Talk of genetics and vice versa

Steven Pinker

Does our ability to talk lie in our genes? The suspicion is bolstered by the discovery of a gene that might affect how the brain circuitry needed for speech and language develops.

"Man has an instinctive tendency to speak, as we see in the babble of our young children," wrote Charles Darwin[1] in 1871, "while no child has an instinctive tendency to bake, brew, or write." Darwin's observation has just been supported in a way he could not have dreamed of, with the discovery by Lai and colleagues[2] (page xxx of this issue) of a gene that is mutated in a disorder of speech and language.

The possibility that human language ability has genetic roots was raised about forty years ago by the linguist Noam Chomsky and the neurologist Eric Lenneberg[3,4]. Chomsky noted that language is universal, complex and rapidly acquired by children without explicit instruction. Lenneberg pointed out that a small number of children fail to display this talent and that such deficits sometimes run in families. Deficits of this kind are now called 'specific language impairment', an umbrella term for language disorders that cannot be attributed to retardation, autism, deafness or other general causes. Specific language impairment not only runs in families but is more concordant in identical than in fraternal twins, suggesting that it has a heritable component[5]. But the inheritance patterns are usually complex, and until recently little could be said about its genetic basis.

Then, in 1990, investigators described the 'KEs' — a large family, of several generations, in which half the members suffer from a speech and language disorder[6]. This disorder is distributed within the family in a manner that suggests it is caused by a dominant gene, or a set of linked genes, on an autosomal (non-sex) chromosome. The press referred to it as a 'grammar gene' (Fig. 1), while sceptics suggested that it merely lowers intelligence or makes speech unintelligible, or even that the disorder is nothing more than an artefact of a working-class dialect.

Extensive testing by psycholinguists, including one of the authors of the paper in this issue[2], suggested that the disorder is more complex than either of these extremes[7,8]. Affected family members do tend to score below average in intelligence tests (perhaps because verbal coding helps performance in a variety of tasks). But the language impairment cannot be a simple consequence of low intelligence, because some of the affected members score in the

normal range, and some score more highly than their unaffected relatives. And although the affected members have problems in articulating speech sounds (especially as children) and in controlled movements of the mouth and tongue (such as sticking out their tongue, or blowing on command), their language disorder cannot be reduced to a problem with motor control. They also have trouble in identifying basic speech sounds, understanding sentences, judging grammaticality, and other language skills. For example, as adults they stumble at a task involving nonsense words that most four-year-olds pass with ease: completing sequences such as 'Every day I plam; yesterday I_____'[9].

In 1998 several of the authors of today's paper linked the disorder to a small segment of chromosome 7, which they labelled SPCH1 (ref. 10). Now, thanks to the discovery of an unrelated person known as CS, who has both a similar speech deficit to the KEs and a chromosomal translocation affecting the SPCH1 segment, Lai *et al.*[1] have narrowed the disorder down to a specific gene, *FOXP2*. In CS, this gene is disrupted by the translocation. In all the affected members of the KE family examined, but in none of the unaffected members, and in none of 364 chromosomes from unrelated, unaffected people, a single guanine nucleotide is replaced by an adenine. (The perfect contingency is in striking contrast to the now-you-see-it, now-you-don't correlations found in the first generation of searches for genes affected in behavioural disorders.) The authors propose that the nucleotide replacement results in substitution of the amino acid histidine for an arginine in one structure — the 'forkhead' domain — in the gene's protein product, presumably altering the protein's function.

Lai *et al.* present hints that *FOXP2* may have a causal role in the development of the normal brain circuitry that underlies language and speech, rather than merely disrupting that circuitry when mutated. *FOXP2* belongs to a family of genes that encode transcription factors (proteins that trigger the copying of genes into messenger RNAs), many of which have important roles in embryonic development. One of the defining features of proteins in this family is the forkhead domain, which contacts a target region in DNA, and it is this domain that is affected by the mutation in *FOXP2*. *FOXP2* appears to be strongly expressed in fetal brain tissue (among other places), and its homologue is expressed in the developing cerebral cortex of mouse embryos. In both CS and the affected members of the KE family, only one copy of *FOXP2* is disrupted. So Lai *et al.* suggest that, at a critical point in fetal brain development, affected individuals have only half the normal amount of functioning transcription factor, which is not

enough to control some aspect of early brain development.

Whatever the exact function of the gene turns out to be, the new work[2] has many implications. As a smoking gun for a genetic cause of one kind of language disorder, the discovery motivates the search for genetic causes for cognitive and learning disorders more generally, relieving the presumption of guilt from mothers (who are often still blamed for everything that goes wrong with their children). It also shows that just because a cognitive disorder has a genetic cause, it is not necessarily untreatable. The affected KE adults learned to compensate for their difficulty in generating complex linguistic forms by memorizing the forms whole and by consciously applying rules they had been taught in language therapy[11]. These and other strategies allow them to converse competently, although this has made life difficult for psycholinguists trying to work out the underlying disorder from the behaviour of affected adults.

If *FOXP2* really does prove necessary for the development of the human faculty of language and speech, one can imagine unprecedented lines of future research. Comparisons of the gene in humans to those in chimpanzees and other primates, and analyses of the types and patterns of sequence variation within the region of *FOXP2*, could add to our understanding of how human language evolved[12,13]. An examination of the functions and expression patterns of the gene (and of other genes it might set off) in fetal and adult brain tissue could shed light on how parts of the human brain are prepared for their role in cognitive information processing.

The discovery of a gene implicated in speech and language is among the first fruits of the Human Genome Project for the cognitive sciences. Just as the 1990s are remembered as the decade of the brain and the dawn of cognitive neuroscience, the first decade of the twenty-first century may well be thought of as the decade of the gene and the dawn of cognitive genetics.

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Figure 1 **Genes and speech: a new link is revealed by Lai *et al.*[1] in this issue.**