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Chapter 14
Psycholinguistics

Key Ideas in this Chapter

- Language is a biological and psychological phenomenon as well as a social and cultural one.
- Psycholinguists study how language is stored in the mind (MENTAL REPRESENTATION) and how it is used during speaking, listening, reading, writing, and signing (PROCESSING).
- Neurolinguists study the brain structures and neurological processes underlying the mental representation and processing of language.
- These brain structures and processes are concentrated in the left cerebral hemisphere for most people, with a special role played by neural circuits in Broca's area and Wernicke's area.
- Broadly speaking, theories of mental representation and processing fall into two classes: CONNECTIONIST accounts, which are closer to the complex biological reality of neural circuits; and MODULAR accounts, which are closer to the kinds of symbolic descriptions of language used throughout this book.
- Language production involves the rapid selection of linguistic structures on different levels. In speaking, it starts with the activation of meaning and finishes with the articulation of speech.
- Language comprehension is more of a 'guessing-game', in which cues from accumulating speech (or text or signing), context and background knowledge, are all exploited in parallel to make understanding happen at lightning speeds.

14.1 INTRODUCTION

In books and films from the genres of science fiction and fantasy, one encounters characters who can read the thoughts of others and/or communicate their own thoughts without using a physical channel. Sometimes it is a specialized skill that only some individuals possess, like several wizards in the *Harry Potter* books, or the Jedi knights in the *Star Wars* movies. And sometimes it is a property of a whole species, like the Vulcans on TV's *Star Trek*, or the elves in Tolkien's *Lord of the Rings*. There are also many entertainers from our own real-life species who have claimed such powers – perhaps most famously Uri Geller, who could also bend spoons by 'mind power' alone.

But telepathy is a physical impossibility, and if it *were* something that human beings were capable of, then we wouldn't need language. In a sense, language is the next best thing to telepathy, and indeed we could argue that it has distinct advantages over it. Spoken and signed language works to communicate and construct meanings with others at lightning speeds and, because we can 'switch it on and off' in production, we can keep our thoughts to ourselves most of the time (useful for privacy, modesty, good taste, subterfuge, *etc.*).

From this perspective, language is a property of the human mind, a psychological system housed in the brain. It is this system that allows human minds to interact through the physical channels of speech, text and sign (the medium of sign languages for deaf people and those whose hearing is impaired). So although in most of this book we concentrate on its social nature, we must always bear in mind that language is also simultaneously psychological. It is constructed in infancy inside our brains, develops there throughout our lives, is activated there whenever we read, write, listen, speak or sign (even to ourselves), and can be lost or compromised if our brains are impaired through injury, illness or old age.

The area of study which explores these issues, psycholinguistics, is our principal concern here. In this chapter, we examine language from the perspectives of brain and mind, and introduce two major kinds of psycholinguistic theory, before sketching some of the processes involved in speaking and listening. There is a separate chapter for one central topic in psycholinguistics, LANGUAGE ACQUISITION, which studies the way in which human beings construct language systems in their minds, in infancy and adulthood (→ 15).

14.2 LANGUAGE, COGNITION AND THE BRAIN

Before we address some of the core issues in the psychology of language, we should try to clarify the difference between mind (an abstract concept) and the brain (a physical entity). As part of human COGNITION, linguistic communication involves mental processes and happens almost instantaneously, so to that extent resembles telepathy. But it is not a supernatural phenomenon: language is very physically grounded, a function of the organic brain. It necessarily involves MOTOR CONTROL on the part of the speaker, writer or signer to generate and direct the physical energy required to span the physical gap between producer and receiver,

Human COGNITION refers to the mental processes, both conscious and unconscious, involved in the ways we perceive, learn, remember, know, categorize, and connect information – and thus how we reason. It is studied by psychologists, linguists, philosophers, neuroscientists, anthropologists, computer scientists and others.

and it relies on SENSORY PERCEPTION on the part of the receiver to *hear* speech and *see* text or sign.

From this perspective, language is a system, located in the brain, which outputs motor activity through the **vocal tract** in speech (➔ 9, 10) and the upper limbs in writing and signing, and receives sensory input through the ears in listening, the eyes in reading text or understanding sign, and the finger tips for reading braille. But how can abstract phenomena like morphemes, word meanings, verb groups, and discourse principles be stored and operate in the organic material of the brain? Where exactly in the brain is language located, and what actually happens when we use it? This is part of a larger question about the relationship between physical and mental structures and processes, or in other words about how the functional architecture of the brain relates to its physical workings.

The terms *input* and *output*, like many used in psycholinguistics, are borrowed from computer science, a rich source of metaphors for trying to understand how the mind works (but not always helpful if the analogy is pushed too far).

Activity 14.1

If you are or were a reader of British children's comics, you might be familiar with 'The Numskulls' from the *Beezer* (and later the *Beano*), relating episodes in the mental life of an unnamed man. Take a look at Figure 14.1, and make a list of the problems it presents as the basis for an explanation of how the mind, the brain, the senses and language work.

The main problem with a Numskull-style representation of cognitive systems like language is that it explains away thinking, seeing, hearing etc. by populating our heads with 'mini-me's' that do the thinking, seeing, hearing etc. for us. But of course this is circular: it cannot be the case that the way we see things is by the images passing through our eyes and then themselves being 'seen' inside our heads. Or that we remember things because someone or something inside us writes them down, or stores an image of them, that 'we' can 'look at' at a later date. Explanations like these are called *homunculus* arguments, from the medieval idea of the 'little human' (the soul) within each of us. They are arguments of infinite regress: presumably the Numskulls (the 'homunculi' of the comic) can talk to each other and read and write because they themselves have mini-Numskulls in their own heads, who have mini-mini-Numskulls inside *their* heads, and so on, *ad infinitum*.

There are essentially two different strategies we can adopt to study cognition (as well as sensory perception and motor activity), and neither of them require the postulation of 'homunculi'. We can take the closest possible view, that of COGNITIVE NEUROSCIENCE, and examine the physical structures that underpin cognitive processes. Or we can step back and take a more general view, that of COGNITIVE PSYCHOLOGY, in which we abstract away from physical structures and processes to highlight more general informational ones (the mind's 'functional architecture'). In practice, psycholinguists draw on methods and insights associated with both strategies. For example, to investigate how morphologically complex words are processed, they might conduct experiments in which people are asked to read prefixed words, suffixed words, and bare stems, using NEUROIMAGING techniques from a neuroscience perspective, and CHRONOMETRIC techniques from a psychology perspective.

Functional NEUROIMAGING (➔ R4.1) measures activity in the brain during different kinds of mental activities to see which areas are activated. CHRONOMETRIC TECHNIQUES measure reaction times to different kinds of stimuli (here linguistic structures), and the times are taken to reflect processing complexity.

If the difference between the two perspectives is not clear, maybe an analogy will help. Think of an image file on a computer, like the one in the lower panel of Figure 14.2. If you

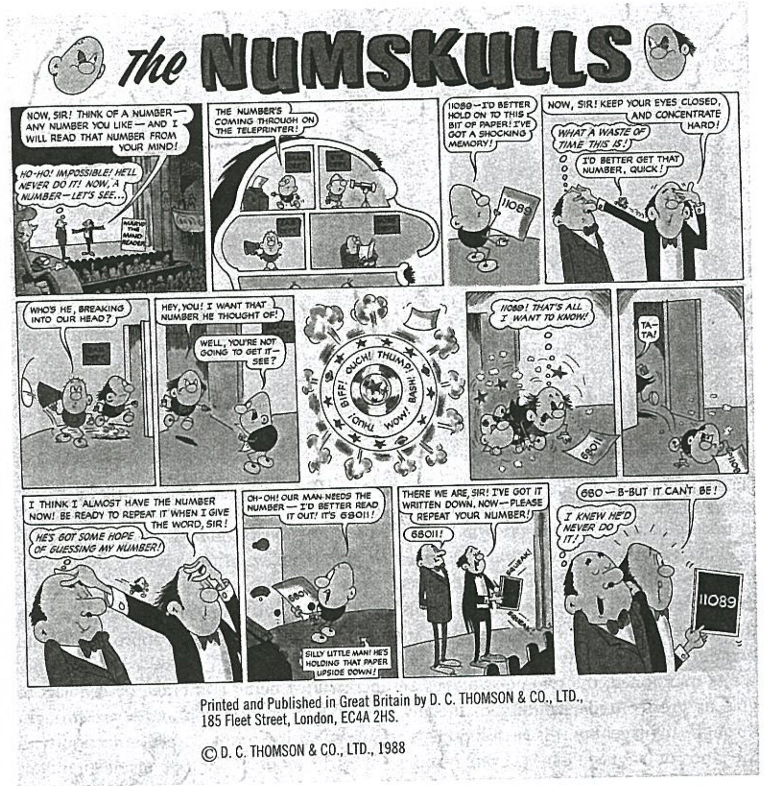


Figure 14.1 An episode of 'The Numskulls' from *The Beezer*, published by DC Thomson and Co. Ltd 1988

are interested in the mechanics of how the photo is formed and how the whole is composed of its constituent parts, you can zoom in to examine how the different parts of the image are represented via shades of greyscale in a particular pattern of pixels (as in the detail of the central section of the main window presented in the upper panel). Or, if you are interested in what the photo *represents*, you can look at the whole image and contemplate a church, with all the encyclopaedic knowledge (➔ 6.1.2) that recognition of the image as a church might trigger. It is at this level also that you might recognize it as a particular *instance* of a church (York Minster) that you have encountered before in a photo or on a visit.

This is the essential difference between looking at language in the brain and looking at language in the mind. **Neurolinguistics** concentrates on language in the brain (≈ how

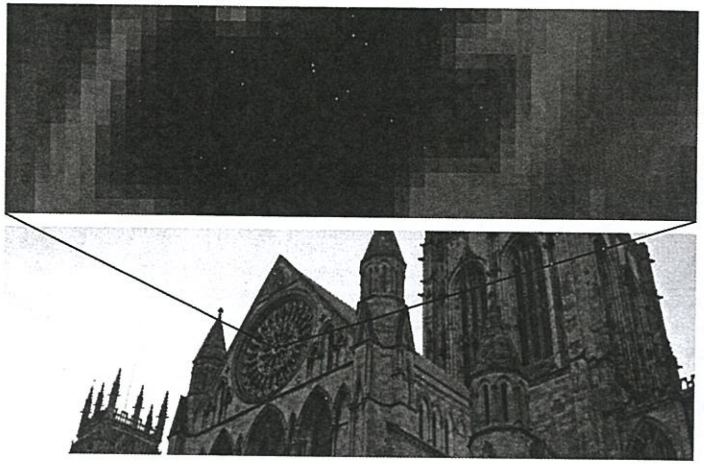


Figure 14.2 Partial image of York Minster from the south, with zoomed-in detail of the centre of the Rose Window (photo: James Bozadjian)

the pixels form the image), while psycholinguistics studies language in the mind (≈ what the image represents). Brain and mind are essentially the same thing, approached from two different perspectives.

As mentioned, the two perspectives are increasingly being combined by scholars to give us greater understanding of the mystery of how we develop and share thought through language. But it is *psycho*linguistic research that has more direct connection with the kinds of language issues covered in the rest of this book. If we look inside a random adult human brain using neuroimaging techniques or dissection, we can't tell which language(s) the individual knows (➔ 16), nor whether they are speakers or signers, literate or illiterate (➔ 1). We can't estimate the size of their vocabulary (➔ 5) or know which dialect they speak (➔ 12). But we *can* locate and measure different kinds of language activity, and this can inform psycholinguistic theory in important ways, as we demonstrate in the rest of this section.

14.2.1 How the brain works

The human brain is a physical organ of immense structural complexity which operates on the basis of, as yet, only poorly understood principles. The workings of the brain can perhaps best be understood in terms of an immense network or system of circuits, through which information flows in parallel, in a constant frenzy of electrochemical currents. The circuits are composed of billions of cells (NEURONS), connected through SYNAPSES. Neuronal networks together constitute a set of anatomical structures which stretch all the way from the nerves in your toes, up to the spinal cord, through the brain stem and thence to the two CEREBRAL HEMISPHERES, the bulging top of the brain made up of a left and a right half. Nerve endings all the way around the body allow us to experience localized sensations (like being tickled on the soles of the feet) and to move the different parts of our bodies independently of each other (e.g. using a foot to depress the accelerator pedal on a car).

Up in the head, the 'higher order' mental functions associated with cognition are mostly under the control of dense neural networks in the CORTEX, a layer of tissue only 2–4 mm deep covering the cerebral hemispheres. The left and right hemispheres, connected together by a bundle of nerve fibres called the CORPUS CALLOSUM, mirror each other in their 'formal architecture', but differ in significant aspects of function. For example, circuits in the *left* cerebral hemisphere control motor activity and sensory input associated with the *right* side of the body, and vice-versa (➔ R4.8). Thus, the operation of a car's accelerator starts with activity in your left cerebral hemisphere, even though the pedal is depressed with the right foot.

Also, the left cerebral hemisphere is more involved in analytic processes involving temporal sequencing (like adding numbers together or playing chess), whereas the right has greater responsibility for holistic processes involving spatial dimensions (like steering your car round a corner or admiring a large painting in a gallery). The memory systems underlying your ability to perform these activities are physically grounded in the interconnected neural circuitry of the hemispheres (and in other brain structures we will not discuss here). During actual performance, energy passes through the circuits in patterned ways, activating different portions of the neuronal network, and this results in sensory experience, logical or intuitive reasoning, voluntary and involuntary movement, etc.

Distinct areas of the cortex in both hemispheres are specialized for different sensory and motor control functions. In Figure 14.3, we have indicated the approximate

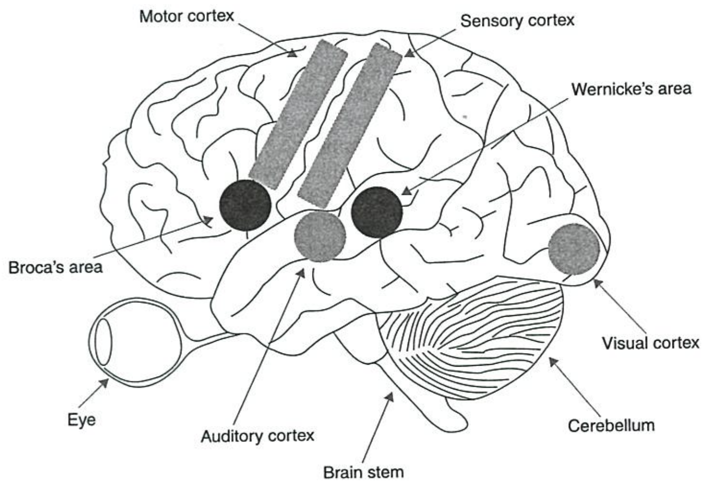


Figure 14.3 The left cerebral hemisphere of the brain (with eye to indicate orientation), showing the approximate location of significant regions

location of the MOTOR CORTEX and the SENSORY CORTEX, on either side of a central fissure that runs down from the top of the head to above the ear. Neural circuits in the former control movement in different parts of the body, depending on the circuits' location in the cortex, while those in the latter are responsible for sensory experience in corresponding regions. For example, wriggling the toes (movement) and stubbing them (sensation), are both associated with the lowest regions of the motor cortex and sensory cortex. Two other regions, the AUDITORY CORTEX and VISUAL CORTEX, are concerned with detailed handling of input from the ears and eyes, respectively. The specialization of distinct neurological structures and areas like this is known as MODULARITY.

14.2.2 Language in the brain

A person's knowledge of the nuts and bolts of language is encoded in constellations of neurons that for most people are concentrated in the left cerebral hemisphere. Over 95 per cent of right-handed individuals are left-dominant for language, as are around 70 per cent of left-handed individuals; of the remainder, half are right-dominant, and half appear to have language spread across both hemispheres (see Fernández and Smith Cairns 2011: 84–89). It should come as no surprise that language shares the same hemisphere as analytic processes such as arithmetic and chess-playing. As described at length in the central chapters of this book (→ 7–11), language use involves the coordinated sequencing and patterning of separate units on various different levels, from phonemes to sentences. Just like maths and chess.

Within the dominant hemisphere, there is evidence that different units of language structure, and different stages and processes of language use, are associated with different anatomical regions. This also should not be surprising, given the cortical modularity for sensory processing and motor control that we have already noted. Comparisons of the language of people with brain damage, post-mortem examination of brains, and neuroimaging from impaired and unimpaired brains, suggest that there are two particular areas associated with language, on either side of another major fissure, the SYLVIAN FISSURE, which runs roughly back from behind the eye to above the ear. These two areas are named after the nineteenth-century physicians who first associated them with language functions: Paul Broca (BROCA'S AREA) and Carl Wernicke (WERNICKE'S AREA).

Exactly which aspects of language structure and use are associated with which area is a matter of considerable debate. Originally it was thought that Broca's area controlled the processes involved in speaking and that Wernicke's area controlled those for listening. The proximity of Broca's area to the motor cortex, and of Wernicke's area to the auditory cortex, seems consistent with this: speaking involves fine muscular control and listening, of course, requires the processing of sound. Broca's area has also been claimed to be where grammar is 'located', whereas Wernicke's area has been argued to be the seat of word meaning. The main evidence for these claims comes from studies of people with language disability or loss, especially **aphasia**, a condition in which language is disrupted independently of other cognitive functions (→ R4.2).

Activity 14.2 O‑ᴛ

Look at the following two-minute stretches of discourse, from aphasic speakers telling the Cinderella story (Berndt 2007: 566):

A. long ago uh (2 sec) one time uh many years ago (2 sec) uh step (2 sec) two sisters and one (2 sec) god mothers yeah uh (6 sec) Cinderella is uh washing uh clothes and uh (2 sec) mop floor (4 sec) one day Cinderella big party in the castle (5 sec) two uh girls (13 sec) dresses is beautiful (2 sec) Cinderella is poor.

B. this is uh something for that and it starts out as and um there is /praetihds/ and he has things to do and ... but anyway ... uh stuff is going along and then they think something and they think okay so he goes now he goes ... This goes on and takes all that and we see that we have things for that ... it's a thing and other things ... and then we /djuz/ all that and he sees that /erawl/ that well he happens to get up and goes things and he's that's good and see so good ...

How would you characterize the language of each? On the basis of what you have read of this chapter so far, which do you think has experienced damage to Broca's area, and which to Wernicke's? What evidence can you offer for your conclusions?

Many people with language disabilities who have trouble combining words and morphemes together fluently have damage to Broca's area, while those with damage to Wernicke's area often speak fluently but with semantically inappropriate word combinations. In Activity 14.2, sample A is from a person with what is called BROCA'S APHASIA and sample B is from a person with what is called WERNICKE'S APHASIA.

Recent advances in neurolinguistics have, however, revealed many cases of people with aphasia in which: (a) damage to Broca's area results in Wernicke-style symptoms and vice-versa; and (b) damage to other parts of the brain results in language behaviours such as those illustrated in Activity 14.2. Additionally, sophisticated neuroimaging techniques have demonstrated that normal linguistic activity involves numerous parts of the brain, including the right cerebral hemisphere and even other parts of the brain, suggesting that language is distributed, rather than located only in the main 'language centres' around the sylvian fissure in the left-hand side of the brain.

14.3 LANGUAGE IN THE MIND

Although the development of neuroimaging techniques means that language can now be studied in the brains of living people without language disabilities, there are still considerable shortcomings associated with neurolinguistic methods. In any case, psycholinguists need to use abstract, psychological concepts in order to characterize the linguistic phenomena they explore in the brain and link them to the categories used in descriptive linguistics. (That is to say, they need to be able to talk about language in the mind, as well as language in the brain.)

See Byrd and Mintz (2010: 255–262) for a brief discussion of the challenges and opportunities of neuroimaging.

Activity 14.3

Cast your eyes briefly over Figures 14.4 and 14.6 on the next few pages, without reading the captions beneath, but paying attention to the overall design and composition of the diagrams. What are the major differences between them? From what you have read about language in the mind so far, which one looks closer to how language is represented physically in the brain, as opposed to functionally, in the mind?

Psycholinguists view language in the mind in essentially two ways, one of which is closer to the neurolinguistic perspective, and is called *connectionist*, and the other which is closer to the linguistic perspective, and is called *modular*.

- Modular theories view language as a symbol- and rule-based computational system, 'hard-wired' into our brains by our genetic code (➔ R4.3), containing specialized knowledge sources (one for phonology, one for syntax, etc.) which are used to run specialized programmes for different aspects of language use, like assembling the sequence of phonemes required by the motor system for an utterance to be produced (PHONOLOGY ➔ 11), or working out who did what to whom when we hear a passive sentence (SYNTAX ➔ 7);
- Connectionist theories view language as a more organic brain-style system, emerging from our experience rather than determined by genetic endowment (➔R4.5), composed of vast interactive networks of neuron-like units which can be activated or deactivated to different degrees via interconnections of different strengths, with no separate sub-systems for syntax, phonology, etc.

In both views, the job of language in the mind is fundamentally the same: to encode aspects of thought into speech, text or sign (in the processes of speaking, writing and signing ➔ 14.4), and to derive thoughts from speech, text or sign (in the processes of listening, reading and comprehending sign ➔ 14.5). Although the modular and connectionist views are pitted against each other as alternatives in the research literature, and some scholars reject one or the other view completely, it is perhaps more helpful to try to understand the advantages and disadvantages of each, as well as their ultimate complementarity.

14.3.1 Modules and symbols

Although the brain might not be as compartmentalized as the rooms of the Numskulls in their oblivious host's head (Figure 14.1), it can be helpful to think of the mind in terms of separate modules, in order to see the wood for the trees – or the cathedral for the pixels in the example of Figure 14.2. We want to be able to look at the image of York Minster and talk about what we see in terms of walls, windows, turrets and towers, rather than the intrinsically meaningless greyscale pixels which actually form the image. In the same way, we want to be able to discuss the psychology of language in terms of phonemes, syllables, morphemes and phrases, and the ways we combine them, rather

than the dense and complex networks of connected neurons which constitute them at the physical level.

The modular view thus parallels the view of many descriptive and theoretical linguists, who recognize separate classes of language structures and rules at different levels, as we have done in some of the central chapters of this book (➔ 5, 7, 8, 11). One formulation of the modular view is illustrated in Figure 14.4 (inspired by Jackendoff 1997). You will see that the upper three modules encapsulate rules (in the sense of regularities) in the three domains of phonology, syntax and concepts, and the arrows in each module indicate that these rules govern sets of possible structures of the corresponding kind.

This is parallel to the notion of the **hierarchy of rank** (➔ Figure 7.1), through which smaller units combine to make successively larger units, all the way from phonemes to texts. The difference is that the hierarchy of rank is a generalization about abstract systems (independent of individual minds) which can characterize the knowledge of a group of speakers of a particular language or variety (Canadian English, Mexican Spanish, Cantonese, etc.), whereas modularity is a theory about how individual speakers *store* and *access* the language system in their own minds: it attempts to explain the MENTAL REPRESENTATION and PROCESSING of language as a property of the species, rather than of individual languages.

Speakers of languages which use a lot of grammatical **morphemes** (➔ 5, 7) are assumed to have corresponding modules in their minds for **inflectional** rules and structures too. Unfortunately, we cannot discuss the psycholinguistics of **morphology** here, for reasons of space, but you will find an accessible introduction in Chapter 11 of Aitchison (2003).

Mental representation is the (temporary or long-term) storage in memory of what we have learned, what we have experienced, what we think, feel, understand, believe, assume, etc. Language rules and structures are assumed to be part of what is represented. Proponents of modularity argue that mental representation can be conceived of in terms of symbolic systems, and that when we access this information, we *process* these symbols

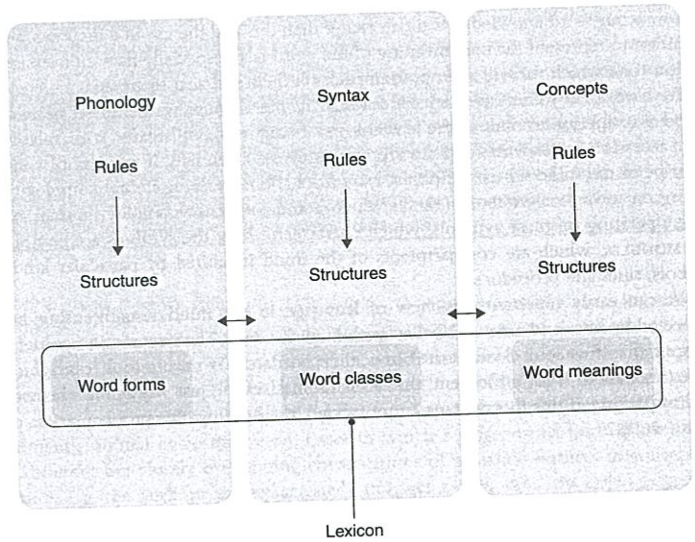


Figure 14.4 A modular view of the mentally represented language system (inspired by Jackendoff 1997)

in the same way a word processing program on a computer takes as input keystrokes and yields as output letters on a monitor.

The rules 'contained' in the first module in Figure 14.4 will constitute the regular patterns by which a speaker combines phonemes in phonological structures like syllables and words (→ 11). Similarly, the rules in the second module will be those that represent the patterns by which the speaker combines words as phrases, and phrases as clauses and sentences (→ 7). The third module is, in effect, the stuff of thought itself: where we mentally create, store and connect together conceptualizations of entities such as 'physical objects, events, properties, times, quantities and intentions' (Jackendoff 1997: 31). Many of these conceptualized entities can be expressed through linguistic structures, from individual morphemes to whole texts, and so constitute the *meanings* of these structures (→ 6, 7).

In Figure 14.4, the place we store the words we know, the MENTAL LEXICON, is represented as embracing a triad of structures from each of the modules, and this corresponds to three different aspects of what it means to know a word (together 'a knot joining some threads', as we put it in Chapter 5). The three threads are: how the word is pronounced/written/signed (*word form*); how it is used in phrases (most importantly *word class*, like noun, verb and adjective → 7); and the concept(s) it is used to express (*word meaning*). For example, the word *apple* will be represented in the mind as three related mental representations (the word's LEXICAL ENTRY) which include the following information:

- the phonological structure: /æpl/
- the word class: *noun*
- the meaning: 'a spherical red, green or yellow fruit that grows on a tree'.

Of course our word knowledge is much richer than this and the use of a dictionary-style definition to represent the core meaning of the word is an especially flagrant oversimplification (one which we will attempt to unpack a little in the next section).

A non-modular approach to language in the mind is adopted by the proponents of COGNITIVE LINGUISTICS (e.g. Evans and Green 2006), according to which linguistic systems are constrained by usage in social contexts, rather than by brain structures, and are not separate from other aspects of cognition.

We have spent some time here on modularity, not because we believe it necessarily provides a superior account of the psychology of language, but because it is (relatively) more accessible to students (and descriptive linguists). Essentially, it is a way of viewing language in the mind which simplifies away from the underlying neural complexity by relying on metaphor: SYMBOLS (→ 1), which 'stand for' more complex internal states, RULES operating on these symbols, which characterize how the symbols are combined, and MODULES, which are compartments of the mind inhabited by particular kinds of symbols, rules and procedures.

We can easily represent this view of language in the mind visually, using boxes connected by lines and arrows, labelled with English words. The next section points out, however, that if we look closer at the boxes, their borders may start to look less rigid; and if we think about it for a moment, the labels themselves are just words that themselves need unpacking. If this thorny issue is not tackled, the homunculus problem arises once again (→ 14.2).

14.3.2 Networks and connections

Modules are ways of conceiving language in the mind as a series of functionally defined boxes and arrows containing symbols and rules. This is not the most insightful metaphorical stance for all aspects of language structure and use. We passed quite quickly over the tricky notion of concepts and word meaning in the previous section, and yet they are critical notions in psycholinguistics. They are also more accurately understood in terms of interconnected networks of shared features, rather than as separate, modular entities (like dictionary entries in lists), so we discuss them in a little more depth here.

Most linguists and psycholinguists, including proponents of modularity, assume that concepts, many of which are associated with individual words, can be broken down into smaller elements, represented by clusters of 'semantic features'. Our mentally represented knowledge of word meanings includes the ways they relate to each other (→ 6.1). For example, we know that the words *jog* and *sprint* are related semantically because they both include the meaning of *run* (they are **co-hyponyms** of the superordinate word, to use the technical terms introduced in Chapter 6).

From a psycholinguistic perspective, it makes sense to think of this in terms of combinations of **semantic** features, which we indicate here in bracketed small capitals. For example, we can say that the meaning associated with the phonological structure /wʊmən/ (*woman*) is the concept in the mind corresponding to the combination of the features [FEMALE], [HUMAN], and [ADULT]. In similar fashion, the concept expressed by the word form *jog* shares a common set of features with that expressed by the word form *sprint*: namely those which in combination make the meaning of the verb *run*. In addition, the *run* features have also been combined with a modifying feature [SLOWLY] for *jog* and [FAST] for *sprint*.

Activity 14.4

Our mental lexicons contain instances where a single set of semantic features (word meaning) is associated with more than one phonological structure (word form). In other cases, the opposite holds: two different sets of semantic features are associated with a single phonological structure. Try to think of three examples of each.

If you are drawing a blank, look at Section 6.3. See if you can find the technical terms there which linguists use to label these phenomena.

The configuration in which two word forms are connected with the same meaning is called SYNONYMY in semantics (→ 6.3.2). Examples include *sofa* and *couch*, *amble* and *stroll*, *post* and *mail*. The opposite is HOMONYMY, in which one word form serves to express different meanings (→ 6.4.2). Examples include *case* ('item of luggage', 'instance', 'argument', etc.), *post* ('upright pole', 'mail', 'position in organization' etc.) and *pen* ('writing instrument', 'animal enclosure', etc.). Cases in which a single word form is associated with different but closely overlapping constellations of semantic features in conceptual structure, e.g. the verb *get* in 'get arrested' and 'get a new car', are called POLYSEMY (→ 6.4.2).

Activity 14.5

Now consider word class. The sentences *It's about to rain again* and *Here comes the rain again* are associated with the same conceptual structure (i.e., they mean the same thing independent of contextual factors). One of the main differences between them is that in the first, *rain* is used as a verb, and in the second, as a noun. Can you think of five more words like this (not weather-related), which have the same phonological structure, are associated with almost identical semantic features, but differ in word class?

These examples show that our mental lexicon is more like a 'word-web' (Aitchison 2003) than the ordered columns of a dictionary (i.e. more connectionist than modular). Words are not just lists of word forms paired with word meanings. Apart from the complexity of hyponymy, synonymy, homonymy and polysemy, there are also multiple connections between grammatically similar words, such as all the nouns, all the non-count nouns (→ 7, 17), and—for speakers of languages like German and Spanish with grammatical gender—all the words which are masculine, feminine, or neuter. Grammatical information of this kind constitutes a level of representation in each word's lexical entry which is called the *lemma* in some theories (e.g. Levelt 1989).

In the next section we will see that the mind also makes connections between word forms, e.g. all the words beginning with /str/ (*straddle, straggle, straight, strain, straw*, etc.) and all the words that rhyme with *post* (*boast, coast, ghost, host*, etc.). So the fact that word forms, classes and meanings are related in so many different ways suggests that a modular account might not be the most illuminating perspective on all aspects of the mental representation and processing of language. The metaphor of networks seems more appropriate, as illustrated in Figure 14.5.

In a connectionist approach to the mind, and therefore to language as part of cognition, our mental representations cannot be symbols (like 'V' for verb), because that ultimately requires a homunculus-type commitment (there would have to be a Numskull inside us who understands what 'V' stands for, so he/she would have to have a mind, and how does it work?). Rather, what we as linguists understand as 'V' (*verb*-ness), is actually a state of the neuronal networks in the brain. Neurolinguists have not yet been able to describe that state, although there is aphasic evidence that verbs can be selectively damaged, leaving other word classes unaffected (e.g. Caramazza and Hillis 1991).

Connectionist descriptions of language in the mind cannot, therefore, be typed onto a page, like the descriptions we use in the rest of this book, because their purpose is to delve beneath the short-hand of symbols, and get closer to the 'sub-symbolic' biological reality of language in the brain. They have, therefore, been modelled in computer programs which simulate brain-style representation and processing (as such, they form part of ARTIFICIAL INTELLIGENCE).

ARTIFICIAL INTELLIGENCE (AI) is the branch of computer science dedicated to the simulation and development of intelligent behaviour in machines, including understanding and producing speech.

Many connectionist networks on computers have modelled acquisition (→ 15), rather than processing, although it is important to recognize that processing is a major part of acquisition: the first thing to happen in children's attempts to work out the rules and structures behind the language in their environment is that they receive acoustic input (manual input for sign languages) and process it. Acquisition simulations start with massively interconnected networks of simple neuron-like units, as yet unassociated with

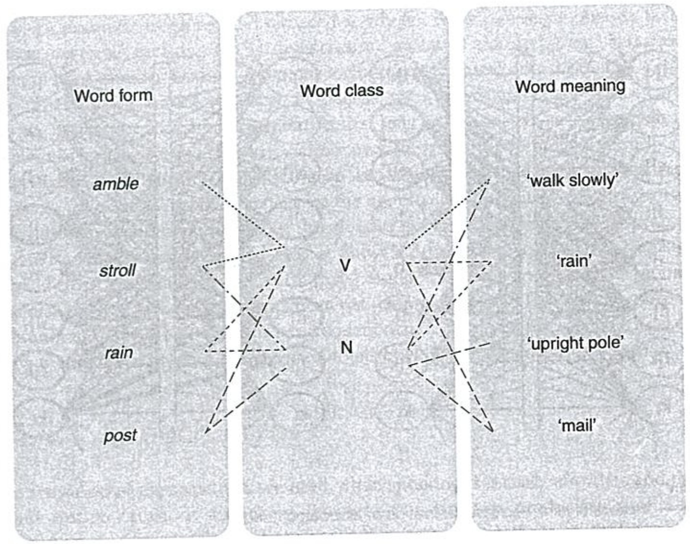


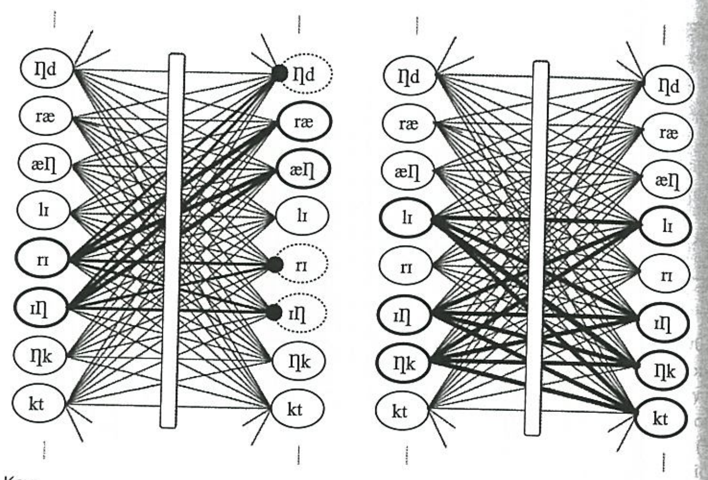
Figure 14.5 Fragments of the network of word forms, classes and meanings that together constitute some of the information in the mental lexicon

any content. Input is repeatedly fed into the model from the environment, and patterns begin to emerge in the strengths of connections activated and the ways some patterns inhibit others (i.e. deactivate them). Intelligent, rule-like behaviour emerges from the patterning of many simple units which, on their own, are meaningless. A well-known early attempt to model the English-speaking child's acquisition of regular and irregular past tense forms (Rumelhart and McClelland 1986) can provide us with an illustration of connectionist formulations of the mental representation of language.

In Figure 14.6 you can see two different states of one part of a (considerably oversimplified) network representing the end state of the learning of the past tense of two English verbs, one regular and one irregular (i.e. part of the mind of a child who has learnt some verb morphology → 5). The first is for the irregular verb *ring* and the second for the regular verb *link*. The activated nodes in the left-hand column represent the child's knowledge of the verb root, and the activated nodes in the right-hand column represent the past-tense form that the child comes to associate with it (there are other, hidden columns of connections in between which we are glossing over here). Each node is short-hand for more dense networks which represent phonological structures (in this case ordered pairs of phonemes) that in combination are associated with word forms.

The phonemes in the network fragments are represented in ordered pairs to capture the child's knowledge of their sequence in the word: /rɪ/ and /ɪŋ/ fit together to make /rɪŋ/ (*ring*) via the shared phoneme /ɪ/.

So in the first network state, /rɪ/ and /ɪŋ/ are together activated by the input [rɪŋ] (*ring*). The word form /rɪŋ/ is associated with /ræŋ/ in the past tense, and this is indicated in the model by the solid lines connecting the /rɪ/ and /ɪŋ/ nodes on the left with the /ræ/ and /æŋ/ nodes on the right. The knowledge that this is an irregular verb is reflected in the inhibitory links between /rɪŋ/ and /rɪŋd/ (*ringed*), represented by the



Key:
—— = excitatory link (increases activation of associated node)
—● = inhibitory link (decreases activation of associated node)
= activated node = node at rest = deactivated node

Figure 14.6 A fragment of a connectionist network in two states, showing the association between irregular *ring* and *rang* in the first, and between regular *link* and *linked* in the second

nodes /rɪ/, /ɪŋ/and /ŋd/. The second network state shows the connections for the regular verb *link* /lɪŋk/ and its past tense *linked* /lɪŋkt/.

In a connectionist model of the past tense, the mind does not explicitly represent a rule about adding *-ed* at the end of verb roots (and therefore encodes no essential distinction between regular and irregular inflection): the patterns emerge from the distribution of activation and association in the network, on the basis of how often, and in what company, the different structures are heard in the input (for an alternative, modular account, see Pinker 1999).

Now that you have an idea of the ways in which psycholinguists describe the mental representation of language, we can proceed to discuss how these representations are accessed in production and comprehension. To keep things (relatively!) simple, we restrict the discussion to spoken language, the 'default' modality.

14.4 LANGUAGE PRODUCTION

For a sociocultural perspective on speakers' potential for making meaning with others, see M.A.K. Halliday's *Language in a Social Perspective* (→ R2.3).

When we speak, the linguistic structures we need in order to make meaning with others are normally activated without effort, below the level of consciousness. If the structures have been used frequently enough on previous occasions they will be *selected* for articulation from memory, as pre-assembled combinations of phonemes and morphemes (for words) and combinations of words (for phrases and sentences). Most of the words we use on a daily

basis, for example, are stored and retrieved as wholes. But so are many phrases, including idioms (*over the hill*, meaning 'old', *at the end of the day*, meaning 'ultimately', etc.) and also many thousands of familiar LEXICAL BUNDLES, including 'templates' with slots, like *Can-I-have-some-X; Y-{be}-looking-forward-to-Z*; etc.). In a sense, then, words and many phrases are 'off-the-peg' structures: they are not new structures, built by 'productive' rule use (→ 1.4).

Regularly, however, we also say entirely new things by combining previously known units to produce previously unheard or unspoken structures needed for novel meanings and purposes (→ 1.4, 5.3.2). This happens via the use of rules in modular theories, or analogy with other structures in connectionist theories. For example, the writer who first coined the prefixed noun *post-hacking* (see the blog at Katwala 2011, for a contender) unconsciously invoked either a mental rule (the prefix {*post-*} is added to nouns to mean 'after [noun]') or a mental analogy (*post-hacking* follows from *post-war*, *post-punk*, etc.). This kind of morphological innovation (→ R2.1) is much less frequent than creativity at the sentence level, as the many thousands of brand-new sentences in this book (or in any corpus) attest to.

14.4.1 Speech errors

The activation of the structures we need when speaking is *normally* effortless and unconscious. But on occasions something goes wrong in language production, and what are called *speech errors* result. These errors reveal something about the mental events that are involved in successful language production, and constitute evidence for theoretical models that have been proposed to shed light on the processes involved. The next activity should be attempted before you read on.

Activity 14.6

Consider the following authentic speech errors, collected by the eminent psycholinguist Victoria Fromkin (1923–2000), available in a browsable online corpus → W14.1.

1 a fifty pound dog of bag food
2 a first fine half
3 Amos Mansdorf from Tel Aviv, Italy
4 and what makes you competent — confident in the figures?
5 and you've prevented — presented us with a problem.

Describe, as fully and explicitly as you can, what you think has happened in each case. On the basis of this very limited set of data, see if you can draw any initial conclusions about: (a) the order in which a speaker selects the words from their mental lexicon and places them in the appropriate syntactic sequence; and (b) the ways that lexical entries are organized together in the mental lexicon.

The first couple of errors in Activity 14.6 indicate that speakers don't just look up the words they need in the order in which the grammatical rules require them to be sequenced. In the first example, the words *dog* and *bag* have been placed in each other's positions, and in the second, *fine* and *first* come out in the wrong order. This suggests that the words are activated *before* they are put into a sequence for delivery in speech.

Of course when we speak, it happens at lightning speed, so we're not aware of the order in which these 'micro events' happen in our minds. McMahon (2002: 2) states: 'we decide to speak, and what about, but the nuts and bolts of speech production are beyond our conscious reach …'. The evidence from speech errors, together with data from neuroimaging and experimental techniques (to be discussed in the next section), reveal a definite time course to language processing, measured in thousandths of a second (milliseconds or ms for short). For example, it has been calculated (Yuan *et al.* 2006) that the average speech rate for English is between 150 and 170 words a minute (that is, one every 350–400 ms).

The multiple connections between words in the mental lexicon facilitate the speed with which we can express ourselves in speech. The third and fourth speech errors in Activity 14.6 involve the activation of the wrong word: *Italy* for *Israel* and *competent* for *confident*. You will no doubt have noticed that in each case the word produced resembles the word intended, both in form and meaning. This is evidence for the kind of connectivity we discussed in 14.3.2: the massive parallel activity in the lexical network ends up activating entries which are closely related to the target entry, because they share semantic features (e.g. [NATION] for *Italy/Israel*, [PERSONAL QUALITY] for *competent/confident*) and form features (initial phoneme, number of syllables, and stress pattern, for both pairs).

You may have noticed too that the pairs of words exchanged and words substituted share another feature: word class (→ 7.3). Nouns exchange places with other nouns, adjectives with other adjectives. Similarly, nouns are produced instead of other nouns, adjectives instead of other adjectives. In the fifth error, a verb in the past tense (*prevented*) is substituted for another verb in the past tense (*presented*). This is not a coincidence: it follows from a model of production in which: (a) words are activated to match the meanings required; and then (b), in a subsequent stage of grammatical encoding, are placed in the positions dictated by the grammatical rules that the speaker knows.

If syntactic encoding (the construction of sentences) follows word activation in the time course of spoken language production, we should expect grammatical morphemes (closed class words (→ 7.3.2) and **inflections**) to be added at this stage too, since their activation is often dependent on (follows from) the syntactic structure selected. For example, the selection of the present participle instead of simple present in English requires the activation of the {*-ing*} morpheme to be added to the activated verb, as well as the auxiliary verb *be* to precede the verb.

Similarly, in passive sentences an NP which is not the actor appears in subject position, and the auxiliary *be* and the past participle {*-en*} are required instead of simple past {*-ed*} (→ 7.4.5). A single communicative situation, involving (almost) identical lexical-semantic content, can lead to the selection of different grammatical structures. Take, for example, the following situations:

A *A nappy-changing situation:*
- a Michael was changing Ben's nappy (when I left the house).
- b Michael changed Ben's nappy (as I left the house).

B *A garden-showing situation:*
- a Mary showed the visitors the garden.
- b The visitors were shown the garden (by Mary).

The first thing that happens in production is that concepts are activated, and this in turn leads to the activation of content words to express these concepts. In the case of the nappy-changing and garden-showing situations in A and B above, these are as follows (where word classes are indicated with subscript N for noun and V for verb):

A $\{Michael\}_{N1}$, $\{Ben\}_{N2}$, $\{nappy\}_{N3}$, $\{change\}_{V}$
B $\{Mary\}_{N1}$, $\{visitor + s\}_{N2}$, $\{garden\}_{N3}$, $\{show\}_{V}$

Next a grammatical template is constructed (through rule use or analogy), including word order and grammatical morphemes:

A *Nappy-changing:*
- a $\{\_\_\}_{N1}$ {was} $\{\_\_\}_{V}$\{-ing\} $\{\_\_\}_{N2}$\{'s\} $\{\_\_\}_{N3}$
- b $\{\_\_\}_{N1}$ $\{\_\_\}_{V}$\{-ed\} $\{\_\_\}_{N2}$\{'s\} $\{\_\_\}_{N3}$

B *Garden-showing:*
- a $\{\_\_\}_{N1}$ $\{\_\_\}_{V}$\{-ed\} {the} $\{\_\_\}_{N2}$ {the} $\{\_\_\}_{N3}$
- b {the} $\{\_\_\}_{N2}$ {were} $\{\_\_\}_{V}$\{-en\} {the} $\{\_\_\}_{N3}$\{by\} $\{\_\_\}_{N1}$

If grammatical morphemes are added after word selection, we might predict that sometimes when the wrong word is selected for the wrong slot in the grammatical template, then they will show up with the wrong morpheme. This happens in the following speech error from Fromkin's database, where the plural inflection is in the right place, but the wrong noun has been inserted:

(1) I would rather gamble $125 than have a hole full of floors.

In the example, the {*-s*} of the intended *holes* is in its syntactically appropriate place, but is attached to *floor*, which should have been inserted in the slot where *hole* actually appears. This preservation of the grammatical template with content words 'dropping into the wrong slots' is commonplace in speech error corpora.

A simple model which encapsulates these insights, and is consistent with speech error data and evidence from aphasia research, is sketched in Figure 14.7 (see also Garrett 1980; Levelt 1989).

The model is clearly a modular one (with boxes and arrows), and helps us to capture the overall sequencing in the process of linguistic encoding. If we want to understand the micro-level mental processes that govern specific lexical choices and outcomes, however, a connectionist account can be more helpful. For example, at the level of phonological structure, we need to be able to explain how speakers select the correct past tense form for the homophonous verbs *ring* ('cause to sound') and *ring* ('encircle') in sentences (2) and (3) below:

(2) Riot police rang the bell before entering.
(3) Riot police ringed the building before entering.

There must be quite complex connections between conceptual structure, the grammatical template level and particular lexical entries to ensure that the {past} morpheme at the grammatical level picks out the irregular morphemes in the lexicon for the 'sounding' concept and the regular morpheme for the 'encircling' concept. Computer simulations of the kind illustrated in Figure 14.6 are well suited to handle this.

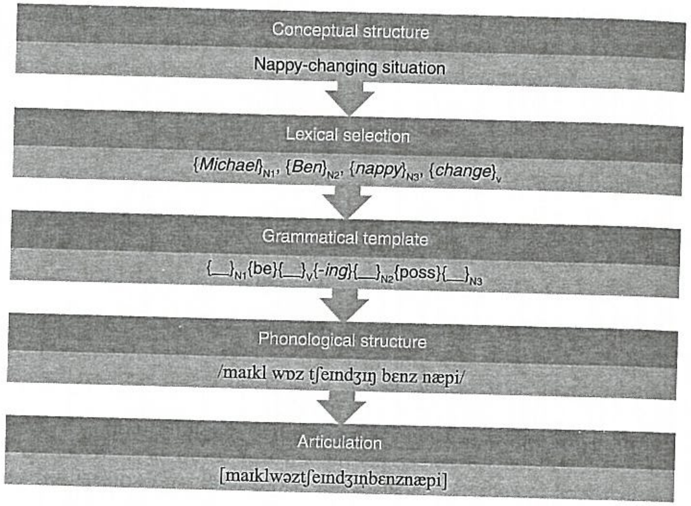


Figure 14.7 A model of language production, showing stages in the production of the sentence *Michael was changing Ben's nappy*

14.4.2 Tip-of-the-tongue states

Consider now another kind of speech error, where the intended word is neither moved nor substituted, but is temporarily unavailable: the so-called tip-of-the-tongue (or TOT) phenomenon. This is a familiar experience for most people: estimates suggest that young adults find themselves in a TOT state on average once a week, and this increases significantly with age. In a TOT state, speakers have passed through the first three stages of linguistic encoding in Figure 14.7, but cannot access the phonological structure of one of the words they want to produce.

One example (from the same online corpus site we used for previous errors) concerns a speaker's mental search for a proper name, Charles Hartshorn. Especially interesting for psycholinguists is the nature of related words that the speaker *does* manage to activate. In this case, they included *reindeer* and *antler*.

> **Activity 14.7**
>
> Why do you think the words *reindeer* and *antler* came to the speaker's mind when they were trying to recall the name Charles Hartshorn? How can we explain this in terms of the mind's connectionist architecture?

The speaker has activated words that are related in meaning to elements of the target word *Hartshorn: hart* and *reindeer* are both deer, and these have prominent *antlers*, which are like *horns*

on other animals. The mind stores word meanings in word-sized bundles of semantic features, connected to phonological structures (word forms) in the mental lexicon. In cases where (some of) the features for one word are shared with *other* word meanings (e.g. [DEER] in the concepts 'reindeer', 'hart', 'stag' etc.), they must be connected to *several* phonological structures (/reɪndiə/, /hɑːt/, /stæg/ etc.).

In speaking, it appears that activation flows along *all* the conceptual-lexical connections, independently of whether the word forms at the other end are the intended ones or not. Normally, the word form which best matches all the features will be the one which is most highly activated and actually gets spoken. But in TOT states, the connection is temporarily out of action, and so unintended but related words rise to the level of consciousness.

Over a period of ten years, Peter Ecke, a multilingual TOT researcher, recorded details of over 100 of his own TOT states, including any partial information and related words that occurred to him during his attempts at lexical selection (Ecke and Hall 2012). Here are some examples:

- Speaking in English (his third language), Peter intended to say the word *fertility* in the sentence *The egg is a symbol of* __. He immediately came up with the translation equivalent *Fruchtbarkeit* in German, his first language, and within seconds produced the English word *fruitfulness*, followed by *maturity*. It wasn't until two minutes later that he was able to access the target word *fertility*.
- Speaking in German (his first language), Peter wanted to say *Inventur* ('stocktaking'), in the sentence *Der Laden macht heute* __ ('The shop is doing ___ today'). Within seconds, he knew that the target word began with *In-*, and after a minute came up with the German word *Inversion* ('inversion'), again needing another minute before he succeeded in finding the target word *Inventur*.
- Speaking in Spanish (his fourth language), Peter was looking for the word *esposas* ('handcuffs'), in the sentence *Usaron* __ ('They used ___'). He initially thought the word he wanted started with /p/, had four syllables, and was feminine in gender. Over the next 40 seconds, he came up with *pinzas* ('pincers'), *parejas* ('couples'), and *gemelos* ('twins'). After a minute he had the target word *esposas*.

Do the following activity before reading further.

> **Activity 14.8**
>
> In the Hartshorn example, the related words that came to the speaker's mind during the TOT state were activated through connections between semantic features and entries in the mental lexicon.
>
> Now see if you can answer the following questions about Peter's multilingual TOT data, using ideas from the connectionist perspective on language in the mind. Look again at Figures 14.5 and 14.7 before attempting this activity.
>
> 1 In the English example, can you explain how and why the speaker might have activated the series of words *Fruchtbarkeit*, *fruitfulness* and *maturity*, in that order?

2 In the German example, how come the speaker very quickly felt that the word started with *In-*, and then produced *Inversion* on the way to the correct word *Inventur*?

3 In the Spanish example, why do you think he was able to correctly guess the gender (feminine) of the intended word? (Hint: gender is one of the word properties represented in the lemma, since it is a grammatical, not a phonological or semantic property.) Also, can you speculate as to why he might have thought the word began with /p/? (Hint: *esposas* has main stress (→ 11) on the second syllable.)

The first example shows that in multilinguals, words from other languages can be activated, even if those languages are not currently being used by the speaker (→ Activity 15.4). In his search for *fertility*, the German word *Fruchtbarkeit* first comes to Peter's mind, possibly because it is better known to him: in connectionist terms, the activation route between the concept and the L1 lexical entry is stronger (has been used more) than the route to the L3 word. This interconnectedness between the mental representations of his different languages is also demonstrated in the third guess. It appears that the activation of *Fruchtbarkeit* sends secondary activation to an L3 word, *fruitfulness*, which is similar in both sound and meaning to it and to the target word (it is also of three syllables, and the first one is a COGNATE: *Frucht* in German is *fruit* in English). The third guess, *maturity*, is now in the right language, and is similar in meaning to the target, sharing also its suffix. Some research has suggested that the separate activation of prefixes and suffixes is another quite common occurrence in TOT states.

The second TOT example also suggests a heightened role for affixes, this time a prefix, {in-}. This is a very common prefix in many Romance languages and those (like German and English) which have borrowed heavily from Latin. This might explain why Peter comes up with the prefix so fast, and his first guess is a word starting with that prefix.

Finally, the third example shows that TOTs involve access to the lemma of the word, where word class and other grammatical properties like gender are represented. Vigliocco, Antonini, and Garrett (1997) have shown that Italian speakers regularly have access to the gender of nouns they are searching for in a TOT state; Vigliocco, Vinson, Martin, and Garrett (1999) further demonstrated that English speakers know whether a TOT noun is count or non-count.

So having a word on the tip of the tongue means that you have got as far as the lexical entry, but that access to the phonological structure is blocked, or only partially available. Some parts of the phonological structure seem to be more accessible than others: most salient are initial phonemes, number of syllables, and possibly also stress pattern (this might explain Peter's activation of /p/, the initial phoneme of the stressed syllable in *esposas*).

A final word about TOT states and language production, before we move on to the flip-side of the process, language comprehension. The kind of words that sometimes get as far as the tip of your tongue but no further are relatively uncommon: *Hartshorn, fertility, handcuffs, stocktaking*, rather than *heart-attack, furniture, happiness, statement*. This is because word frequency is psychologically real. Frequency estimates using language **corpora** measure the number of tim

speakers and writers in different contexts. But in individual minds, frequency manifests itself in terms of the relative 'state of rest' of the mentally represented lexical entry. Less frequently accessed words take more activating, and sometimes the amount of activation is not enough for the (full) phonological structure to become available for articulation: this is the case of TOTs.

14.5 LANGUAGE COMPREHENSION

When someone produces language, it is usually because there is someone around to hear it, and they are participating in talk-in-interaction (→ 2). So what is happening in the minds of listeners as speakers speak? Both speaking and listening draw upon language structure and contextual knowledge in the social act of talk, but they involve fundamentally different mental events. Speakers devise and execute a plan, selecting and constructing linguistic structure to represent the meaning or message they wish to share; listeners, on the other hand, are essentially involved in a guessing-game, identifying clues to meaning from the accumulating speech stream, in a time frame over which they have little control. But like production, the comprehension process can be usefully modelled and explained using elements of both connectionist and modular theories of language and mind.

Although human beings cannot read the thoughts of others telepathically, they can recover meaning from sound at lightning speeds. In moments so brief that they seem to us instantaneous, we decode phonological, morphological, lexical, syntactic, and semantic structure, using data from the acoustic energy of the speech signal, represented temporarily in WORKING MEMORY, and from our own knowledge of language, stored in LONG-TERM MEMORY.

At the heart of the process is word recognition: the activation of entries in our mental lexicons that best match the sounds we are hearing, so that their meanings can in turn be activated and the basic elements of the speaker's message can be assembled.

Prior context plays a central role in making the word recognition process so fast. If context is informative enough, hearers don't actually have to hear every word being spoken to them, and the next best thing to telepathy occurs. For example, the odds are good that with the prior context *Sally burst out*, the most highly activated candidate to follow will be *laughing*, even though other words are possible. If you had richer prior context and knew Sally was sad, she is more likely to have burst out *crying*. But *laughing* is much more frequent in this position, as well as being more frequent overall. We saw in our discussion of TOTs that less frequent words are harder to select for production. They are also slower to be recognized in comprehension.

In the British National Corpus (BNC; → W14.2), *laughing* occurs 2448 times, compared with 1873 times for *crying*. It occurs 123 times after *burst out*, compared with only six times for *crying*.

Activity 14.9 0┬┬

Can you guess what the next word might be in the following contexts (not necessarily one that ends the utterance)? If you can't, is there any other attribute of the word that you can be reasonably sure of?

1 They met at a jazz club in New ___
2 The organizers give a prize ___
3 Mary reached for ___
4 She pursed her ___
5 Bob read an ___

Now try to identify what kinds of knowledge were activated in your mind to guess the word or its attribute. Be as precise as possible.

During comprehension, hearers can exploit many different kinds of information in order to make upcoming input more quickly and easily decodable: cues in the speech signal itself, properties of their mentally-represented lexicon and grammar, and stored knowledge of the world as they have experienced it. The use of mentally-represented information not present in the acoustic input is called *top-down* processing, and the use of cues in the speech signal itself is called *bottom-up* processing. In top-down processing, the non-linguistic information can come either from the immediate physical or social environment, or from knowledge accumulated through previous experience. Linguistic information can be from any level in the hierarchy of rank (→ Figure 7.1), from the text level to the phonological.

Working together and in parallel, the top-down and bottom-up processes will generate a variety of possible analyses of the input at any given moment, but some will be more highly activated in working memory than others. For example, imagine you are hearing the utterance in (4) during a conversation in the London office where you work. Let us focus on what is happening in your mind at the point where you have heard the acoustic input corresponding to the first two phonemes of the word *Paris* (indicated by the vertical bar)—about a second into the utterance.

(4) Jacques worked in Pa|ris before he joined us here.

Encyclopaedic knowledge (→ 6.1.2) activated by knowledge of who *Jacques* is (or of the French name *Jacques*, if you don't know the person) might send some activation to the lexical entry *Paris* early on in the utterance (it might even be triggered by the francophone word-initial phoneme /ʒ/). Once recognized, the meaning of the word *worked*, in combination with *in*, will lead you to expect a location or area of business. Once you have recognized the word form *in*, you can activate its word class (preposition), and this will in turn activate syntactic knowledge that the prepositional phrase it heads will contain a following noun phrase, headed by a noun (→ 7.4.2). So you will (subconsciously) be expecting a noun.

From the speech stream itself, the pronunciation of *in* as [ɪm] will already have given you a head-start with the phonological structure of the noun, by setting you up to expect a bilabial initial consonant (*in* takes the form [ɪm] due to what is called *anticipatory assimilation* (→ 9) with the following consonant). All this evidence will converge on the likelihood that the word you have begun to hear is *Paris* (as opposed to *Pakistan*, *pantomime*, etc.) and to inhibit other possible analyses (such as *impassively*). So maybe you do not need to hear what is left of the word (i.e. the [rɪs] of *Paris*) before you recognize it?

This is indeed what the evidence from psycholinguistic experiments suggests. Let us take a look at one such experiment, conducted by William Marslen-Wilson and Lorraine Tyler over 30 years ago (Marslen-Wilson and Tyler 1980), a classic demonstration of how context is used to speed processing. The experiment used PRIMING, one of the most common techniques used in psycholinguistics. In SEMANTIC PRIMING, a word related in meaning to the target is provided to participants in advance. This reliably decreases the amount of time needed to recognize the target word, compared with unrelated primes. For example, priming *table* with *chair* will make it faster to recognize than priming it with *hair*. Similar effects occur with PHONOLOGICAL PRIMING (e.g. *table* primed by *taper*). Such effects provide compelling evidence for the interactive flow of information in the networks which constitute the mental lexicon.

The goal of Marslen-Wilson and Tyler's (1980) study was to shed light on the role of syntactic and semantic knowledge in the time course of spoken word recognition. Specifically, they wanted to test whether all sources of knowledge used in processing interact and operate in parallel, or whether they are serially ordered, as reflected in the hierarchy of rank. The task required participants in the experiment to listen to pairs of sentences through earphones, and press a response button as fast as possible when they heard a word which had been primed in advance. For example, in the following pair of sentences, they would be asked to press the button as soon as they heard the word *lead*.

(5) The church was broken into last night. Some thieves stole most of the *lead* off the roof.

The average time taken to respond to the target word (for 45 participants listening to nine pairs of sentences each) was 273 ms. This is 94 ms shorter than the average duration of the target words. The researchers estimate that between 50 and 75 ms is needed to decide to respond and then do so. This gives us an estimate of around 200 ms for word recognition, a figure that has been confirmed by many other experiments as an average for word recognition in English. This result shows the extreme speed with which hearers are able to match the input with words in their mental lexicons. (To put these times into perspective, it took one of us 15,430 ms to look up the word *lead* as fast as we could in the print version of *The Concise Oxford Dictionary*, according to a digital stopwatch.)

To measure the effect of syntactic and semantic context, the researchers also played participants pairs of sentences like the following:

(6) The power was located into great water. No buns puzzle some in the *lead* off the text.
(7) Into was power water the great located. Some the no puzzle buns in *lead* text the off.

The pair of sentences in (6) has exactly the same syntactic structure as (5), but the words do not make sense together. The word *lead* appears at exactly the same point in the input as it did in (5), but this time there is no prior semantic context. In (7), the syntactic context is also removed, leaving no useful prior context at all. The average reaction time for targets in pairs of sentences of type (6) was 331 ms. For target words in sentence pairs like (7), the average reaction time increased to 358 ms. Statistical tests show that these differences are very unlikely to be the result of chance.

So Marslen-Wilson and Tyler's study found that when hearing a word with both syntactic and semantic prior context (i.e. the way we normally hear words), its recognition is around 85 ms faster than when hearing it with no prior context (e.g. in sentence pairs of type (7)). But when there is syntactic context (e.g. in sentence pairs of type (6)), the difference is reduced to 58 ms. This suggests that hearers are using prior context to recognize words faster, and that meaning contributes more than grammar to the task. But the fact that syntactic structure provides a 27 ms advantage over random words suggests that even when meaning is absent, syntactic processing is going on and interacts with lexical processing. This is consistent with elements of both modularity and connectionism.

First, from a modular perspective, the experiment shows that the syntactic processor functions independently of the presence of a communicative act. We cannot help but work out the grammatical relationship between words, even when there is no meaning to decode. In this sense, processing is modular, using separate sources of knowledge which function independently of each other. But these independent processing modules exchange information in order for the whole system to operate more effectively.

In other words, the modules interact. And this makes sense from a connectionist perspective, according to which processing happens in parallel, with all sources of information being tapped simultaneously and spreading activation throughout the whole network of processing units. In the case of word recognition that we have been discussing here, candidate mental representations of word forms can be activated during comprehension on the basis of activation from syntactic and semantic representations being built for previously processed structures. So once more, the connectionist brain seems to sit at ease in a modular mind: only the perspective changes.

Activity 14.10

One of us overheard the following exchange between a native-speaker of English, about to make a big pot of tea, and a native-speaker of Turkish with advanced-level competence in English:

'Will four teabags be enough?'
'Forty bags?!'

Can you provide a psycholinguistic account for what is happening here, and suggest why this particular misunderstanding is unlikely to occur between two native speakers of English? (Hint: You may want to look at the commentary on Activity 9.2.)

14.6 OTHER TOPICS IN PSYCHOLINGUISTICS

There are many other issues of interest to psycholinguists beyond those discussed here. We end this chapter by acknowledging some of them and giving some pointers to further information for readers interested in following them up. The issues selected for mention here fall into five broad areas:

- the relationship between language and thought
- levels of processing
- different modalities for language use
- language disability
- bilingual/multilingual representation and processing.

First, in the most general area of language and mind, we have not touched upon the extent to which the evolution of language in the species has driven or been driven by developments in other areas of our capacity for, and exercise of, cognition (see Aitchison 2000). For example, was the evolution of language possible because we developed complex patterns of thought, or was it the other way round? Related to this, and of long-running popular interest, is the extent to which the particular languages we speak can mould the ways we perceive and interact with the world (➔ 1, 13; Steinberg and Sciarini 2006 Chapter 9). For example, do we think more or more precisely about certain concepts because we have words for them?

Next, there are many issues in processing that are the object of rigorous ongoing research, but have not been discussed here. At the speech end of processing, we have not addressed the question of how speakers' activation of word forms leads to actual articulation (see Levelt 1989, Chapters 8–11; ➔ 9 and 10). Neither have we addressed how the vibration of air molecules caused by articulation impinges on hearers' eardrums, nor how linguistic information is extracted from it (see Byrd and Mintz 2010, Chapter 5). At the conceptual end of processing, we have not discussed how speakers package their messages into text-level or discourse units, nor how hearers use pragmatic and other knowledge to interpret such units (see Fernández and Smith Cairns 2011, Chapter 8; ➔ 3). The morphological level of processing is another intriguing area of study, for those languages that make any significant use of derivation and inflection (see Marslen-Wilson 2007).

Thirdly, we have restricted our discussion to speaking, listening and phonological representation, although for many people, especially those involved in teaching, it is reading, writing and signing that are of particular interest (the use of **phonics** in literacy teaching is an especially controversial question rooted in psycholinguistic research: see Harley 2008, Chapter 8). The question of how we process written text is a fascinating one, especially with respect to the role of phonological representations in reading and writing, and the type of writing systems associated with particular languages (see Harley 2008, Chapter 7; ➔ R3.2). Similarly, the processing of sign language (and the extent to which it resembles or differs from the processing of speech) continues to intrigue psycholinguists (see Emmorey 2002, Chapter 4; ➔ R3.5).

Fourthly, psycholinguists are very interested in cases where language representation and processing are impaired in some way (see Ingram 2007). For one thing, such cases reveal how the 'normal' system works (as discussed in 14.2.2); but, more importantly, we can use psycholinguistic theory in the assessment and treatment of people with brain-related language disabilities (Hall *et al.* 2011, Chapter 14). Apart from aphasia, there is also particular public interest in psycholinguistic models of DYSLEXIA, a common disability affecting the processing of alphabetic text (see Byrd and Mintz 2010, Chapter 12).

Finally, there is the issue of storing and using more than one language. Do multilingual speakers store their languages in separate language modules, or do they interact in one multilingual network? (The evidence suggests the latter: see Schwartz and Kroll 2006; ➔ Activity 15.4). There is also a lot of interesting work on the relationship between multilingualism (➔ 16) and cognition in general, especially with regard to whether knowing more than one language confers advantages in cognitive abilities beyond language, such as in creativity and 'metacognitive' processes (see Baker 2011, Chapter 7).

14.7 SUMMARY

The study of language in use considers not only the organization of talk, text and signing as they figure in social and cultural domains, but also how they are implemented at the biological and psychological levels. Neurolinguistic and psycholinguistic theories attempt to explain the representation and processing of language in the brain and the mind from different vantage points.

- Neurolinguistic research has pinpointed some of the areas of the brain which are responsible for speaking, listening, reading, writing and signing. Although many parts of the brain are involved, a central role appears to be played by neural circuits around the Sylvian Fissure in the left cerebral hemisphere. The evidence comes principally from the study of language impairments and from neuroimaging techniques.
- Psycholinguistic research investigates language in the mind, at a level which abstracts away from the biological reality of brain structures and processes. There are two main ways in which psycholinguists approach the phenomenon of human language:
  - Connectionist approaches, which emphasize the sub-symbolic 'brain-style' nature of representation and processing, which emerges during development in vast distributed networks of simple units, through which activation flows in parallel.
  - Modular approaches, which emphasize the different kinds of knowledge encapsulated in symbolic representations of language, and how they are accessed in processing at separate stages from separate (possibly innate) components of mind.

COMMENTARY ON ACTIVITIES

O━╥ Remember that this symbol indicates that there is a commentary on the activity that you can find on the companion website at www.routledge.com/cw/merrison.

FURTHER READING and REFERENCES

Suggestions for further reading on the topics discussed in this chapter can be found on the companion website (www.routledge.com/cw/merrison).

Any piece of academic writing must always provide a list of publications to which reference has been made. Unusually and very unconventionally, this information is provided on the companion website (www.routledge.com/cw/merrison). Always ask your tutor about how you are to present references for any piece of work that you submit.

Chapter 15
Language Acquisition

Key Ideas in this Chapter

- Children build their own language systems by participating in linguistic interactions, and as young as six months old they begin to understand some expressions.
- Children simultaneously have to learn vocabulary, patterns for making sentences, a system of pronunciation, conventions of appropriate use, while also developing skills for fluent production and comprehension.
- Pronunciation starts with unsystematic 'chunks', but becomes increasingly patterned.
- Within their first year, children become less sensitive to phonological distinctions not relevant in the language they are acquiring.
- Word learning starts slowly, but sustained acceleration begins around the middle of the second year, when the first sentences are also constructed.
- Hierarchical constituent structure, recursion and coordination appear in child syntax around the age of two years.
- Over the past century second language acquisition theories have successively concentrated on structural linguistic aspects of the process, on its psycholinguistic requirements, and on the socio-cultural dimension of communication with other people.