Perception

FOR LAST BUT NOT LEAST

Mirror cells in talking parrots?

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A curious observation was made by us, just over thirty years ago, on the pupils of a pet parrot (Gregory and Hopkins 1974). Answering to the name of Seraphita, the parrot was a Yellow Fronted Amazon, Panama variety *(Amazona acrocephala panamensis*), aged about nine years and owned for the last five by the second author of this paper, entitled: “Pupils of a talking Parrot”. Observations were carried out over a period of two years, with experiments based in the Brain and Perception Laboratory in the Medical School of the University Bristol.

The curious observation was seeing the pupils of Seraphita’s eyes suddenly contracting, and then rapidly expanding and contracting while she spoke, with her vocabulary of twenty or so words. Further, and this was even more surprising, her pupils would contract and expand similarly when she was silent, but was apparently attending to familiar words uttered in her presence. This response went beyond words, for Seraphita’s pupils also responded to certain mechanical sounds, especially after a few trials to the distinctive whirr of the motor-driven Nikon camera, which (with Philip Clarke’s skill) produced the fine portrait of Seraphita that graced the front page of *Nature*, of December 20/27 1974. Pupil changes were recorded on 16 mm ciné, and related to time and sound amplitude with a stop-motion projector, a film editor for counting frames, and an Ampex audio tape recorder and oscilloscope. (Video cameras were not available at that time).

The observations and measurements, may be summarised:

1. The pupils contracted suddenly to about half normal size, then expanded and contracted to follow the energy envelope of words and imitated sounds of her repertoire.

2. The pupil modulation started before the utterance, with about 200 ms anticipation.

3. Occasionally, small amplitude pupil modulation would occur spontaneously, a few seconds before vocalization, suggesting internal 'rehearsal' for vocalising.

4. Similar pupil modulation accompanied familiar words spoken to her, and to certain sounds. These pupil changes were more variable. They occurred while she was silent but 'attending', looking with a beady eye. Unlike the anticipatory changes associated with her vocalisation, these pupil responses followed normal reaction-time delay to stimulus words or sounds.

5. Both for the changes associated with vocalization and responding to heard words or sounds, the pupil changes occurred only for apparently meaningful words or sounds. They did not accompany short loud "squawks", believed to be innate calls. New sounds could elicit pupil responses after a few trials, as found with the Nickon camera whirr, which she soon learned to imitate. It may be noted that the distinctive whirr was special, occurring on occasions when we, and the camera captured her attention.

It is known that the pupils of parrots' eyes work with striate 'voluntary' muscles (Walls 1963), so can contract or expand very rapidly. They are hardly at all affected by light level; but contract for near vision, especially with the challenging manual-and-beak task of grasping and opening nuts. Parrot vision has limited stereo, with about 1 percent overlap of the eye's fields, evidently used for manipulation.

The pupil variations seem to be associated with attention to tasks. It is, perhaps, suggestive that human eye blinking is affected by the difficulty of tasks, such as tracking, including anticipated difficulty (Poulton and Gregory 1952). These tasks need not be visual, and can be auditory, as for auditory tracking of a variable tone to a changing note. (Gregory 1952). Typically, there is a short burst of several rapid blinks just before anticipated difficulty, then greatly reduced blink-rate during a task that requires maintained attention. For lengthy tasks, such as mechanical drawing, this can produce corneal damage, by lack of tear fluid. Normally blinking occurs before the cornea dries. Blinking is not usually reflex, and is not initiated by drying of the cornea; but is driven by a cortical oscillator, allowing blinks to occur well before danger of damage from corneal drying. Blink rate is normal in the saturated dust-free atmosphere of a Turkish bath, Ponder and Kennedy (1928). Evidently the rapid anticipatory blinking prior to difficult task serves to spread tear fluid evenly across the cornea for maximal visual resolution, as tear fluid builds up as a ridge across the pupil with a single blink, giving optical distortion. So the anticipatory burst of rapid blinking clearly has a visual function – which, however, occurs also for non-visual tasks, associated with attention.

It seems that attention is key to the variations in human blink rate and to the parrot's pupil changes, though their functions are different. Both are activated by striate voluntary muscle systems, though for humans, as no doubt for birds, these attention-related changes are unconscious.

Observing zoo parrots, suggests the pupil changes are less marked when birds are subjected to daily 'pretty polly", and so on. Owners of talking parrots have confirmed the ‘Seraphita Effect’ in their birds, though I do not know whether this is a feature of all talking parrots. It seems less marked in parrots in zoos, perhaps as words lose significance with mindless repetition, so the birds become bored. Lack of these pupil changes should warn zoos to protect their talking birds from assault by inane human nonsense.

The pupil changes of the parrot are more elaborate than the short anticipatory increase, and then maintained reduction of blink rate with human blinking, which has a useful optical function. Do these pupil changes of the parrot have an optical function? They are not merely reduction of optical aperture, giving increased depth of field and in bright light increased resolution, for challenging manipulative tasks. Following the amplitude envelope of auditory signals has no such obvious optical benefit. This is different from the changes of human blink rate, as these are optically useful. The Seraphita Effect seems to be intimately related to the parrot brain’s signal processing. Are these clearly visible pupil changes, signals to near-neighbours - gestures - so parrots can read each other’s minds?

If so, perhaps the Seraphita Effect is related to quite recently discovered primate mirror cells, associated with communication by gestures, as they fire when gestures are made or recognised. They are localised in pre-Broca’s speech area, suggesting that speech originated from hand waving. (Gallese, Fadiga, Foggasi, Rizzolatti (1996)). Mirror cells are involved in human speech, as shown with positron emission tomography, (Rizzolatti, Arbib, Padiga, Metelli, Bettinardi, Perani, Fazio (1996)). Such evidence for primates and humans, raises the question: Do talking parrots have mirror cells?

It should not be hard to record their activity if indeed mirror cells do exist in the brains of talking birds. If they do not: Is there an alternative, more ancient neural system for communication? As birds are believed to be descendants of the dinosaurs, of up to two hundred million years ago, is it possible that we can see social signals of dinosaurs in the eyes of parrots?

NB. As this still incomplete study is somewhat unusual, as it spanned over fifty years, and except for its start was not an 'official' project, a brief history might be in order. It started in the early 1950's, when I was assistant to Christopher Poulton, in the Medical Research Council's Applied Psychology Unit (APU) at Cambridge

This project was aimed to question whether candidates for pilot training, having unusually high blink rate, should be barred from flying. The experiments with visual tracking showed that blinks almost ceased at critical moments, which was accepted as evidence that these candidates should be allowed to continue training to fly. Christopher Poulton was a superb experimenter, with immense patience; for this project, reading miles of pen recordings far into the night. He was famous for accepting the power of experimental data, while distrusting, and even discouraging speculation. He would have dismissed this parrot project as idle science fiction, and of course this may right. However this may be I owe a dept of gratitude to my Christopher Poulton, who set standards hardly possible to emulate. I went solo to measuring blink rate in non-visual tasks, as this had low priority for Chris as it was not in our brief, and perhaps it looked too speculative. But these experiments were based on Chris Poulton's work, on blinking during visual tracking (for which I was his assistant), and used his methods, as blinking was recorded with an EEG amplifier from electrodes near the eyes, with pens writing on moving paper.

The co-author of the *Nature* (1967) paper that first reported the parrot pupil observations - Sue Hopkins - was my sister-in-law. My then wife, Freja, helped. Prue went on to start and for several years run the private zoo at Linton, near Cambridge. Sadly she died quite recently so preventing her from co-authoring this follow-up. I hope she would approve.

The photography (in natural lighting in Seraphita's home environment) was done by Philip Clarke, who became a leader in the world of ballooning at Bristol. The data were analysed in the Brain and Perception Laboratory, in the Department of Anatomy in the University of Bristol. B & P was funded by the MRC for twenty years. This still unfinished project depended on the tolerance, indeed encouragement of the MRC for some wild card projects, as also the Universities of Cambridge and Bristol. Long may this enlightened policy continue.

I do not know what happened to Seraphita. It seems her pupils have become our teachers.

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