# Impaired recognition and experience of disgust following brain injury

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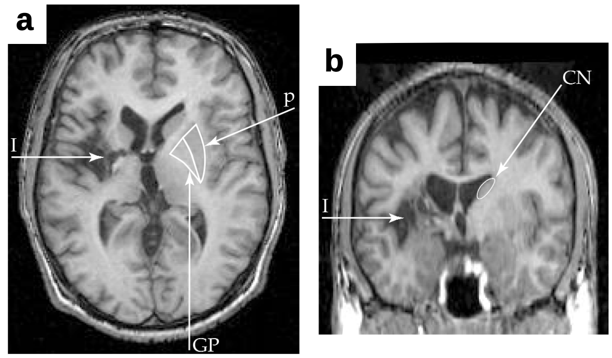


**Fig 1.** T1-weighted MR images showing a left hemisphere infarction involving the posterior part of the anterior insula, posterior insula, internal capsule, putamen and globus pallidus. (**a**) Axial image. (**b**) Coronal image also shows damage to the head of the caudate nucleus. The intact right putamen (P) and intact right globus pallidus (GP; **a**) and intact right head of caudate (CN; **b**) are outlined. White arrow, insula lesion (I).

Huntington's disease can particularly affect people's recognition of disgust from facial expressions[1,2], and functional neuroimaging research has demonstrated that facial expressions of disgust consistently engage different brain areas (insula and putamen) than other facial expressions[3–5]. However, it is not known whether these particular brain areas process only facial signals of disgust or disgust signals from multiple modalities. Here we describe evidence, from a patient with insula and putamen damage, for a neural system for recognizing social signals of disgust from multiple modalities.

It is important to investigate the fundamental predictions of the multi-modal hypothesis. These are, first, that brain injury affecting the areas identified by functional imaging research should produce a selective impairment in recognizing signals of disgust, and second, that this impairment should affect the recognition of disgust signals from other modalities than just the face. To date, neither prediction has been investigated.

NK was selected for testing solely because his lesions selectively involve brain areas identified by fMRI as important for processing facial expressions of disgust (Fig. 1), and he was unaware of the study's purpose. (For test details, see refs. 1, 6, 7 or www.mrc-cbu.cam.ac.uk~andy.calder/disgust.) NK is a 25-year-old male of average intelligence (Raven's Matrices, 46; SCOLP, 50$^{th}$ percentile; Spot the word, 43/60; estimated WAIS full scale IQ, 105 ± 13). He has normal basic visual processing (VISTECH VCTS 6000) and normal hearing threshold levels (within 15 dB) for the frequency range 250–8000 Hz, including frequencies critical for speech.

On the Benton test of unfamiliar face matching, NK's performance (50/54) was normal relative to matched controls (10 male, 10 female; age 28.5 ± 6.4, mean ± s.d.; controls' performance, 49.2 ± 3.7). On a second test of famous face recognition, NK could identify famous faces as familiar (30/30; controls, 27.5 ± 3.2) and remember the famous people's occupations (30/30; controls, 27.0 ± 3.5) and names (30/30; controls, 23.7 ± 4.7). He also correctly rejected unfamiliar faces (10/10; controls, 9.4 ± 1.1; 3 males and 7 females, mean age, 28.2 ± 7.9).

Our tests of emotion recognition used a forced-choice procedure in which the emotion conveyed by each stimulus was identified by selecting one label from a list comprising a label for each emotion tested; emotion labels were visible throughout testing. Test 1 used faces from the Ekman and Friesen series[8] and contained examples of six facial expressions (Table 1). Test 2 contained pictures of the same six facial expressions (from the JACFEE series[9]) plus an emotion conceptually similar to disgust, contempt. For both tests, NK was significantly impaired only in recognizing expressions of disgust. For the JACFEE faces, NK's recognition of contempt was

**Table 1. Facial and vocal expression recognition.**

| | NK | | Controls (mean ± s.d.) | |
|---|---|---|---|---|
| **Facial expression** | | | | |
| | 1. Ekman & Friesen | 2. JACFEE | 1. Ekman & Friesen | 2. JACFEE |
| Anger | 9 / 10 | 5 / 8 | 8.2 ± 1.8 | 6.3 ± 1.1 |
| Contempt | — | 3 / 8 | — | 6.0 ± 2.7 |
| Disgust | 5 / 10*(1.68) | 4 / 8 **(2.81) | 8.2 ± 1.9 | 7.0 ± 1.1 |
| Fear | 7 / 10 | 8 / 10 | 7.8 ± 1.8 | 6.3 ± 1.5 |
| Happiness | 10 / 10 | 8 / 8 | 9.9 ± 0.1 | 8.0 ± 0.0 |
| Sadness | 8 / 10 | 8 / 8 | 8.6 ± 1.7 | 7.2 ± 1.0 |
| Surprise | 8 / 10 | 8 / 8 | 8.5 ± 1.3 | 6.8 ± 1.1 |
| **Vocal expression** | | | | |
| | 3. Non-verbal sounds | 4. Emotional prosody | 3. Non-verbal sounds | 4. Emotional prosody |
| Anger | 18 / 20 | 7 / 10 | 17.8 ± 2.3 | 8.5 ± 1.5 |
| Disgust | 3 / 20***(28.05) | 4 / 10**(2.57) | 19.7 ± 0.6 | 7.9 ± 1.5 |
| Fear | 14 / 20 | 8 / 10 | 15.9 ± 2.7 | 7.9 ± 1.6 |
| Happiness | 14 / 20 | 9 / 10 | 15.8 ± 2.4 | 8.2 ± 1.6 |
| Sadness | 18 / 20 | 7 / 10 | 17.1 ± 2.5 | 8.4 ± 1.4 |
| Surprise | 15 / 20*(2.06) | — | 18.6 ± 1.7 | — |

Controls were matched to NK for age and education. For Ekman and Friesen[8] faces, 32 male, 26 female, mean age, 27.3 ± 5.6; for JACFEE[9] faces, 12 male, 13 female, mean age, 30.4 ± 9.9; for non-verbal emotional sounds, 9 male, 9 female, mean age, 26.3 ± 8.2; for emotional prosody, 9 male, 7 female, mean age, 28.0 ± 7.4. *$p$ < 0.05 versus control; **$p$ < 0.01; ***$p$ < 0.001; $Z$ scores in parentheses.

**Table 2. Self-assessed experience of three negative emotions.**

| | NK | Controls |
|---|---|---|
| **Emotional experience questionnaires** | | |
| Anger (max, 200) | 116 | 119.3 ± 23.5 |
| Fear (max, 375) | 121 | 123.4 ± 23.3 |
| Disgust (max, 100) | 21.87*(2.03) | 48.9 ± 13.3 |
| Food (max, 100) | 12.5$^b$(1.54) | 46.7 ± 22.3 |
| Animals (max, 100) | 0**(2.41) | 58.6 ± 24.3 |
| Body products (max, 100) | 0**(2.57) | 58.1 ± 22.6 |
| Sex (max, 100) | 87.5 | 66.2 ± 17.3 |
| Envelope violation (max, 100) | 12.5*(1.66) | 59.2 ± 28.1 |
| Death (max, 100) | 0$^b$(1.41) | 39.7 ± 28.1 |
| Hygiene (max, 100) | 37.5 | 26.5 ± 14.7 |
| Magical (max, 100) | 25 | 36.0 ± 23.0 |

Scores lower than control mean indicate a reduction in self-assessed experience of the emotion; for scoring method, see ref. 1. The disgust scale contained eight subscales corresponding to disgust-provoking situations associated with food, animals, body products, sex, envelope violation (damage to the body envelope), death, hygiene and magical (disgust by connotation; for example, chocolate shaped like feces). Matched controls were 15 males and 19 females, mean age, 25.32 ± 6.27, of similar age and education to NK. *$p < 0.05$ versus control; **$p < 0.01$; $^b p < 0.1$; $Z$ scores in parentheses.

not significantly impaired, but was also low.

Test 3 included examples of non-verbal emotional sounds (for example, laughter for happiness, retching for disgust) associated with the six basic emotions[6] (Table 1). NK showed a marked impairment in recognizing disgust, and a comparatively mild deficit in recognizing surprise. Test 4 assessed recognition of emotion from prosodic cues and included sequences of five random digits (for example, 5, 2, 4, 6, 9) spoken to convey one of five emotional prosodies (Table 1); NK showed a significant impairment in recognizing only disgust.

NK incorrectly categorized disgust facial expressions as anger for Ekman and Friesen faces, and as anger and contempt for the JACFEE faces. For the non-verbal emotional sounds, NK incorrectly labeled disgust as fear and sadness; for the emotion digits, he labeled disgust as anger and happiness. NK's most common confusion (disgust with anger) was also found for controls.

Our results support the idea that NK has damage to a system involved in recognizing social signals of disgust, regardless of their modality. Moreover, the specificity and cross-modal nature of these impairments is consistent with the idea that NK's deficit is restricted to disgust rather than resulting from impaired auditory or visual processing. However, NK's deficits could equally reflect a semantic impairment for disgust; he may not have understood the term. To address this interpretation, we asked him to identify the emotions illustrated in pictures of scenes (from a standardized set[10]) depicting one of four emotions (happiness, sadness, fear, disgust); examples included people at a graveside for sadness, and a filthy toilet for disgust. NK had no difficulty in identifying the emotions conveyed by these pictures (disgust, 8/10 versus controls, 7.9 ± 1.3; fear, 10/10, controls, 8.8 ± 1.0; happiness, 10/10, controls, 9.8 ± 0.6; sadness, 7/10, controls, 7.7 ± 1.2; 6 males and 12 females, mean age 30.1 ± 8.0). This demonstrated that NK's deficit in recognizing disgust from the social signals of human beings did not reflect impaired knowledge of the concept of disgust. NK's ability to identify emotion from scenes contrasts with his poor performance with facial and vocal expressions. However, the content of emotional scenes is easier to verbalize and more semantically rich than facial and vocal signals.

We investigated whether NK's deficit also affected the intensity of his reaction to plausible disgust-provoking scenarios, using a questionnaire testing the experience of disgust; additional questionnaires investigated his experience of anger and fear (Table 2). NK's scores for the anger and fear questionnaires did not significantly differ from the controls' mean scores. In contrast, his overall score for disgust was significantly lower than the controls. NK also showed a significant or borderline reduction in his scores for five of eight disgust subscales, scoring at or near the minimum score on the categories of food, animals, body products, envelope violation and death.

Our results demonstrate that NK shows a consistent and largely selective deficit in recognizing disgust from facial signals, non-verbal emotional sounds and emotional prosody, and is less disgusted than controls by disgust-provoking scenarios. These results are consistent with the existence of a supramodal system for recognizing signals of disgust in others and indicate that this system may be closely linked to the experience of being disgusted. These findings support the idea that the neural substrates of emotional experience are engaged during recognition of emotion expressed by others[11].

NK's neural damage includes the insula and putamen, which fMRI studies consistently show to be involved in processing facial expressions of disgust. Huntington's patients have damage to the putamen and other striatal regions, and neuroimaging shows that the insula is also damaged in these patients (C.F.-N. *et al. Amer. Acad. Neurol. Abstr.*, A152–A153, 1999). Therefore, it seems plausible that an insula-striatal system[12] may be involved in recognizing signals of disgust in others. As shown by fMRI, the insula is activated by unpleasant tastes[13], and theories of disgust emphasize its origin as a response to offensive foods[14]. In addition, the insula receives information from the five sensory modalities[15]. These observations suggest that an insula-striatal system may be involved in disgust across all sensory modalities.

ACKNOWLEDGEMENTS

*We thank NK and his family for their time and assistance. Thanks also to Brian Cox for preparing the graphics.*

RECIEVED 1 AUGUST; ACCEPTED 27 SEPTEMBER 2000

1. Sprengelmeyer, R. *et al. Brain* 119, 1647–1665 (1996).
2. Gray, J. M., Young, A. W., Barker, W. A., Curtis, A. & Gibson, D. *Brain* 120, 2029–2038 (1997).
3. Phillips, M. L. *et al. Nature* 389, 495–498 (1997).
4. Phillips, M. L. *et al. Proc. R. Soc. Lond. B Biol. Sci.* 265, 1809–1817 (1998).
5. Sprengelmeyer, R., Rausch, M., Eysel, U. T. & Przuntek, H. *Proc. R. Soc.Lond. B Biol. Sci.* 265, 1927–1931 (1998).
6. Scott, S. *et al. Nature* 385, 254–257 (1997).
7. Calder, A. J. *et al. Cognit. Neuropsychol.* 13, 699–745 (1996).
8. Ekman, P. & Friesen, W. V. *Pictures of Facial Affect* (Consulting Psychologists, Palo Alto, California, 1976).
9. Matsumoto, D. & Ekman, P. *Japanese and Caucasian Facial Expressions Of Emotion (JACFEE) and Neutral Faces (JACNeuF)* (San Francisco State Univ., San Francisco, 1988).
10. Lang, P. J., Bradley, M. M. & Cuthbert, B. N. *International Affective Picture System (IAPS)* (NIMH Center for the Study of Emotion and Attention, 1995).
11. Adolphs, R., Tranel, D., Damasio, H. & Damasio, A. *Nature* 372, 669–672 (1994).
12. Chikama, M., McFarland, N. R., Amaral, D. G. & Haber, S. N. *J. Neurosci.* 15, 9686–9705 (1997).
13. Small, D. M. *et al. Neuroreport* 10, 7–14 (1999).
14. Rozin, P., Haidt, J. & McCauley, C. R. in *Handbook of Emotions* (eds. Lewis, M. & Haviland, J.) 575–594 (Guilford, New York, 1993).
15. Mesulam, M. M. & Mufson, E. J. *J. Comp. Neurol.* 212, 38–52 (1982).