Language and genetics

Humans have a unique natural ability to develop highly complex linguistic systems — an ability that lies in our genes but is also shaped by our different environments. We can learn languages from others and use them to share our thoughts, feelings and desires; languages are the foundation of society, culture and science. So it is perhaps not suprising that all aspects of language — including structure, global distribution, acquisition, processing in the brain, role in thought and actions, and links with culture and education — can be considered to be important subjects of research.

What is so special about our genetic make-up that allows us to use language? How does this ability relate to other higher cognitive functions, like human memory and mathematical or musical ability? Until recently, it has been hard to even pose these questions. The past few years, however, have seen the rapid development of methods to analyse genes quickly and relatively cheaply. At last we can begin to study the genetic basis of human cognition and, hence, language. Three examples of ongoing research are described here.

LANGUAGE PROCESSING

The human genome does not 'create' languages; however, it does direct the organization of the human brain and some peripheral organs that are prerequisites for the language system, and is probably responsible for the significant differences in language skills between individuals. At the extremes are people with extraordinary gifts for learning many languages and undertaking simultaneous interpretation, and people with severe congenital speech disorders[1].

Exciting early results have identified a gene underlying one form of speech disorder known as verbal dyspraxia[2]. This serious impairment is characterized by problems in articulation, along with other linguistic symptoms. Genetic studies of an English family with verbal dyspraxia have shown that the condition results from a mutation in the gene, known as FOXP2 (Fig. 1) – located on chromosome 75, which affects the language areas of the brain via several intermediate steps. Although this speech deficit is rare, it now seems that the same genetic mechanism could play a role in other, much more common congenital speech pathologies.

However, FOXP2 is not a 'language gene' — that is a term coined by the media. The same mutation also affects the liver for example, and the non-mutated gene is found in many other animals, such as the mouse, which do not speak. Rather, it is one of many genetic components important in the development of language ability[3]. Nevertheless, its discovery was the first small breakthrough in understanding the genetic basis of human language[4].

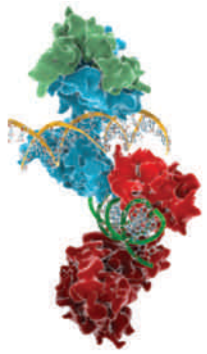
LANGUAGE AND POPULATIONS

Anthropologists believe that modern humans originated in Africa. Is there a link between the spread of languages and the genetic differences between the peoples who speak them?

Recent research using modern scientific methods has thrown up some surprises. One of the most interesting shows how genetic and linguistic classifications of populations can diverge. Most European languages belong to the Indo-European group. Two notable exceptions are Basque, which is relatively isolated, and the Finno-Ugric languages, in particular Finnish. Modern Finns have been found to be genetically close to Indo-Europeans, but genetically different from their Saami neighbours whose language is also Finno-Ugric[5].

Fig. 1 | The FOXP2 gene

Thought to be linked to speech disorder



One study is examining the effect of contact between prehistoric populations with different sociocultural backgrounds in different locations, particularly Africa and Siberia, on language and genetics. The types of contact that occurred are unknown, so it is hard to assess their consequences using only linguistic methods. Molecular genetic analyses can help spot a bottleneck, or founder effect, that might indicate a mixing of different populations, or reveal discrepancies between genetic and language relationships indicative of recent language drift[6].

Another study is addressing the development and spread of languages over larger geographical areas. The traditional methods of comparative historical linguistics, based primarily on similarities in vocabulary, can make sense of language evolution over only the past few thousand years at most. The new project adapts the widely used methods of evolutionary genetics — namely, the construction of phylogenetic trees (Fig. 2) — with the phonological, morphological and syntactic features of language as raw data, primarily to study the sophisticated languages and peoples of Melanesia (an area covering most of the islands north and northeast of Australia)[7].

The methods were developed and tested on a small well-researched subgroup of Austronesian languages and are now being applied to the much more complex relationships between the Papuan languages spoken in the same area. The results suggest that these languages derive from a common

The languages of the world, which form part of and are the main bearers of cultures, are highly diverse. The capacity to develop, learn and use them, however, belongs to our shared genetic heritage. These aspects of language are researched intensively at the Max Planck Institutes for Psycholinguistics, Evolutionary Anthropology, and Human Cognitive and Brain Sciences.

- Genetic methods have revolutionized research into many aspects of languages, including the tracing of their origins.
- Gene variants underlie individual language skills.
- Genetic predisposition might favour the evolution of structural features of languages.

phylum that is much older than the Australian languages, which arrived in the area only 3,000 years ago[8].

STRUCTURAL DIFFERENCES

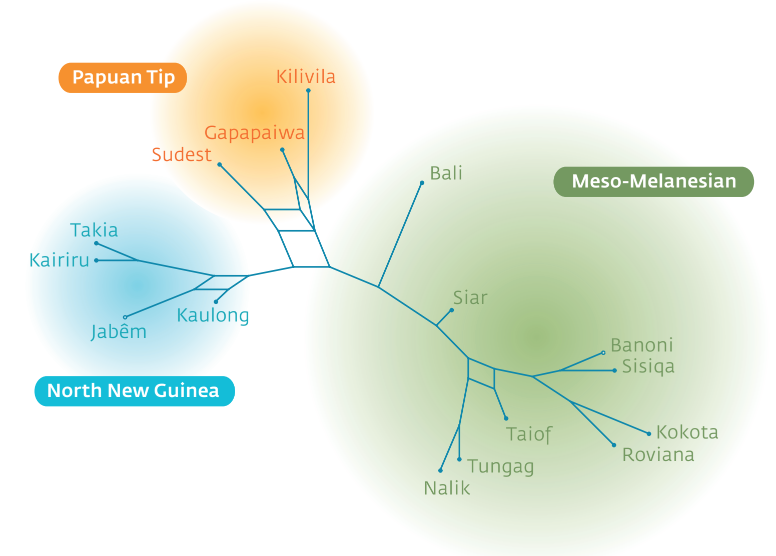
Languages are not inborn. There are approximately 7,000 languages in the world today, and learning any one of them is a lengthy process that takes around a decade. There is no reason why a Chinese child growing up in Germany should learn to speak German any worse than a German child or a child of any other nationality. A specific genetic predisposition, however, might influence the evolution of particular structural features of a language within a group of genetically similar individuals, for example whether the language is tonal or non-tonal.

Chinese is perhaps the most well-known of the tonal languages, in which a single syllable can convey different meanings according to whether it is spoken in a consistent tone or a rising, rising–falling or falling tone. The distribution of tonal and non-tonal languages corresponds closely with the distribution of two alleles, or forms, of the abnormal spindle-like microcephaly-associated (ASPM) and microcephalin genes[9,10]. Of course, alleles by themselves do not directly lead to the evolution and use of tonal languages; children with different forms of the genes will still be able to learn tonal languages. A particular genetic predisposition in a population, however, might favour the emergence of languages with particular structural characteristics. It is now possible to study whether there might also be a genetic predisposition to other structural properties, like poverty or richness of inflexion.

Science historians are familiar with the power of new technologies to revolutionize science. We are standing before an advance that will feel particularly close to home. Over the next decade or so, we can expect new genomics technologies to further our understanding of one quintessential aspect of being human: language.

For references see pages 94 and 95

Fig. 2 | Phylogenetic trees are used to study the sophisticated evolution of languages in Melanesia



Adapted from Fig. 7 in Ref. 2

left | While languages are not inborn, certain genetic predispositions in a genetically similar population may favour the emergence of languages with particular structural characteristics – an example thereof is the distinction between languages that are tonal (such as Chinese) and non-tonal (such as German).

Fig 1: Ramon Andrade, Science Photo Library / Photos: Jodi Cobb, National Geographic and Guang Niu, Getty Images