nestor, A., Plaut, D. C. and Behrmann, M.). From a practical perspective, these findings make possible a broad range of image-reconstruction applications via a straightforward methodological approach and, from a theoretical perspective, the current results provide key insights into the nature of high-level visual representations.

Impact/benefits: The present work establishes a novel approach to the study of visual representations. This approach allows researchers to estimate the structure of human face space as encoded by high-level visual cortex, to extract image-based facial features from this structure and to use such features for the purpose of facial image reconstruction. The derivation of visual features from empirical data provides an important step in elucidating the nature and the specific content of face representations. Further, the integrative character of this work sheds new light on the existing concept of face space by rendering it instrumental in image reconstruction. Last, the robustness and generality of the reconstruction approach is established by its ability to handle both neuroimaging and psychophysical data.

Background: The reconstruction of images from neural data can provide a unique window into the content of human perceptual representations. While recent efforts have established the viability of this enterprise using functional magnetic resonance imaging (fMRI) patterns, these efforts have relied on a variety of prespecified image features. Here, we take on the twofold task of deriving features directly from empirical data and of using these features for facial image reconstruction. First, we use a version of reverse correlation to derive visual features from fMRI patterns elicited by a large set of homogeneous face exemplars. Then, we combine these features to reconstruct novel face images from the corresponding neural patterns. This novel approach allows us to estimate collections of facial features associated with different cortical areas as well as to achieve significant levels of reconstruction accuracy. Furthermore, we establish the robustness and the utility of this approach by reconstructing face images from patterns of behavioral data.

Participants viewed a set of 120 face images (60 identities x 2 expressions), carefully controlled with respect to both high-level and low-level image properties. Each image was presented at least 10 times per participant across 5 fMRI sessions using a slow event-related design and participants performed a one-back identity task across variation in expression. Cortical areas that exhibited separable patterns of activation to different facial identities were first demarcated. Then confusability matrices from behavioral and neural data in these areas to determine the general organization of face space were constructed and visual features accounting for this structure were extracted by means of a procedure akin to reverse correlation. Last, the very same features were used for the purpose of face reconstruction.

The results revealed that: (i) a range of facial properties such as eyebrow salience and skin tone govern face encoding; (ii) the broad organization of behavioral face space reflects that of its neural homologue, and (iii) high-level face representations retain sufficient detail to support reconstructing the visual appearance of different facial identities from either neural or behavioral data.

Nestor, A., Plaut, D. C. and Behrmann, M. Feature-based face representations and image reconstruction from behavioral and neural data. Proc Nat Acad Sci, in press.

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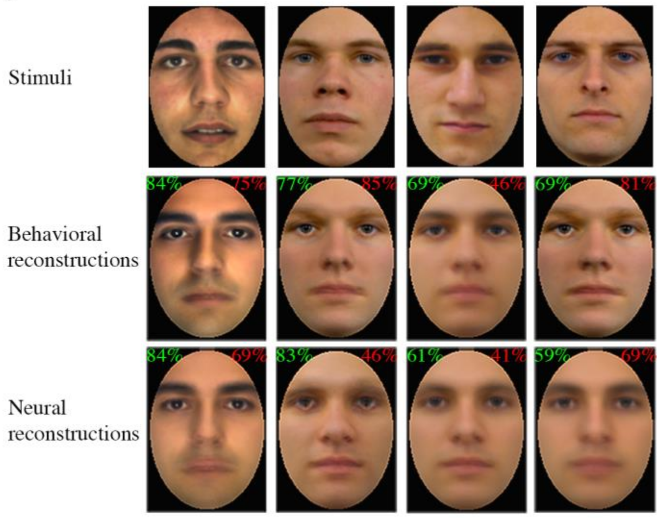
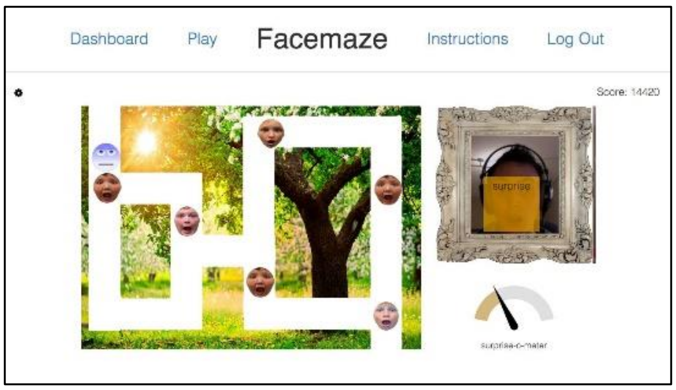


Legend: Examples of face stimuli and their reconstructions from behavioral and fMRI data for neutral facial expressions. Numbers in the top corners of each reconstruction show its average experimentally-based accuracy (green, left corner) along with its image-based accuracy (red, right corner).

Training Facial Expressions in Autism

Outcome: Individuals with Autism Spectrum Disorder (ASD) learn to produce accurate facial expressions and remediate expression skills by playing FaceMaze-- a fun, gamified expression training platform utilizing real faces and Emotient's real-time facial expression recognition feedback. After FaceMaze training, preliminary analysis shows that participant improve in their abilities to perceive and produce facial emotions.

Impact/Benefits: As a web-based training platform, FaceMaze makes expression training mobile, accessible, and affordable for families and individuals with ASD. Emotient's state-of-the-art expression recognition technology is combined with the best in empirically-based game design strategies to create a powerful and engaging facial expression training tool.



Explanation: Impairments in social communication and interaction experienced by individuals with ASD is augmented by production of disorganized and ambiguous facial expressions that fail to accurately communicate feelings. In a pacman-style format, FaceMaze trains expression production skills with instant corrective feedback. The child overcomes the face blockers in their path by mimicking their expressions and receiving feedback in the emotion mirror. Preliminary analysis of pre- and post-FaceMaze measures show improvements in perception of dynamic expressions. Analysis of expression production quality is hypothesized to show significant improvements after training, as seen in related literature. Improvements in facial expression quality results in better communication of emotions, further social successes, and improved interpersonal relationships.

TDLC Researchers Advocate for Science of Learning in Washington DC (2015-16)

Outcome:
In June and September 2015, Temporal Dynamics of Learning Center (TDLC) scientists and trainees met with various elected officials and federal agency leadership to advocate for support for Science of Learning research, training, translation and Science, Technology, Engineering and Math (STEM) education and diversity initiatives.

Impact/benefit:
As the Science of Learning Centers (SLC) program sunsets in 2016, we want to encourage elected officials, Congressional committee members, and agency leadership to continue support for this type of research, training and translation programming in the future. The National Science Foundation's initial investment in this group of researchers and students/trainees has grown beyond expectation, has yielded tremendous scientific breakthroughs and benefits, and it is important to continue and build upon this success! In addition, the outcomes of the initial research are changing the way we think about education, and have led to several international collaborations as other countries begin to set up their own science of learning centers based on the U.S. model. Members of Congress are much more likely to support research, training and translation programs and initiatives if they understand how it benefits people, communities, and the economy.

Background/explanation:
In June 24, 2015, TDLC Co-Director Andrea Chiba and Project Scientist Alex Khalil traveled to Washington, D.C. to lead a Congressional Briefing on the Science of Learning, along with representatives from the five other Science of Learning Centers (SLCs) (View invite). Following that visit, TDLC received a visit from Congressional Staff on Sept. 2, 2015. Four members of Congressional Staff and a member of the National Science Foundation (NSF) toured various NSF-funded projects at UC San Diego. Drs. Chiba, Cottrell, Sejnowski, Poizner, Bartlett, Tallal, Forster, Khalil, Minces, and Snider participated in their tour of TDLC (click here for agenda). Other Science of Learning Directors Patricia Kuhl (University of Washington), Nora Newcombe (Temple University) and Barbara Shinn-Cunningham (Boston University) also presented results from their research in order to raise awareness of the importance of SLC work.

Due to the visit in September, Dr. Paula Tallal was invited to testify before the Committee on Science, Space and Technology for the U.S. House of Representatives on H.R. Bill 3033, the READ Act. In her oral and written reports, she highlighted the Science of Learning Centers (SLCs), specifically suggesting that NSF develop mechanisms to capitalize on the advances from the SLCs. (Video of testimony, Dr. Tallal begins at 1 hr 32 min mark).