available to anyone in the world with internet access, not just the privileged scientists of the industrialized world. It would be yet another case of the internet's democratizing influence.

Why do you write for the general public? I have always enjoyed reading popular books about animals and science in general. This kind of literature is far more important than many academics realize. It is this literature which draws students into a field, which motivates grants and donations, which gives a field a public face. We get so carried away by our own little corner of science that we don't realize that for the vast majority of people even the best written technical report is totally inaccessible. People need a translator to understand the issues at hand. Many of the translators are so-called 'science writers', some of whom do an excellent job. But I happen to believe that the ideal translators are the scientists themselves.

For me, this means a double career. In the daytime, my research team produces around a dozen technical reports in peer-reviewed journals per year. In the evenings and weekends, I write my popular books. The first kind of writing is enormously constrained as it must follow the rules of method description, give references to the literature, employ the right terminology and use the right statistics, otherwise the reviewers will let us know. The second kind of writing is freedom! It cannot deviate from the truth by too much, yet it allows me to address larger issues, some of which can barely be mentioned in the scientific literature. For example, animal emotions and empathy are still taboo topics, even though neuroscientists are at the moment going all out with regards to human emotions and empathy.

This will be the next frontier in my field. It used to be that the words 'animal' and 'cognition' could not be mentioned in the same sentence; now the stricture applies to 'animal' and 'emotion'. I predict that there will come a day that the second taboo is considered equally puzzling as the first.

Have you seen public attitudes change? Apart from the perennial controversies surrounding evolution here in the USA — an issue beyond the grasp of my European brain — there have been dramatic changes in public opinion in favor of those who try to put human behavior in an evolutionary light. The days when Ed Wilson got doused with water are behind us. One can now say (as I like to do) that humans are essentially apes and suggest genetic influences on behavior without meeting the incredible hostility that marked the 1970s.

One time, long ago, I was attacked for claiming that male chimpanzees are dominant over females — how did I know this? wasn't I projecting male prejudices onto their society? — whereas recently, I attended a lecture where a speaker listed biologically based gender differences, a lot of them, and I saw young people in the audience yawn! Apparently, the effect of the Y chromosome on behavior has become a boring topic.

I lecture in many countries, and often end up in public debates. Until recently, I found the French most averse to Darwinian explanations. But even there, all of a sudden the sun has come through the clouds: comparisons between apes and humans are accepted when only a few years ago they were seen as deeply offensive. Evolutionary explanations are becoming all the rage among French intellectuals.

In about three decades, the general public in the West has moved from fear of biology to fascination. Now let's see if the social sciences will follow by putting more evolution into their thinking and curriculum. It is bound to happen.

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Quick guide

Congenital amusia

Lauren Stewart

What is it? Congenital amusia, also called developmental amusia or dysmusia, is a lifelong disorder characterized by a difficulty in perceiving, or making sense of, music. People with amusia fail to recognize familiar tunes, cannot tell one tune from another (unless the tunes have lyrics) and often complain that music sounds like noise.

Is it the same as tone-deafness? People typically use the term 'tone-deafness' as a label for people who cannot sing in tune, but while many people claim to be tone-deaf in this sense (15% of the population), only about 4% of the population are estimated to have perceptual difficulties with musical listening (Kalmus and Fry, 1980).

Do I have it? To find out, take an online musical listening test at www.delosis.com/listening/home.html. As a guide, a score below 22 would be in the amusic range, though the cut-off varies with age (see http://www.brams.umontreal.ca/peretz/).

Why haven't I heard of it before? The first report of amusia was published more than a century ago (Grant-Allen, 1878) but it is only within the last five years that case studies have been anything other than anecdotal. It is now possible to systematically assess different aspects of people's musical listening ability. The Montreal Battery for the Evaluation of Amusia (MBEA; Peretz, 2003) consists of seven subtests, each comprising a pair of musical phrases which are either exactly the same or slightly different. The nature of the deviation is systematically different in each

subtest: scale, contour, interval or rhythm.

Is it a pitch problem? While most normal listeners can judge the direction of a pitch change with intervals smaller than a semitone, people with amusia often require the change to be much greater, for example, close to the distance between the first two notes of *Somewhere over the Rainbow* (Peretz *et al*., 2002; Foxton *et al*., 2004). Given that most pieces of Western music move in steps of a semitone, it is not surprising that, for amusics, all the songs tend to sound the same. However, Foxton *et al.* (2004) found that increasing a pitch change so that it exceeds an amusic's pitch threshold does not overcome the problem when the task is to spot the difference between two musical phrases, showing that there is no simple relationship between the ability to hear a pitch change between two notes and the ability to hear a change in the context of a whole phrase.

It seems likely that the ability to integrate a sequence of pitch changes into a coherent whole and form a representation of it in short-term memory requires an intact ability to perceive differences between individual notes.

Is the problem specific to music? So far, the evidence would suggest so. People with amusia have normal intellectual functioning — Milton Friedman and Che Guevara are both thought to have been afflicted — and do not appear to have had any difficulty in understanding speech, including the melody of speech. However, some researchers feel that the preserved ability to perceive intonation in language is more apparent than real.

In languages such as English, pitch changes are often several semitones, commonly co-occur with changes in stress and timing, and are used to convey emphasis, emotion or a questioning style, rather than semantic meaning. For all these reasons, subtle problems in hearing pitch differences are unlikely to be a limiting factor for comprehension. It will be important to investigate whether amusics who speak a tonal language are sensitive to pitch change in a linguistic context, as changes in a language such as Mandarin are subtle and can profoundly alter semantic meaning.

Can people with amusia hear rhythm? The MBEA includes a test of rhythmic perception and those with amusia often score in the normal range, although this aspect of the disorder seems variable (Che Guevara was notoriously useless on the dance floor, as depicted in the film *The Motorcycle Diaries*). Auditory psychophysics shows that, even though a group of people with amusia failed to spot subtle deviations in pitch from a monotone standard, they were able to spot deviations in time (Hyde and Peretz, 2003). However, the story is not so simple: another group of amusics performed poorly when deviations from isochrony were presented in the context of a changing pitch (Foxton *et al*., 2006), suggesting that pitch processing problems can limit the development of rhythmic and timing abilities.

Do people with amusia enjoy listening to music? Some people with amusia describe music as sounding like a noise or like banging, and go to great lengths to avoid being in situations where music will be played, while others, who are just as perceptually impaired, derive considerable pleasure from listening to music.

Music contains a myriad of sound elements and those who appreciate music may be getting pleasure from the tone colours used and/or the combination of instruments and rhythms that they hear. The reasons for such individual differences in musical appreciation are far from clear but such dissociations between perception and emotional appreciation are also seen in neuropsychological patients.

Does the condition run in families? A study by Denis Drayna (2001) using the 'distorted tunes test' (similar to the scale subtest of the Montreal Battery for the Evaluation of Amusia) with a group of identical and non-identical twin pairs, found that musical listening ability is about 80% heritable. Whether or not this level of heritability extends to amusia depends on whether amusia is found to occupy the tail end of the musical listening ability spectrum or to be a categorically distinct phenomenon. However, familial cases of amusia are common and pedigree analyses have suggested a pattern of autosomal dominant inheritance with imperfect penetrance (Kalmus and Fry, 1980). Genetic linkage studies of amusia are currently in progress.

Do these people have normal brains? People with amusia do not have a history of neurological damage and structural brain imaging using magnetic resonance imaging (MRI) does not reveal any gross anatomical differences. However, the technique of voxel-based morphometry allows structural MRI data from two groups, for example amusics *versus* non-amusics, to be interrogated with respect to potential regional differences in grey and white matter volume.

A recent study (Hyde *et al.*, 2006) using this approach revealed differences in white matter between amusics and control participants in the right frontal cortex, suggesting that abnormalities occur in areas outside of the auditory cortices. The involvement of right frontal cortex in musical perception is not unprecedented: an fMRI study revealed a similar area to be involved in the musical listening behaviour of non-amusic individuals when musical pitch has to be retained in memory (Zatorre *et al.*, 1994).

What can amusia contribute to our understanding of the brain? An understanding of amusia has implications

that extend well beyond our conception of normal and disordered musical processing. It provides a model that can be used to ask how potential changes at the genetic level impact upon brain structure function and, ultimately, behaviour. If amusia can be thought of as a disorder of connectivity, one might hypothesize that those genes which encode fibre tracking proteins will be found to be atypical. Though speculative at present, any such finding could shed light on a number of other developmental disorders. Though different development disorders are very different at the behavioural level, it remains possible that they are underpinned by a similar genetic mechanism operating at a different locus and/or at a different points during the developmental trajectory.

Where can I find out more?

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Essay

Alzheimer's discovery

Ralf Dahm

On November 3rd 1906, the young doctor Alois Alzheimer delivers a talk in which he describes the psychiatric symptoms and changed brain histology of his late patient Auguste D. This moment marks the first publication of what was to become one of the most infamous afflictions, the disease that today bears his name: Alzheimer's disease.

Alois Alzheimer (1864–1915) first encountered Auguste D. on November 26th, 1901. At that time, Alzheimer (Figure 1) was an assistant physician at the psychiatric institution in Frankfurt am Main. Auguste D., 51 years old, had been admitted the day before by her husband. For eight months she had been developing progressive changes in her personality. Her memory started to fail her and she began having difficulties organising the household and preparing food. Frequently she was lost in familiar situations and developed a fear of people she knew well. She became unduly jealous against her husband and at times even imagined that someone wanted to kill her and began to shout wildly.

At the clinic, Auguste D. was spatially and temporally disorientated, generally confused, anxious and reluctant to cooperate with the institution's personnel. When Alzheimer spoke with Auguste D., he noted that although she spoke clearly and articulated well, she often stopped mid-sentence as if she were at a loss or indecisive as to whether she was saying the right thing. When reading she often pronounced words in a meaningless fashion or spelled them out letter by letter. Also when writing, she repeated syllables multiple times, omitted letters or entire syllables and generally broke off rapidly (Box 1).

Alzheimer had never encountered a patient with such symptoms before. He was fascinated by Auguste D.'s case and decided to examine her more closely. The Frankfurt institution was a congenial place for his studies. Its director, Emil Sioli, implemented innovative approaches for the analysis and treatment of psychiatric disorders. Interviews with patients were seen as an important means to better understand their afflictions and the study of brain pathology was viewed as a central tool in psychiatric investigations — approaches not widely followed at that time. To further these aims, Sioli allowed his doctors to devote a substantial amount of time to their research interests.

To learn more about Auguste D.'s affliction, Alzheimer systematically interviewed her and recorded her answers in detailed protocols (Box 1). When he addressed her with specific questions, she often evaded them or her replies did not relate to his questions. When talking spontaneously, she frequently used paraphrases and inappropriate words or strings of words put together in wrong and senseless combinations. Generally, she named objects Alzheimer showed her correctly, but some she no longer recognised and did not know how to use them.

The case of Auguste D. as recorded by Alzheimer accurately describes the clinical symptoms of many patients suffering from Alzheimer's disease: her increasingly failing memory, notably her early problems to establish memories for recent events; her impaired comprehension, unpredictable behaviour and psychosocial inaptitude; her disorientation;