Temporal Dynamics of Learning Center

Research Highlights
2014-2015

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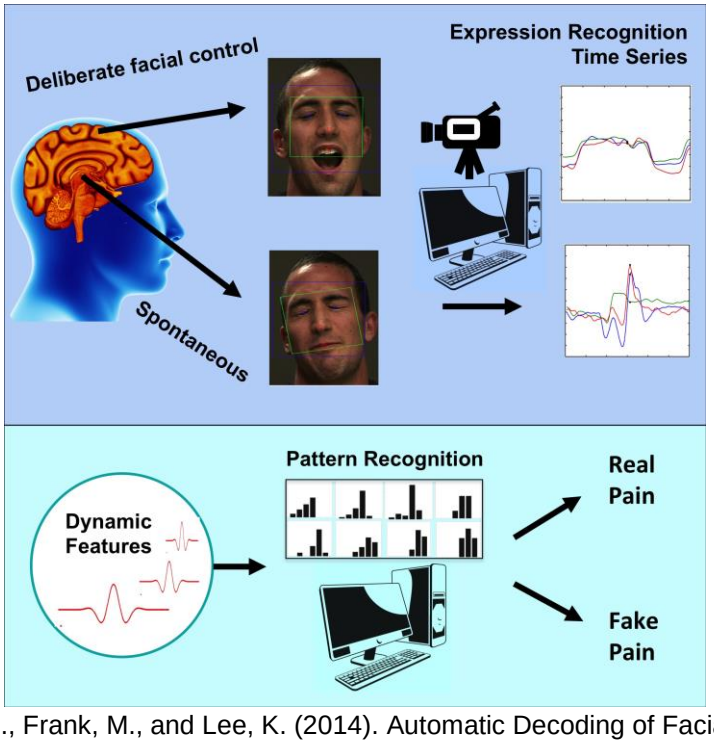
Using Automated Facial Expression Recognition Technology to Distinguish Between Cortical and Subcortical Facial Motor Control

Outcome: Researchers at UC San Diego, University at Buffalo, and University of Toronto have developed a computer vision system that distinguishes faked from genuine facial expressions of pain. The system outperformed human observers, who had at most a 55 percent success rate, even with training, whereas a computer vision and pattern recognition system was accurate about 85 percent of the time.

Impact/Benefits: This finding demonstrates that genuine and posed facial expressions can be distinguished from their dynamic signatures. Thus, it is possible to distinguish two different types of neural control of the face: A cortical system that controls deliberate facial movements, and a subcortical system that controls spontaneous facial movements.

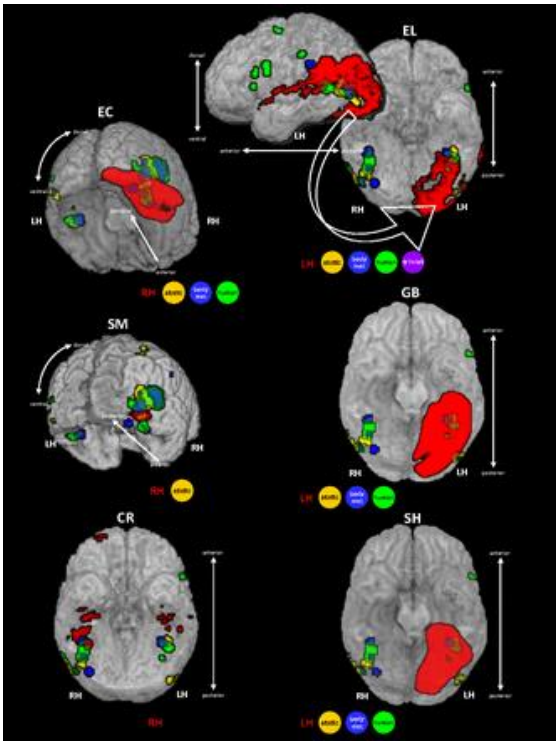
Background/Explanation: In highly social species such as humans, faces have evolved to convey rich information for social interaction, including expressions of emotions and pain. Two pathways in the brain control facial movement. One pathway originates in the cortex and controls deliberate facial expressions. Another pathway originates in deeper, subcortical areas and drives spontaneous facial expressions of felt emotions. The cortical system enables humans to simulate facial expressions of emotions not actually experienced. Their simulation is so successful that they can deceive most observers. Machine vision may, however, be able to distinguish deceptive from genuine facial signals by identifying the subtle differences between cortically and subcortically driven movements. Here, we show that human observers could not discriminate real from faked expressions of pain better than chance, and after training, improved accuracy to a modest 55%. However a computer vision system that automatically measures facial movements and performs pattern recognition on those movements attained 85% accuracy. The machine system's superiority is attributable to its ability to differentiate the dynamics of genuine from faked expressions. Thus, by revealing the dynamics of facial action through machine vision systems, this approach has the potential to elucidate behavioral fingerprints of neural control systems involved in emotional signaling.



Bartlett, M., Littlewort, G., Frank, M., and Lee, K. (2014). Automatic Decoding of Facial Movements Reveals Deceptive Pain Expressions. Current Biology. 2014 Mar 31;24(7):738-743. doi: 10.1016/j.cub.2014.02.009.
DOI: http://dx.doi.org/10.1016/j.cub.2014.02.009. Epub 2014 Mar 20. Link to article

Brain Research Shows Different Pathways Are Responsible for Person and Movement Recognition

Outcome:
Researchers from University College London (UCL), Carnegie Mellon University, and UC San Diego have found that the ability to understand different movements, such as walking and jumping, engages different brain mechanisms from those that are used to recognize who is initiating the action (Gilaie-Dotan, S., Saygin, A.P., Lorenzi, L.J., Rees,G. and Behrmann, M). In the study, individuals with lesions to the ventral aspects of the visual pathway evinced normal biological motion perception despite their marked impairments in form perception.



Impact/Benefits:
The analysis revealed that the ventral aspects of the form pathway (e.g. fusiform regions, ventral extrastriate body area) are not critical for biological motion perception. These counterintuitive findings indicate that biological motion can be perceived and processed normally even when the ability to perceive the form or the actor executing the movements is impaired. The study illustrates for the first time how individuals with prosopagnosia, or face blindness, are still able to recognize other people's movements. The investigators hypothesize that the role of these ventral regions is to provide enhanced multiview/posture representations of the moving person rather than to represent biological motion perception per se.

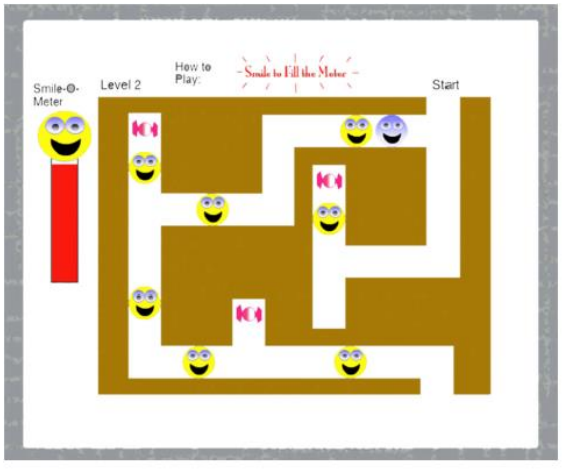
Background/Explanation:
Identifying the movements of those around us is fundamental for many daily activities, such as recognizing actions, detecting predators, and interacting with others socially. A key question concerns the neurobiological substrates underlying biological motion perception. Although the ventral “form” visual cortex is standardly activated by biologically moving stimuli, whether these activations are functionally critical for biological motion perception or are epiphenomenal remains unknown. To address this question, the researchers examined whether focal damage to regions of the ventral visual cortex, resulting in significant deficits in form perception, adversely affects biological motion perception.

Six patients with damage to the ventral cortex were tested with sensitive point-light display paradigms. All patients were able to recognize unmasked point-light displays and their perceptual thresholds were not significantly different from those of three different control groups, one of which comprised brain-damaged patients with spared ventral cortex (n > 50). Importantly, these six patients performed significantly better than patients with damage to regions critical for biological motion perception. To assess the necessary contribution of different regions in the ventral pathway to biological motion perception, the researchers complement the behavioral findings with a fine-grained comparison between the lesion location and extent (see Figure), and the cortical regions standardly implicated in biological motion processing. This analysis revealed that the ventral aspects of the form pathway (e.g. fusiform regions, ventral extrastriate body area) are not critical for biological motion perception.

Gilaie-Dotan, S., Saygin, A.P., Lorenzi, L.J., Rees,G. and Behrmann, M. (2014). Ventral aspect of the visual form pathway is not critical for the perception of biological motion. Proceedings of the National Academy of Sciences (PNAS); 112(4). E361-E370, doi: 10.1073/pnas.1414974112. Link to article

Teaching Emotional Skills to Children with Autism

Outcome: TDLC's Jim Tanaka at the University of Victoria is partnering with Marni Bartlett at the University of Victoria to create an exciting, innovative software game to help children with autism spectrum with their facial emotions using a state-of-the-art computer technology, Emotient Analytics. Emotient Analytics is a revolutionary web-based platform that evaluates facial expressions in real time via webcam input. Using this state-of-the-art technology program, we designed the FaceMaze, a fun interactive game where the player navigates a pacman-like icon through a maze, collecting candy points. Blocking the player's path are gremlins that can only be removed by producing the proper facial expression (happy, sad, angry, surprise). The player's expression is recorded and evaluated in real time by the Emotient Analytics software. In a to-be-published study, we found that playing the FaceMaze game for fifteen minutes was sufficient to significantly improve the abilities of children with autism to produce happy and angry expressions, as judged by naïve observers.



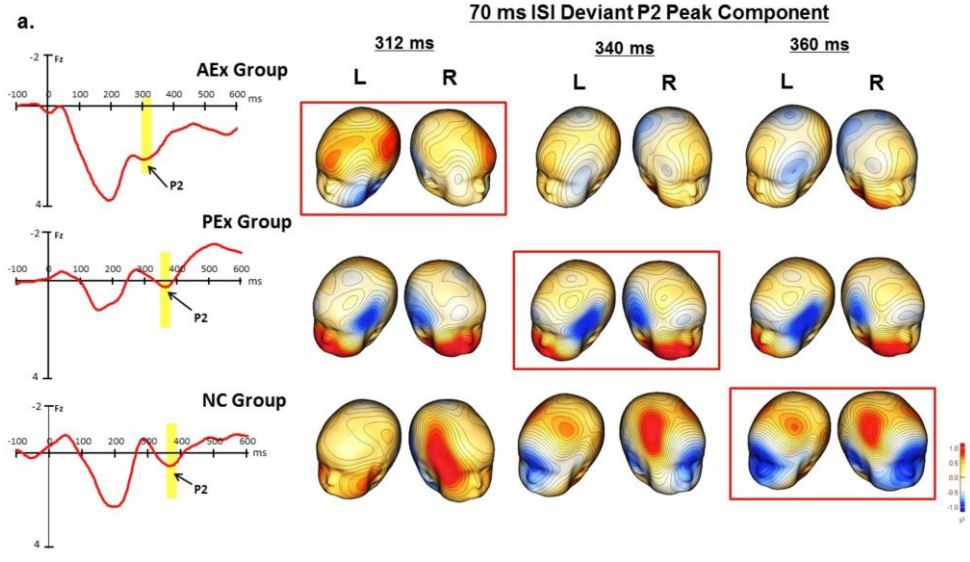
Impact/Benefits: FaceMaze is an innovative intervention game that addresses impaired social communication, a core symptom of autism. Individuals with autism show profound deficits in their ability to produce and interpret facial emotions. Children with autism have a tendency to produce facial expressions that are either affectively flat or difficult to interpret. Because faces are a primary source of human interaction, the inability to produce facial emotions has adverse consequences for developing good social communication skills. The goal of FaceMaze is to create an intervention treatment that is both fun and effective. The potential impact and benefits of the FaceMaze program are significant. By providing a science- and evidence-based intervention that is engaging, accessible and cost-free, we hope to improve the everyday social lives of children with autism and their families.

Background/Explanation: Children with autism spectrum disorder (ASD) show deficits in their ability to produce facial expressions. In this study, a group of children with ASD and IQ-matched, typically developing (TD) children were trained to produce ‘‘happy’’ and ‘‘angry’’ expressions with the FaceMaze computer game. FaceMaze uses an automated computer recognition system that analyzes the child's facial expression in real time. Before and after playing the Angry and Happy versions of FaceMaze, children posed ‘‘happy’’ and ‘‘angry’’ expressions. Naive raters judged the post-FaceMaze ‘‘happy’’ and ‘‘angry’’ expressions of the ASD group as higher in quality than their pre-FaceMaze productions. Moreover, the post-game expressions of the ASD group were rated as equal in quality as the expressions of the TD group. FaceMaze is a promising, cost-effective training program in facial expression production that is engaging for the child and that can be conducted in a safe, familiar setting.

Gordon, I., Pierce, M. S. & Tanaka, J.W. (in press). Training voluntary facial expressions using automated, real-time feedback. Journal of Autism and Developmental Disorder.

Plasticity in Developing Brain: Active Auditory Exposure Impacts Prelinguistic Acoustic Mapping

Outcome: Researchers at the Infancy Studies Laboratory at the Center for Molecular and Behavioral Neuroscience, using a series of 8-10 minute experimental sessions with babies ages four to seven months, discovered a way to help them organize the brain pathways that will help them perceive language. In the study, Dr. April Benasich and team demonstrate that active exposure during early infancy to nonspeech stimuli containing linguistically relevant acoustic cues appears to confer a significant acoustic processing advantage when compared with passive exposure or maturation alone. Specifically, such experience appears to facilitate neural plasticity and more efficient sensory processing during the developmental period when infants are constructing their sensory maps.



Impact/Benefits: The promise of selectively “fine-tuning” acoustic mapping as it emerges has far-reaching implications for the amelioration and/or prevention of developmental language disorders. Further exploration of experience-dependent neural mechanisms underlying acoustic mapping will provide the opportunity to identify and characterize the earliest precursors and biological markers of normative and disordered language processing.

Background/Explanation: A major task across infancy is the creation and tuning of the acoustic maps that allow efficient native language processing. This process crucially depends on ongoing neural plasticity and keen sensitivity to environmental cues. Young babies are constantly scanning the environment to identify sounds that 'might' be language. Between 4 and 7 months of age, infants are setting up their pre-linguistic acoustic maps. In this study, babies’ brains were gently guided to focus on the sensory inputs that are most meaningful to the formation of these critical maps. For the 8 to 15 percent of infants at highest risk for poor auditory processing and subsequent language disorders, this baby-friendly behavioral intervention could have far-reaching implications and may offer the promise of improving or perhaps preventing language difficulties.

Benasich, A.A., Choudhury, N.A., Realpe-Bonilla, T., & Roesler, C. (2014). Plasticity in Developing Brain: Active Auditory Exposure Impacts Prelinguistic Acoustic Mapping. The Journal of Neuroscience; Oct. 1, 2014; 34(40):13349-13363.

TDLC's First MOOC Yields a Staggering Number of Students on Coursera!

Outcome: TDLC's Dr. Terry Sejnowski and Visiting Scholar Dr. Barbara Oakley have put together a Massive Online Open Course (MOOC) for Coursera on "Learning How to Learn: Powerful mental tools to help you master tough subjects." TDLC's first venture into the MOOC arena with Coursera generated tremendous worldwide interest; when the MOOC launched in August 2014, 197,000 “learners” from over 206 different countries joined the month-long course. Due to its success, this MOOC was offered again in October 2014 with over 125,000 learners. According to Class Central, "Learning How to Learn" is currently the most popular MOOC of all 253 MOOCs from major universities around the world.

Impact/Benefits: The course has broad appeal by offering strategies to help improve the way anyone learns, as the course summary describes: “Whether you are an outstanding or a struggling student, ‘Learning How to Learn’ will give you powerful mental tools that will help you learn more effectively in tough-to-master subjects. You will discover practical, immediately useful insights that will help you to more deeply master your studies.”

Although “Learning How To Learn” is immensely popular, the MOOC has the potential to reach an even broader audience. On problem, Dr. Sejnowski shares, is that they are still not reaching high school and college students. Only 3% of those who attended were under age 20, and the largest demographic is in the 25 – 34 age group. These are professionals who want to learn new skills to compete in the marketplace. 75% have a bachelor's degree or higher. Dr. Sejnowski hopes to incorporate additional strategies to reach high school and college students in the future. He, like Dr. Oakley, realizes that this popular course – and others like it – have the potential to have a significant and transformative educational impact.

Background/Explanation: The idea for the MOOC germinated after a brainstorming session between Dr. Terry Sejnowski, TDLC Co-Director and Head of the Computational Neurobiology Lab at The Salk Institute, and Dr. Barbara Oakley, Author and Associate Professor in the School of Engineering and Computer Science at the University of Oakland. In March 2013, Barbara Oakley gave a presentation at a TDLC-sponsored event celebrating Brain Awareness Week (BAW). In her Webinar, “How to Learn More Deeply and Creatively: Concrete Tools from Neuroscience and from Zombies,” she captivated her audience with a discussion of the brain and different ways of thinking about thinking. Using the latest research about how the brain works, she shared strategies on how to learn optimally, improve test-taking, combat procrastination, and better retain information. It was clear that Dr. Oakley had key ingredients for a great MOOC, and TDLC possessed in depth research on learning and the brain. Thus was born the idea for a MOOC that addressed “Learning How to Learn.” Dr. Jeffrey Elman, who organizes MOOCs at UC San Diego, was of great help in the launch with Coursera. The work that went into creating “Learning How to Learn” is now paying dividends.

- Link to Learning How to Learn on Coursera

A New Test for Individual Differences Research in Face Recognition

Outcome:
Researchers in the NSF-sponsored Temporal Dynamics of Learning Center have developed a new task for measuring individual differences in holistic face processing, The Vanderbilt Holistic Face Processing Test (VHPT-F). Holistic processing measured in this new test correlates with the standard measure of holistic processing, but shows better psychometric properties (e.g., better internal consistency and test-retest reliability), providing a useful tool for studying face recognition and individual differences in high-level vision.

Impact/Benefits:
Holistic processing is a key behavioral signature of expert face perception. In the standard task used to measure holistic processing, participants are instructed to attend to one face half (e.g., top), while ignoring the other face half (e.g., bottom), but are unable to do so; the to-be-ignored half interferes with performance because faces are processed as wholes. While the standard task performs very well in group studies, it has poor psychometric properties for measuring individual differences. The VHPT-F is freely available (http://gauthier.psy.vanderbilt.edu/resources) to facilitate work on individual differences in high-level vision, and can easily be adapted for use with clinical populations.

Background/Explanation:
Tasks used in group studies are designed to achieve an optimal level of difficulty, usually to avoid floor and ceiling performance levels. To create a more reliable measure better suited for individual differences work, VHPT-F trials vary in difficulty, and in the extent to which they should tap into holistic processing, allowing more precise measurement of holistic processing across the full continuum of ability. For example, trials where the target part is a very small part of the face (e.g., eyes only) should be processed holistically by most subjects except those with the least holistic tendencies; trials where the target part is a very large part of the face (e.g., top 2/3) should not be processed holistically except by those with the most holistic tendencies.

Examples of parts participants are asked to selectively attend on the VHPT-F (on the real test trials use unfamiliar faces).

Richler, J.J., Floyd, R.J., & Gauthier, I. (2014). The Vanderbilt Holistic Face Processing Test: A short and reliable measure of holistic face processing. *Journal of Vision, 14,* 1-14.

Wang, C.-C., Ross, D.A., & Gauthier, I., & Richler, J.J. (in preparation). Validation of the Vanderbilt Holistic Face Processing Test.

TDLC Researchers Advocate for Science of Learning in Washington DC (2014)

Outcome:

During the week of Society for Neuroscience Annual Meeting in Washington DC this past November, 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/Benefits:

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 to build upon this success! 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. TDLC follow up advocacy includes spring 2015 meetings in Washington DC and an educational letter writing campaign.

Background/explanation:

Center Directors Dr. Garrison Cottrell, Dr. Andrea Chiba and Dr. Terry Sejnowski, Research Experience for Undergraduates (REU) Site Program Trainee Sarah Saturday, TDLC DOT Programs Manager Carmela Arstill and TDLC Executive Director Kim Hutson de Belle met with the White House Office of Science and Technology Policy's Dr. Philip Rubin (SBE Assistant Director) and Dr. Monaco Basco (Neuroscience, Mental Health and Broadening Participation Assistant Director); with various elected officials and their staffers who have oversight on science and education committees including Rep. Scott Peters (CA-D), Rep. Chaka Fattah (PA-D), Rep. Dan Lipinski (IL-D) Sen. Feinstein (CA-D), and Sen. Boxer (CA-D); with the Congressional STEM Education Caucus staff; and with US Dept. of Education/National Center for Education Research/IES Associate Research Scientists Dr. Christina Chhin, Erin Higgins, and Robert Ochsendorf. Special thanks to the amazing UC Washington Center (UCDC) staff – Marjorie Duske (Director of Science and Technology), Christopher Carter (Legislative Director) and Shoshana Derrow (Director of Health and Clinical Affairs).

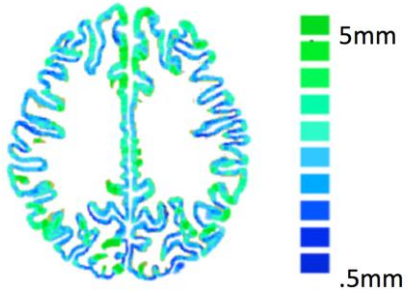
TDLC Advocacy Documents

- TDLC Brochure
- TDLC Poster
- Research & Training
- Student Recruiting
- Diversity, Outreach and Translation

Cortical thickness in Fusiform Face Area predicts Face and Object Recognition Performance

Outcome:

New research from a team of researchers at Vanderbilt University, part of the Temporal Dynamics Learning Center supported by NSF, used functional magnetic resonance imaging (fMRI) to study the structural correlates of face and object recognition ability. Prior work had shown that perceptual experts, such as car aficionados, have more activity in their visual system when they look at objects in their expert category.



The new work reveals that experts also have thicker gray matter in a critical part of the brain that is called the fusiform face area (FFA) and is known to be important for face recognition. A surprising finding of this work is that while people with a thicker FFA performed better with vehicles, it was those with a thinner FFA who performed better with faces and living objects.

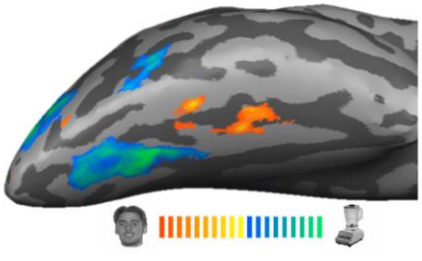


Fig. 2. Inflated part of the right hemisphere showing face- and object-selective clusters in warm colors. Thickness estimates from the cortical grey matter of these clusters was measured in this work.

Impact/Benefits:

This research offers important insights into the role of the FFA in visual perception and visual memory. Together with prior functional effects in FFA, the findings demonstrate that this region is important beyond faces, for non-face object processing. This structural effect of expertise has an interesting advantage over the more standard functional expertise effects: it could lead to a relatively faster accumulation of evidence across different labs, because a relatively quick behavioral test to measure object recognition ability can be easily administered, after the fact, to subjects who participated in any fMRI study that localized the FFA (*see McGugin, R.W., Richler, J.J., Herzmann, G., Speegle, M. & Gauthier, I. 2012. The Vanderbilt Expertise Test Reveals Domain-General and Domain-Specific Sex Effects in Object Recognition. Vision Research, 69:10-22)*.

Background/Explanation:

The FFA is 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 explanation of such results is that experts pay more attention to objects in their domain of expertise, driving signals up. The new work shows an effect of expertise with non-face objects in FFA that cannot be explained by differential attention. The team measured cortical thickness in functionally-defined regions in a group of men who varied in their expertise effects for cars in FFA. While subjects with a thicker FFA cortex performed better with vehicles, those with a thinner FFA cortex performed better with faces and living objects. 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. (submitted). *Cortical thickness in fusiform face area predicts face and object recognition performance*.