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NEW RESEARCH REVEALS MORE ABOUT HOW THE BRAIN PROCESSES FACIAL EXPRESSIONS AND EMOTIONS

Brain feedback from facial mimicry used to interpret ambiguous smiles, shape relationships of power and status

NEW ORLEANS — Research released today helps reveal how human and primate brains process and interpret facial expressions, and the role of facial mimicry in everything from deciphering an unclear smile to establishing relationships of power and status. The findings were presented at Neuroscience 2012, the annual meeting of the Society for Neuroscience and the world's largest source of emerging news about brain science and health.

Facial mimicry — a social behavior in which the observer automatically activates the same facial muscles as the person she is imitating — plays a role in learning, understanding, and rapport. Mimicry can activate muscles that control both smiles and frowns, and evoke their corresponding emotions, positive and negative. The studies reveal new roles of facial mimicry and some of its underlying brain circuitry.

Today's new findings show that:

- Special brains cells dubbed "eye cells" activate in the amygdala of a monkey looking into the eyes of another monkey, even as the monkey mimics the expressions of its counterpart (Katalin Gothard, MD, PhD, abstract 402.02, see attached summary).
- Social status and self-perceptions of power affect facial mimicry, such that powerful individuals suppress their smile mimicry towards other high-status people, while powerless individuals mimic everyone's smile (Evan Carr, BS, abstract 402.11, see attached summary).
- Brain imaging studies in monkeys have revealed the specific roles of different regions of the brain in understanding facial identity and emotional expression, including one brain region previously identified for its role in vocal processing (Shih-pi Ku, PhD, abstract 263.22, see attached summary).
- Subconscious facial mimicry plays a strong role in interpreting the meaning of ambiguous smiles (Sebastian Korb, PhD, abstract 402.23, see attached summary).

Another recent finding discussed shows that:

- Early difficulties in interactions between parents and infants with cleft lip appear to have a neurological basis, as change in a baby's facial structure can disrupt the way adult brains react to a child (Christine Parsons, PhD, see attached speaker's summary).

"Today's findings highlight the role of facial expressions in communication and social behavior," said press conference moderator Ruben Gur, PhD, of the University of Pennsylvania, an expert on behavior and brain function. "Brain circuits that interpret the face appear ever more specialized, from primate 'eye cells,' to brain feedback that enables us to discern meaning through facial mimicry."

This research was supported by national funding agencies, such as the National Institutes of Health, as well as private and philanthropic organizations.

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Abstract 402.02 Summary

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The Eyes Tell All

Primate study finds brain cells that appear dedicated to understanding the emotion of eyes

A primate study has discovered neurons in the brain's amygdala, a structure dedicated to emotion, that appear to be specialized to process information about the eyes of others. These "eye cells" respond when looking at or into the eyes of another monkey, and respond differently to the eyes of neutral versus emotional faces. The findings were presented at Neuroscience 2012, the annual meeting of the Society for Neuroscience and the world's largest source of emerging news about brain science and health.

The eyes convey a wealth of information about the feelings and intentions of others. Emotions change the size of pupils, the frequency of eye movements, and the expression of the eyes. The new research, presented by principal investigator Katalin Gothard, MD, PhD, from the University of Arizona, is the first to find specialized neurons that appear finely tuned to respond to and interpret the eyes.

"It is likely that normal social behavior depends on the activity of these eye cells," Gothard said. "Given these findings, it is not surprising that in many brain disorders associated with abnormal amygdala function, such as schizophrenia or social anxiety, eye contact and social interaction is impaired."

The researchers simulated real-life situations by showing monkeys short videos of other monkeys displaying aggressive, neutral, and friendly facial expressions. The viewer monkeys made eye contact and mimicked the behaviors of the video monkeys. While the monkeys watched the videos, researchers monitored the activity in the amygdala, a brain structure that processes emotions and detects facial expression. They found that 23 of 151 cells tested were activated only when the viewer monkey was looking at the eyes of the video monkey. Four of these cells showed greater activity when the viewer and movie monkeys made eye contact.

This research was supported with funds from the National Institute of Mental Health and the National Science Foundation.

Scientific Presentation: Monday, Oct. 15, 9–10 a.m., Hall F-J

402.02, Looking at the eyes engages single unit activity in the primate amygdala during naturalistic social interactions

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TECHNICAL ABSTRACT: The eyes convey a wealth of information. A single glance at the eyes is sufficient to extract information about the emotional state (e.g. pupil diameter, frequency of eye movements, facial expressions), motivation, and even the intentions of others (e.g. direct threatening stare, frequently glancing at the same object/individual). Looking at the eyes is critical for complex social behaviors such as gaze-following and eye-contact induced facial mimicry.

We induced these behaviors in monkeys by exposing them to video clips of conspecifics displaying neutral, agonistic, or affiliative behaviors. In different segments of these videos, the movie monkey's eye gaze was directed toward or away from the viewer monkey. Each movie frame was co-registered with the scan path of the viewer monkey to identify time periods when the viewer was looking at the eyes of the movie monkey. We hypothesized that these periods of "eye-looking" would induce heightened activation of single neurons in the amygdala. Moreover, we expected that this activation should vary depending on the social information conveyed by the eyes (e.g. eye direction, facial expression). We found that 23/151 (15%) of neurons in the amygdala discharged selectively or exclusively when the viewer monkey looked at the eyes of the movie monkey. These neurons had a response latency of 100-150 ms from the start of fixation on the movie monkey's eyes. They exhibited either excitatory (12) or inhibitory (6) responses to looking at the eyes, and either no response (or a polar opposite response) to looking at other parts of the face or body. Five neurons showed mixed, excitatory/inhibitory responses. While the majority of these neurons showed a phasic response when the eyes were looked at, a subset were tonically active the entire time that the eyes were scanned. Of these "eye-looking" neurons, 4 showed significantly greater activity when the movie monkey's gaze was directed at the viewer (eye-contact) than when its gaze was averted. Additionally, 5 neurons differentiated among the eyes of neutral, agonistic, and afilliative expressions. These findings indicate that the amygdala contains neurons that are specialized to extract socio-emotional signals conveyed by the eyes during naturalistic social interactions.

Abstract 402.11 Summary

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Do Powerful People Return Smiles Less?

Social status causes the powerful and powerless to "mirror" faces differently

Whether or not a person mimics the facial expressions of another — such as returning a smile — appears to depend, in part, on how powerful the mimic feels, and the status of the person they are "mirroring." Powerful individuals suppress their smile mimicry toward high-status people, while powerless individuals mimic everyone's smile, according to findings presented at Neuroscience 2012, the annual meeting of the Society for Neuroscience and the world's largest source of emerging news about brain science and health.

Mimicry and imitation, including facial mimicry, are social behaviors that play a role in learning, understanding, and rapport. The new research, presented by Evan Carr, a graduate student at the University of California, San Diego, is the first to examine how power and status influence facial mimicry.

"Mimicry has been shown to help build relationships, and both power and status seem to affect how we unconsciously employ this strategy," Carr said. "These findings may speak to how social hierarchies often form 'under the radar' — quickly, efficiently, and without awareness."

The researchers asked 55 participants to write short reminders of events to induce subjective feelings of either powerfulness or powerlessness. Participants then viewed happy and angry videos of people that were either high-status (e. g., a physician) or low-status (e. g., a fast-food worker). While participants viewed the videos, researchers measured the response from two facial muscles: the zygomaticus major ("smiling muscle" that raises the corners of the mouth) and corrugator supercilii ("frowning muscle" that furrows the brow). These measurements provided a clear gauge of mimicry behavior when participants were feeling either powerful or powerless.

All participants tended to mimic frowns from high-status individuals more so than their low-status counterparts. Smiling was more complex: powerful subjects showed very limited "smiling muscle" response to other high-status people, instead returning more smiles to low-status people. This pattern changed with powerless participants, however, who smiled more at everyone.

This research was supported with funds from the University of California, San Diego.

Scientific Presentation: Monday, Oct. 15, 10–11 a.m., Hall F-J

402.11, Differential states of subjective power influence spontaneous facial mimicry.
***E. W. CARR**, P. WINKIELMAN, C. OVEIS; UCSD, La Jolla, CA

TECHNICAL ABSTRACT: Subjective power involves the feeling of being able to control or influence the actions of others. Evidence from psychology and neuroscience has also identified behavioral mimicry as an index for interpersonal affiliation and rapport. Yet, research into how different levels of subjective power directly impact mimicry behavior is surprisingly limited. We used facial electromyography (fEMG) to measure motor unit action potentials (MUAPs) from two muscles in the face: zygomaticus major ("smiling muscle" that brings up the corners of the mouth) and corrugator supercilii ("frowning muscle" that furrows the brow). To examine mimicry behavior, subjects watched dynamic videos after completing a writing prime to induce feelings of high- or low-power. Videos were of happy and angry expressions for 4 different FACS-coded models that were randomly assigned to high- and low-status jobs. We measured fEMG response at 500ms intervals across 80 5-second video trials and used linear mixed models (REML) for repeated measures analyses. Zygomaticus analysis showed a significant 3-way interaction, where control participants showed standard mimicry with more zygomaticus activity to happy videos; however, high-power subjects mimicked low-status models more, and showed a reversed mimicry pattern for high-status models compared to other conditions, $p<0.05$. Low-power subjects did the opposite, where they seemed to reverse mimic low-status models, although this pattern did not reach significance, p=n.s. Data from the zygomaticus also revealed that reactivity unfolded differently across the 5000ms trials in a significant condition*status*time 3-way interaction, $p<0.05$. Corrugator evaluation showed a main effect of valence, where all participants reacted with more mimicry (more corrugator response to angry videos), $p<0.01$. This was qualified by a subordinate significant 2-way interaction that showed more mimicry occurred to high-status models across all conditions, $p<0.05$. Therefore, we have shown that (1) feelings of high- and low-power lead to distinct changes in spontaneous facial mimicry (and these changes are different between high- and low-power states), and (2) these effects are impacted by the perceived status of the mimicry target. Correspondingly, the present research establishes a relationship between power

and mimicry. The results suggest that subjective states of high-power and low-power can have fundamental impacts on emotional awareness and perception, which are evident in nonverbal behaviors such as mimicry. The current study spurs interesting and immediately applicable questions for research in emotion, relationships, and social hierarchies.

Abstract 263.22 Summary

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Vocalizations and Facial Expressions Come Together in the Monkey Brain

Study reveals new insights in how monkeys recognize identity of faces and facial expression

Brain imaging studies have revealed the specific roles of different regions of the macaque brain in understanding facial identity and emotional expression, including one brain region previously identified for its role in vocal processing. The findings were presented at Neuroscience 2012, the annual meeting of the Society for Neuroscience and the world's largest source of emerging news about brain science and health.

In every-day life, faces provide vital social information, allowing recognition of other individuals and quick assessments of their emotions, mood, and intentions. The primate study, presented by lead author Shih-pi Ku, PhD, from New York University, found for the first time that the brain's ventral prefrontal cortex (vPFC) in monkeys, a region associated with understanding vocal information, also differentiates between facial expressions. In addition, the brain's superior temporal sulcus (STS) has neural circuits that differentiate facial expressions.

The study also revealed that the brain's anterior hippocampus — known for its role in memory — helps to identify faces of individuals even with different expressions. In humans, recordings of single neurons in this brain region in epileptic patients have revealed cells that encode the abstract concept of a person, including the face and the name.

The researchers presented monkeys with images of faces of different individual monkeys displaying a variety of facial expressions. Scientists recorded each monkey's brain activity as they viewed the images. They used a special experimental paradigm in the magnetic resonance scanner to detect the presence of specialized neural circuits that were too small to be resolved by the scanner's standard method.

"The new findings provide evidence for similar neural systems in humans and monkeys for the high-level processing of facial cues," Ku said. "Particularly intriguing is that vPFC is involved in facial expression processing, as it is in close proximity to vocal information processing. This suggests the vPFC integrates vocal and visual facial information to get a better grasp of social content."

This research was supported by Max-Planck Society.

Scientific Presentation: Sunday, Oct. 14, 2–3 p.m., Hall F-J

263.22, Facial expression and identity encoding in macaques revealed by fMRI adaptation

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TECHNICAL ABSTRACT: fMRI has revealed a face processing network in the macaque brain that encompasses regions in the superior temporal sulcus (STS), the lateral and ventral temporal cortex, the medial temporal lobe and in the prefrontal cortex (Tsao and Livingstone 2008; Ku, Tolias et al. 2011). However, the functionality of each individual face-responsive patch is largely unknown. In humans fMRI evidence suggests that the middle STS is important for facial expression encoding, while the ventral temporal cortex is primarily involved in identity encoding (Haxby, Hoffman et al. 2002). This is consistent with single unit studies showing facial expression selective cells in the STS and identity encoding neurons in LTG in monkeys. However, there is no equivalent evidence indicating such a functional segregation in terms of BOLD responses to face stimuli. In order to examine whether there is a similar response pattern in monkeys and to further identify more candidate brain regions which might be also important in encoding these two aspects of faces, we scanned two awake and five anesthetized monkeys at 7Tesla. Using an adaptation paradigm we found that STS was sensitive to changing facial expressions independent of changing of identities in all awake and anesthetized monkeys. In brain regions not covered in the awake monkeys, the same contrast revealed that the medial orbital frontal cortex (area 47/12) of four anesthetized monkeys was also sensitive to changing facial expressions. In addition, we found that the anterior hippocampus of the two awake and three anesthetized monkeys was sensitive to changing identities. The results suggest differential selectivities for the encoding of facial expressions and of identities across a network of regions in the monkey. References Haxby, J. V., E. A. Hoffman, et al. (2000). The distributed human neural system for face perception. Trends Cogn Sci 4(6): 223-233. Ku, S. P., A. S. Tolias, et al. (2011). fMRI of the face-processing network in the ventral temporal lobe of awake and anesthetized macaques. Neuron. Tsao, D. Y. and M. S. Livingstone (2008). Mechanisms of face perception. Annu Rev Neurosci 31: 411-437.

Abstract 402.23 Summary

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What Makes a Smile Authentic?

People use facial expressions and facial mimicry to evaluate the true meaning of smiles

Although the smile is one of the most ubiquitous signals in human interactions, its meaning can be unclear. New findings show that people use facial mimicry to interpret the meaning of ambiguous smiles. The findings were presented at Neuroscience 2012, the annual meeting of the Society for Neuroscience and the world's largest source of emerging news about brain science and health.

How people judge whether a smile expresses true joy, mere politeness, or some other shade of emotion has been a mystery. Yet reading such nonverbal cues is a foundation of human relationships. One theory holds that along with a smile, people interpret the presence of the "crow's feet" wrinkles around the eyes as a sign of true enjoyment. But the new findings, presented by Sebastian Korb, PhD, of the University of Wisconsin, Madison, add a new twist to smile interpretation.

"Our research suggests that facial mimicry is useful for the interpretation of ambiguous facial expressions, such as smiles," Korb said. "There seems to be no simple way to judge the authenticity of a smile: crow's feet around the eyes alone aren't enough, but combining with other features of a smile can reveal much. Mimicry might help a perceiver put this complexity together, because it helps them feel what the smiler is feeling."

To investigate how people judge smiles, researchers showed videos of different types of smiles, created with avatar models. Participants rated how authentic they found each smile. Meanwhile, surface electrodes on the participants' faces monitored four facial muscles to evaluate facial mimicry.

Participants mimicked nearly all smiles; the stronger the smile, the stronger the mimicry. But participants used mimicry preferentially to assess the meaning of ambiguous smiles. Finally, people who rated themselves higher on some aspects of emotional intelligence also tended to rely on mimicry more.

This research was supported with funds from the Swiss National Science Foundation, the Swiss Center for Affective Sciences, Geneva, and the University of Geneva, Switzerland.

Scientific Presentation: Monday, Oct. 15, 10–11 a.m., Hall F-J

402.23, Mimicking authentic smiles – An EMG study

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TECHNICAL ABSTRACT: Smiling is one of the most ubiquitous signals in human interactions and it occurs in a wide range of social contexts. Despite smiles being frequently perceived in every-day life, the perceptual processes leading to the interpretation of a smile as being "authentic", i.e. expressing happiness or enjoyment, remain unclear. The literature generally favors the interpretation that smiles with orbicularis oculi contraction (producing "crow's feet" wrinkles around the eyes) are perceived as more joyful and thus authentic than other types of smiles. Therefore, the orbicularis oculi has been suggested as a marker of enjoyment. However, less is known about how judges use smile intensity as a marker of authenticity, and how smile intensity interacts with orbicularis oculi contraction to create the percept of an authentic smile. Finally, the link between facial mimicry (FM) and ratings of authenticity remains unclear.
Here, dynamic stimuli of avatars displaying 19 types of smiling with various degrees of mouth opening, smile amplitude, and orbicularis oculi activation, were created based on the Facial Action Coding System (FACS). 31 participants watched and rated the authenticity of the smiles, while FM was assessed by recording electromyography (EMG) from 4 facial muscles.
Results showed that the orbicularis oculi is not a marker of authentic smiles per se, but does so in combination with strong zygomaticus activation. In fact, weak smiles displaying an orbicularis oculi contraction were judged as less authentic than strong smiles with orbicularis oculi. When ordering trials by rating of authenticity, we found that activation of the zygomaticus and orbicularis oculi correlated with ratings of authenticity for smiles of weak and medium intensity, but not for the strongest smiles. This supports recent models of embodiment, postulating that FM may be more relevant for emotion perception when the facial expression is somewhat ambiguous.

Speaker's Summary

Speaker: Christine Parsons, PhD
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A Minor Change to the Structure of an Infant's Face Disrupts Adults' Neural Processing: a Unique Window into Early Parental Responses (402.14)

Poster Session: Motivation and Emotions: Human and Primate Social Communication
Monday, Oct. 15, 9–10 a.m., Hall F-J

Both Darwin and Lorenz argued that infant faces play an important role in eliciting responsive care from adults. Infant faces have been shown to elicit early, specific activity in the orbitofrontal cortex (OFC), a key cortical region for reward and affective processing. This OFC activity is suggested to provide the necessary tagging to mark infant faces as special, in this way facilitating parenting behaviour. A causal test of the relationship between infant facial configuration and early OFC activity is provided by naturally-occurring changes to the infant facial structure. One such change is cleft lip, which represents a relatively limited, localised abnormality, associated with disruption to early parenting. We investigated brain activity in response to briefly presented (300ms) infant faces with cleft lip and healthy infant and healthy adult faces using magnetoencephalography. Ten healthy adults (6 males) with no experience of caring for, or close contact with, infants with cleft lip participated. Face stimuli consisted of 36 images of adults, 36 images of healthy infants and 18 images of infants with cleft lip, all front on, with eyes open and a comparable direction of eye gaze. Source reconstruction using linearly constrained minimum variance (LCMV) beamforming revealed the previously-described OFC activity at 140msec in response to infant faces but not to adult faces or infant faces with cleft lip. While activity later in time (170msec) in the fusiform face area was of similar magnitude for adult and healthy infant faces, it was substantially weaker for the infant faces with cleft lip. This suggests that the M170 can be attenuated by changes to the internal facial configuration and is consistent with the notion that this face-specific component is involved in the structural encoding of faces (Eimas, 2000). This is the first evidence that a limited change to the typical facial structure can disrupt the robust neural activity usually seen in response to infant faces. These findings are a first step towards a neurobiological explanation of why early interactions between parents and infants with cleft lip can be disrupted.