

acquisition of language by non-human primates Since the 1970s several research projects have introduced PRIMATES of various species to certain modes of non-verbal communication: natural SIGN LANGUAGE, invented systems of symbols to be communicated via a keyboard, plastic chips to be arranged in sequence. Many apes have achieved an impressive ability to use these systems to acquire food and other rewards. The most recent general assessment (Wallman, 1992) is however that there is no compelling evidence that the apes have acquired the ability to encode propositions syntactically (in contrast to human children who demonstrate such ability from the beginning of multiword utterance production).

See also: grammar

Reference

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bilingualism Ability to communicate in two languages (in more than two languages, multilingualism). A categorical distinction between 'real' bilinguals and non-bilinguals cannot be drawn; rather, there is a continuum from grossly unbalanced to closely balanced mastery of different languages. However, even the most balanced bilinguals differ in how they use their languages - a particular technical vocabulary may be primarily accessible in one language, for instance. The use of more than one dialect (for example, a regional and a standard variant), or of more than one speaking style (such as formal versus informal) draws on the same abilities to select situationally appropriate language.

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(ii) *Linguistics*: A unit formed of other separate instances of the same unit; for instance, a word formed from two other words, such as 'mail-box'.

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compound (i) *Chemistry*: A substance made of two or more elements (see PERIODIC TABLE OF THE ELEMENTS) joined together; a substance produced by the union of two or more separate components. For example, sodium and chloride are elements; sodium chloride - common salt - is a compound.

development of language-specific phonology During the first year of life INFANT SPEECH PERCEPTION becomes attuned to the PHONOLOGY of the environmental language. SPEECH PRODUCTION follows more slowly, but by

school age children command production of the PHONETIC contrasts displayed in the language of their environment. Faultless acquisition of more than one language-specific phonology is possible for children, but this ability declines rapidly from the teenage years. For adults, production and PERCEPTION OF SECOND LANGUAGES not acquired in childhood is difficult; in both, the native-language phonology interferes with the learning of a new system, causing 'foreign accent' in production and making perception more effortful.

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gender (i) *Linguistics*: Mutually exclusive formal grammatical categories into which languages may separate nouns.

(ii) *Biology*: The genetic sex of an individual as female or male, revealed by genotype (that is, XX for females, XY for males, in animals)- Gender is often viewed as fixed by genetic

factors which stimulate STEROID HORMONES to differentiate the anatomy and physiology of the individual along gender lines during PERINATAL development. This organizational groundwork is then built upon or activated by hormones during puberty: (1) to promote the adult neuroendocrine functions of the gonads (that is, egg production in the ovaries versus spermatogenesis in the testes); (2) to generate secondary sex characteristics (such as growth of facial and body hair, muscle development and deepening of the voice in males; growth of breasts, hip widening and fat deposition in females); and (3) to act on different regions of the brain to promote patterns of release of HORMONES, behaviour or cognitive function that are sexually stereotyped (for example, LORDOSIS in females versus MOUNTING BEHAVIOUR in males). Thus, by adulthood, the gender of most individuals can be recognized by their PHENOTYPE, behavioural patterns or neuroendocrine functions. Gender, as determined by genetic sex, is not always consistent with an individual's gender identity, sex role, or sexual orientation. For example, there are cases in which genetic XY males have had their penises mutilated during postnatal circumcision. Such males are reassigned as females, given appropriate surgery to produce female external genitalia, raised as females in society, and given ESTROGEN and PROGESTERONE during and after PUBERTY to promote and maintain the growth of female secondary sex characteristics. Some of these individuals become the 'other' sex without ever knowing the truth, whereas others do not display a gender identity consistent with the reassignment. Nature also provides genetic mutations that make it difficult to determine gender. Several mutations exist in which chromosomal structure is altered, leading to ambiguous phenotypic traits. Persons can be born with XXY (KLINEFELTER'S SYNDROME), XYY, XXX (TRIPLE-X SYNDROME), XXYY, or XO (TURNER'S SYNDROME) chromosomal structures. Some are born with hermaphroditism, for example, as XX females with CONGENITAL HYPERPLASIA of the ADRENAL GLAND that has resulted in a Partial penis, partial vagina, partial uterus, and malformed ovaries. Some are born as XY males with ANDROGEN INSENSITIVITY SYN-

DROME that has resulted in external differentiation as a female (although such individuals are sterile). As with cases where the penis has been removed, the sex of these individuals is often reassigned. Such surgical, hormonal and social intervention can create a gender identity consistent with the external gender, but is no guarantee.

See also: feminine; organization effects of steroid hormones; sex differences; sexual differentiation; sexual dimorphism

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proposed by the linguist Noam Chomsky, of grammar as a device for generating all and only the permissible sentences of a language. Transformational grammars - again due to Chomsky - capture the relations between different syntactic forms expressing the same underlying proposition. Thus 'Jack built the house', and 'The house was built by Jack' may be described as having a common underlying structure, with the addition of a passive transformation in generating the second. 'Colourless green ideas sleep furiously' is Chomsky's famous example of a sentence which is syntactically permissible though meaningless; it illustrates the separability of syntax and SEMANTICS. (In certain contexts this sentence is now however highly likely, and thus also illustrates the separability of semantics and frequency of occurrence.) Just as different syntactic forms can express one underlying proposition, so can the same form express more than one meaning: English grammar generates 'Charles is the man I want to succeed' to convey at least five propositions (I want Charles to have success; I want to follow Charles; I need Charles if I am to have success; I want Charles to follow [X]; I need Charles if I am to follow [X]). *Grammatical words* (or function words) are words which primarily perform a syntactic function - such as articles, conjunctions, prepositions, pronouns. They contrast with lexical, or content words: nouns, verbs, adjectives. Languages differ according to whether they largely use independent words for such syntactic functions (as English does), or whether they prefer some other means such as affixes or word order. The degree to which thematic relations of case (for instance, subject, object, instrument), verb mood (for instance, factual, possible) and aspect (for instance, completed, uncompleted) are explicitly represented by the grammar also differ widely across languages. So, again, does preferred order for the basic propositional relations subject, verb, object; across the world's languages all possible orderings may be observed.

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grammar The grammar of a LANGUAGE is the set of rules controlling the permissible sentences of that language. Grammatical sentences are those which speakers of the language accept as well-formed, ungrammatical sentences are those which they cannot accept. In its widest sense, grammar includes a language's SYNTAX, MORPHOLOGY and PHONOLOGY, and Permissible semantic structures. In narrower senses it refers to the permissible sequential structures of words within sentences - that is, syntax plus morphology. Grammars can also be books describing the grammar of particular languages. *Generative grammar* is the notion,

grand mal seizure

Grassman's Laws

Guide, Cambridge University Press: Cambridge.

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infant speech perception Speakers of all languages begin life with identical LANGUAGE processing systems, but attune to the PHONOLOGY of the environmental language during

their first year. Early in that year infants discriminate many PHONETIC contrasts, but by mid-year they begin to acquire the relevant environmental phonological categories; at about 10 months they are, like adult listeners, inattentive to contrasts not used in the phonology of the environmental language. PERCEPTION OF SECOND LANGUAGES in later life is not helped by this efficient early specialization.

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language The human faculty of communication; or, a system of spoken communication particular to a community. 'Man has an instinctive tendency to speak', wrote Charles Darwin (1809-1882) in *The Descent of Man*. Human beings acquire language from their environment without explicit instruction being necessary; and although unimpaired individuals will naturally acquire spoken language, SIGN LANGUAGE can also be acquired via environmental exposure. A human being who is exposed to no linguistic input at all in childhood will however fail to acquire normal linguistic competence; in particular, the individual's command of GRAMMAR will be impaired. Language is species-specific (see ACQUISITION OF LANGUAGE BY NON-HUMAN PRIMATES), and is supported by specialized language areas of the brain, especially in the FRONTAL LOBE and TEMPORAL LOBE of the LEFT HEMISPHERE (BROCA'S AREAS, WERNICKE'S AREAS); damage to these areas results in APHASIA.

The particular linguistic system acquired by a developing human will be that of the environment, not of the individual's progenitors: a child of English-speaking parents adopted as an infant by Eskimos will acquire perfect Inuktitut, not English. In childhood, more than one language can be acquired easily (see BILINGUALISM), but languages acquired after childhood will rarely be acquired to full competence, especially in their phonological system (see DEVELOPMENT OF LANGUAGE-SPECIFIC PHONOLOGY).

Eastern African hominids dated by archaeologists at about 100 000 years ago display the lower larynx and larger pharynx characteristic of modern humans, and may have been the first of our ancestors capable of wide-ranging vocal communication. There are currently around 5000 distinct languages in the world, most of which can be grouped into 30 or so language families. English is a member of the West Germanic branch of the Indo-European family, which includes most of the languages of Europe, parts of the Near East, and the Indian subcontinent. It is hard to define what counts a distinct language versus a dialect; such distinctions are more often drawn for political

rather than linguistic reasons. Norwegian and Danish are thus termed separate languages although they are largely mutually intelligible, while Alabama English and Newcastle-upon-Tyne English, or Neapolitan versus Genoan Italian, each pair of which may fail the mutual intelligibility test, are held to be, respectively, dialects of English and Italian. The most important properties of natural language are: (1) the encoding of meaning via sound is arbitrary: with only extremely rare exceptions, the form of language is independent of the meaning it signifies. ('Language' is no more transparent of its meaning than 'Sprache' or 'langue'.) (2) Language is compositional: sentences, words, syllables, phonemes are all composed of elements which can be combined in other ways to make other sentences and so on. (3) Language is systematic and rule-governed. Rules of grammar apply to the order of words within sentences, rules of MORPHOLOGY to the order of morphemes within words, rules of phonology to the order of phonemes within syllables, and so on. In English, *man bites dog* is a possible sentence, but *bites dog man* is impossible; *un-November-y* is a possible word coinage, but *y-November-un* is not; *slomp* is a possible syllable but *lsopm*, *oslmp* and *pmlso* are not. (4) Language is creative; most sentences that a language user speaks, hears (and reads or writes) are novel, at least to that person. Further, because the grammars of natural languages allow recursive operation, every language user is in principle capable of producing an infinite number of different sentences.

The language faculty in humans is not simply dependent upon general cognitive abilities; retarded individuals, with for example WILLIAMS SYNDROME, may have unimpaired linguistic competence, while the condition known as SPECIFIC LANGUAGE IMPAIRMENT is just that - mental impairment which is specific to the use of language, while other cognitive abilities are in principle intact. Language may be encoded in secondary representations such as WRITING. In contrast to the development of spoken language in childhood, the use of such cultural forms of representing language - that is, reading and writing - can only be learned via explicit instruction. Written language,

which serves to transmit meaning in the absence of personal contact between the producer and the comprehender, differs from spoken language in many ways: it tends to be more formal, and more elaborate (sentences with several subordinate clauses, and parentheses, such as this one, are more likely to occur in written than in spoken language); it tends to contain fewer contextually bound expressions such as *here* and *this* than spoken language; and in many orthographies writing provides a structural system of punctuation with no direct parallel in speech. Disorders of reading and writing due to developmental impairment or brain injury may also exist independently of other areas of linguistic competence (see ALEXIA, DYSLEXIA, AGRAPHIA, DYSGRAPHIA).

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lexicon (mental lexicon) The MEMORY store containing the pairing of word form and meaning for all vocabulary items a person knows. These may be single WORDS, or compound words (*look up; hot dog*), or fixed phrases (*good heavens; break the ice*), or stems (*hensch-*), or affixes (*un-, -able*). The content of the lexicon differs across languages, some languages having mostly stand-alone words, others mostly stems and affixes. The size of an educated adult's lexicon has been estimated at over 150000 entries. Access of the lexicon in WORD RECOGNITION involves mapping a word form (spoken or written) onto its meaning; in SPEECH PRODUCTION meanings are activated first, word forms later.

See also: language

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morphology The internal structure or make-up of entities, such as words (in linguistics), animals, plants and their constituent cells (in biology), or the earth and its features (in geology).

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motor theory of speech perception The theory that holds that speech is perceived via recognition of the speaker's intended phonetic gestures; early statements of the theory proposed invariant motor commands underlying the articulatory gestures corresponding to the PHONEME being uttered, but later the invariant feature was proposed to be the (more abstract) intentional structures controlling articulatory movements. Heterogeneity and interdependence of gestural cues to a single phoneme however pose serious problems for the model (see Klatt, 1989).

See also: speech perception

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pellet

perception of second languages

perception of second languages The DEVELOPMENT OF LANGUAGE-SPECIFIC PHONOLOGY in childhood is highly efficient, and effectively tailors SPEECH PERCEPTION to the native

language. In consequence, perception of second languages acquired beyond childhood becomes inefficient: PHONETIC contrasts absent from the native language are not easily perceived (for example, English [r] and [l] for Japanese-speakers) and segmentation of continuous speech into individual words is difficult (subjectively, the second-language speech seems too fast to keep up with). Listeners use segmentation procedures which exploit aspects of language-specific PHONOLOGY such as rhythm, and where native and second languages differ in rhythm, these procedures are inefficient, even counter-productive.

See also: word recognition

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phobic anxiety

phonological dyslexia

phoneme A speech sound such as a vowel or a consonant; the smallest independent unit capable of distinguishing two WORDS - for example, *grammar* from *glamour*.

See also: phonetics; phonology

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(i). Phonology is distinguished from PHONETICS. Phonology tells us that *leaping* and *reaping* are different words in English (but such a contrast does not exist in the phonology of Japanese); and that the first phoneme of *leaping* is the same as the last phoneme of *ball*. Phonetics tells us that in most English dialects these two realizations of the same phoneme are pronounced quite differently.

See also: speech production; speech perception

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phonological store A limited-capacity SHORT-TERM MEMORY system that briefly retains spoken information. The memory traces of information held in this store fade and disappear within one to two seconds, but a process of REHEARSAL can ensure continued retention. The phonological store is assumed to play an important role in LANGUAGE acquisition, spoken-language comprehension, and learning to read.

See also: articulatory loop; central executive; working memory

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phonology (i) The system and patterns of sounds occurring in a given language. Phonology includes both segmental (see PHONEME) and supra-segmental patterning (see PROSODY). (ii) A branch of linguistic science: the study of

prosody This term is used to refer to the norms of verse metrics (by students of poetry); to the abstract organizational structure which determines the grouping and relative salience of phonological units (mainly by phonologists); to the linguistic structure expressed in the supra-segmental properties of utterances (mainly by phoneticians and psycholinguists); and to the supra-segmental properties themselves - the PITCH, tempo, LOUDNESS and TIMING patterns of speech (mainly by speech researchers in applied PHONETICS and engineering). All definitions relate to the original Greek meaning of a sung accompaniment, and all would include accent, stress and rhythm as aspects of prosody.

See also: phonology

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sign language A gestural LANGUAGE used by the deaf and hearing-impaired. Many sign languages exist, having developed separately from spontaneous gestural systems of deaf people in different lands, and sign languages are, unless related, not mutually intelligible. The GRAMMAR of sign language is as abstract and complex as that of spoken language; its realization in space exhibits structure analogous to the PHONOLOGY of spoken language; and sign languages possess universal characteristics found in all natural languages. Early exposure to sign language exploits the deaf child's language-learning abilities and can avoid cognitive development being slowed by the unavailability of auditory language input.

See also: auditory perception; deafness

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sleep walking

slow-wave sleep

EMOTION, fatigue and drunkenness may render malfunction in speech production more likely.

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slips of the tongue Speech errors, involving mis-selection, misordering or misformation of parts of an intended utterance. Slips of the tongue are not intentional (as puns or word play), nor do they result from deficits in articulatory (as a lisp) or linguistic competence (as misuse of a word); they arise through temporary malfunction of the normal processes of SPEECH PRODUCTION. They can involve linguistic units at any level - sound, MORPHEME, word, SYNTAX, meaning. Slips of the tongue do not necessarily provide evidence of underlying states of mind, although intense

speech perception This term refers to the process which transforms the auditory representation derived by peripheral AUDITORY PERCEPTION into a representation which can be used to access the LEXICON. The acoustic signal corresponding to a particular lexical representation is highly variable: the length and shape of vocal tracts differ as a function of age, sex and body size; speakers can be nearer or further away, tired or excited or angry, speak-

ing slowly or rapidly; they can have a cold in the nose or a mouthful of food; there may be barriers intervening between speaker and hearer, or background noise. This extreme variability motivates the assumption that speech perception converts the acoustic input into a relatively abstract (or normalized) form to use for lexical access. Since the lexicon is very large, it is also attractive to propose that this conversion process makes use of a small set of sub-lexical units. Candidate sub-lexical units have been the units of analysis used by linguistics, with the PHONEME the most popular choice because (by definition) it is the smallest unit into which speech can be sequentially decomposed. However phonemes do not possess constant, invariant properties. They are variable due to the factors described above; and they are subject to co-articulation - that is, the acoustic form of phonemes conveys information not only about the phonemes' own identity but also about the nature of their phonetic context. Other candidate units include (below the phonemic level) featural representations or spectral templates, and (above it) SYLLABLES, DEMI-SYLLABLES AND DIPHONES (the syllable 'keep', phonetically [kipl, consists of two demi-syllables: [ki], [ip], and four diphones: when 'keep' is uttered in isolation these are silence-to-[k], [k]-to-[i], [i]-to-(p), [p]-to-silence). Research in speech perception has chiefly addressed the factors determining listeners' identification of phonemes. Phoneme identification tends to be categorical; this can be shown with a continuum of sounds progressing in equal steps from a clear realization of one phoneme to a clear realization of another. (For example, a continuum from |pi| to |bi| formed by shortening the voice onset time - time between release of the lip closure and beginning of the vowel.) Listeners will identify the sounds as belonging to one category or the other, not as between the categories. Phoneme perception also involves sensitivity to the contextual variability of phonemes, in that listeners adjust their expectations of different cues for a phoneme according to the context in which it occurs. For example, voice onset time can be evaluated in relation to the duration of adjacent vowels.

See also: motor theory of speech perception;

phonology; speech production; word recognition

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speech production To produce speech, the speaker expels air from the lungs through the vocal tract, and modulates the airflow by changing the vocal tract's shape and moving the tongue against the lips, teeth, alveolar ridge (behind the upper teeth) and palate, thus creating speech sounds. Voiced sounds (vowels, many consonants - for example [d], [l], [m] and [v]) involve audible vibration produced by the vocal folds in the LARYNX; unvoiced sounds (other consonants - for example [t] and [f]) are produced without such vibration. The speech sounds are produced in a smooth continuous manner which has the effect that the articulation of a sound overlaps with the articulation of adjacent sounds (known as co-articulation). One result of this is that the same PHONEME can be produced differently in different phonetic contexts (compare the [k] in 'key' and 'caw'). The production of sounds is the final stage of a process that begins with the planning of a message to be spoken, and continues via the selection of words and syntactic structure to convey this message, the determination of the appropriate phonological structure (including prosodic form) of the chosen sequence of words, and the specification of the precise phonetic form to be articulated. The selection of words from the mental LEXICON in speech production proceeds in two stages: first conceptual representations are mapped onto the meaning representation of words, then the phonological forms linked with these meaning representations are activated. The construction of syntactic form is in part dependent on the precise words chosen and in part on the conceptual content of the message. Speech production sometimes goes wrong, and such SLIPS OF THE TONGUE can occur at any level of

production: choosing the concept ('Pass the dog' instead of 'pass the salt' when the speaker is looking at the dog), selecting the words (instead of 'Sunday' the semantically related 'Monday' or the phonologically related 'summer'), constructing the syntax ('the boys who I saw the boys'), determining the phonological form ('Lunday sunch' for 'Sunday lunch'); and many more. Slips can thus provide evidence about the processes and stages involved in speaking. During speech production speakers monitor their output and may repair infelicitous or faulty utterances; this monitoring can also apply to any aspect of the output - style, content, words, syntactic form, pronunciation. What aspects of the output are monitored depends however on where the speaker's attention is directed (a non-native speaker may concentrate on careful monitoring of pronunciation, a witness in court may concentrate on correct choice of formal style, etc.)

See also: grammar; phonology; prosody; speech perception

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stress (linguistic)

stria medullaris

stress (linguistic) Accentuation of syllables within words, or words within sentences.

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syncope

systole

syntax (i) Grammar, or the structure of permissible sentences in a language; (ii) a branch of linguistic science: the study of [i].

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word recognition Perceiving language is a RECOGNITION process: perceivers cannot know in advance what an incoming message will be, but must understand it via recognition of the parts of which it is made up - the WORDS which they already know and have stored in their mental LEXICON. Any language user knows tens of thousands of different words; but these are constructed of only a handful (on average, 30 to 40) different sounds in the PHONETIC repertoire of the language (and represented in written form by only a handful of elements, for example, the 26 letters in the alphabet used for English). The consequence of this is that words inevitably resemble other words, and may have other words embedded within them (thus 'great' sounds like 'grape' and 'crate', and contains 'grey' and 'rate' and 'eight'; its written form looks like 'greet', and contains 'eat'). Word recognition therefore involves identifying the correct form among a large number of competing forms. The recog-

nition of spoken words takes place in time - words are not heard all at once, but from beginning to end. Further, words usually occur in longer utterances of continuous speech, in which there are no reliable cues to where one word ends and the next begins. Thus listeners must segment utterances into the portions which correspond to individual words. Research on spoken-word recognition has addressed the temporal course of the activation of lexical representations, competition between similar and overlapping words, and the effects of unclear or distorted speech sounds. The recognition of written words is, in most orthographies, facilitated by explicit coding of the boundaries between lexical units - for example the spaces between words in written English, or the separation of characters in written Chinese. Research on written-word recognition has addressed the question of whether a written form is recognized directly or activates the phonological (see PHONOLOGY) form of the word, and on the way in which different orthographies are read. Finally, the form of words varies widely across languages; some languages (such as Turkish) construct words from stems with very many morphological affixes, while other languages (such as Chinese) use virtually no affixes but allow many cases of a single form encoding multiple meanings; some languages distinguish between closely related words, such as different forms of a verb, by means of affixes (English for example), while others vary the sounds within the word (Hebrew for example); and there are many other types of variation, so that word recognition necessarily involves some language-specific aspects.

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Eimas, pp. 138-179, Academic Press: New York.

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words Independently combinable units contributing meaning and/or function to a sentence.

See also: lexicon; grammar; phoneme

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