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Chapter 14

The Language-to-Object Perception Interface: Evidence from Neuropsychology

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Cognitive neuropsychology has as its principal aim the elucidation of the organization of the cognitive system through the analysis of the difficulties experienced by neurological patients with selective cognitive difficulties. As far as the relation between vision and language is concerned, the area that has been most extensively investigated concerns the semantic representation of objects. By contrast, the relation between how representations of space are accessed from vision and how they are accessed from language has been little touched; spatial operations have not been subject to much cognitive neuropsychology investigation.

If we consider objects, then the Gibsonian tradition teaches us that the richness of information available in the visual field is such that many of their properties may be inferred fairly directly from the visual array. Yet there are many other aspects of the visual world that cannot be inferred from the information in the visual field alone—the structural aspects of an object that are hidden from the present viewpoint, the potential behavior of an object and of the other objects likely to be found in its vicinity or that go with it in some other way. There are also wider properties of an object that may be accessed such as the perceptual features it has when experienced through other modalities, how it is used and by whom, what its function is, what types of thought process it triggers, and what intentions it may help to create. How are the processes involved in accessing these properties of an object when it is presented visually related to the way they are accessed when it is presented verbally?

This issue has been the subject of considerable controversy in cognitive neuropsychology in recent years for two reasons. A number of striking syndromes seem to relate very directly to it. In addition, the theory that most directly reflects the surface manifestations of the disorders differs from the standard theory in other fields where the issue has been addressed.

A model widely referred to in this book and in current cognitive science is that of Jackendoff (1987). Language is viewed as involving three main types of representation —phonological structures, syntactic structures, and semantic/conceptual structures.

As far as the semantic/conceptual structures are concerned, meanings have internal organization built up from a set of primitives and principles of combination, one of the primitives being the entity "thing." However, in addition to its phonological, syntactic and conceptual structures the representation of a word may contain specifically visual structures. The visual structures involved are, however, explicitly identified with the 3-D structural description level of Marr (1982).

Although Jackendoff's theorizing was concerned specifically with words and their meanings, the issues it addresses and in particular its position on the organization of the cognitive systems mediating semantic processing are closely related to issues recently much debated by cognitive neuropsychologists. A topic on which there has been much cognitive neuropsychology research in recent years is whether the semantic systems accessed when a word is being comprehended are the same as those used in the identification of an object, given that its structural description has already been determined. Some cognitive neuropsychologists have argued that they are the same, but others have claimed that they differ at least in part.

Approaches closely related to Jackendoff's have been adopted by certain cognitive neuropsychologists (e.g., Caramazza, Berndt, and Brownell 1982; Riddoch and Humphreys 1987). The best developed current neuropsychological account of a theory of this type is the organized unitary content hypothesis (OUCH) of Caramazza et al. (1990), which utilizes a feature based theory of semantic representations. More specifically, it holds that "access to a semantic representation through an object will necessarily privilege just those perceptual predicates that are perceptually salient in an object". Thus while many elements of the semantic representation are as easily accessible from visual as from verbal input, some aspects of the semantic representation are more easily accessed from its structural description than from its phonological representation. Access properties can be asymmetrical. The authors' rationale for assuming an asymmetric relation derives from consideration of certain conditions to be discussed shortly.

There is an older tradition in neuropsychology, however, which can be traced back at least as far as Charcot (1883) and Wernicke (1886). Certain syndromes suggest that visually based knowledge may be partly separable from verbally based knowledge. This perspective has been explicitly adopted more recently by a group of neuropsychologists (e.g., Warrington 1975; Beauvois 1982; Shallice 1987; and McCarthy and Warrington 1988) using the terminology *visual semantics* and *verbal semantics*. although the conceptual basis of the two types of representation has not been clearly articulated (see Caramazza et al. 1990; Rapp, Hillis, and Caramazza 1993; and Shallice 1993).

An intermediate position has been advocated by Bub et al. (1988) and by Chertkow and Bub (1990). Following Miller and Johnson-Laird (1976), they argue that a specific stage intervenes between attaining the structural description and accessing the amodal "core concept" of an object. Accurate identification of object is held to require more than just a characterization of an object's structure, but must involve criteria which are more functional than structural. They therefore argue for the existence of a subsystem that contains only the application of the *functional* and perceptual criteria necessary for object identification, receiving the output from the structural description system and sending output to the core amodal semantic system. Thus "visual semantics" is reduced very considerably in its scope.

We thus have one position in cognitive neuropsychology (Caramazza et al. 1990) that is entirely compatible with Jackendoff's perspective in holding that there is a single semantic/conceptual system. In addition it, namely the Caramazza et al. perspective, holds that accessing certain aspects of the semantic representation can be easier from the structural description than from phonology. Two other positions, (Warrington 1975; Chertkow and Bub 1990) hold that Jackendoff's view is too gross a characterization of the subdivisions of the cognitive system involved in semantic processing, and that more than one semantic/conceptual system exists. A fourth position, which has yet to be formally articulated, holds that semantic representations are processed through a connectionist network of which different regions are more specialized for different types of semantic subprocess, but neither subprocess nor region can be characterized in an all-or-none fashion (see, for example, Allport 1985; Shallice 1988a).

Two main types of syndrome have been used to argue that the semantic-conceptual system is not in fact unitary but contains a number of types of subsystem—those involving some form of category specificity, and the modality-specific aphasias, in particular, optic aphasia. I will review the evidence from each in turn and then relate them to the alternative theories. A third syndrome—selective progressive aphasia—will also be addressed.

14.1 Category Specificity

The first group of syndromes responsible for the plausibility of the position that the semantic system is not unitary but composed of a number of subsystems are those manifesting so-called category specificity. The performance of the patient for some categories of knowledge is far better than for others. Of particular relevance is the syndrome originally described in four patients with herpes simplex encephalitis (Warrington and Shallice 1984). These patients had a selective problem in identifying animals, plants, and foods, while being able to identify man-made artefacts much better. For example, one of these patients, J.B.R., could name only 6% of living things and 20% of foods but could name 54% of man-made objects. Moreover, if the judges assessed whether a description of a line drawing of the object "grasped the core concept," the contrast was even greater (living things, 6%; foods, 20%; but man-made objects, 80%). A similar effect was found when the patient was asked to give the meaning of the object's name and this, too, was assessed as to whether the core concept was grasped (living things, 8%; foods, 30%; man-made objects, 78%).

Similar effects have now been obtained with other patients with the same etiology (Pietrini et al. 1988; Sartori and Job 1988; Silveri and Gainotti 1988; Laurent et al. 1990; Swales and Johnson 1992; Sheridan and Humphreys 1993; Sartori et al. 1993; De Renzi and Lucchelli 1994). However, in the last few years there have been a rash of claims that these dissociations are essentially a result of characteristics of the stimulus set rather than evidence for a particular type of underlying organization of the semantic system.

Funnell and Sheridan (1992) initially claimed that the dissociations might arise because words matched for word frequency as used, say, by Warrington and Shallice (1984) may not be matched for visual familiarity. Indeed, McCarthy and Shallice (see Warrington and Shallice 1984) had shown that living things were less familiar to subjects than artefacts when matched for word frequency. Warrington and Shallice (1984) had dealt with this problem by showing that the dissociations were still present when differences in familiarity were taken out as a covariate. Moreover this explanation does not account for the way that the impairment of the patients involved foods as well as living things, as McCarthy and Shallice found foods to be more familiar than artefacts when word frequency is controlled.

A stronger argument was presented by Stewart, Parkin, and Hunkin (1992), who found that the category-specific dissociation of a herpes simplex patient, H.O., disappeared when word frequency, familiarity, and visual complexity were *all* controlled simultaneously. However, the basic dissociation, while statistically significant, was much weaker in H.O. than in some of the patients described earlier. Moreover, the nonliving category included objects like swamp, geyser, volcano, and waterfall instead of being composed solely of artefacts. Most critically, Sartori, Miozzo, and Job (1993) used stimuli matched on these three variables with their patient Michaelangelo, who showed a clear and significant category-specific effect of artefacts over living things on two different stimulus sets (living things, 30% and 40%; artefacts 70% and 76%).

Yet another possible artifact has been suggested by Gaffan and Heywood (1993), who argued that a critical variable was the density of exemplars within a category, which they held to be greater for living things than for artefacts. Because living things are more similar to each other and so less discriminable than artefacts, any discriminability problem would have a greater effect in the category of living things.

Riddoch and Humphreys (1987) had made a similar point previously and shown that there was more overlap between line drawings of animals than between line drawings of artefacts.

Gaffan and Heywood buttress their position on the difficulty in discriminating between living things, as opposed to artefacts, by considering the identification performance of three groups of subjects using the Snodgrass and Vanderwart (1980) stimuli. The first group were two patients of Farah, McMullen, and Meyer (1991), who showed standard category-specific effects; the second were normal subjects, who, however, were given only a 20 ms exposure; and the third used six monkeys, who were tested on how well they could decide which of two presented items was in a previously trained set. All three groups of subjects in their very different tasks showed an advantage of man-made objects over living things.

Gaffan and Heywood (1993) argue "These results from monkeys are contrary to Warrington and Shallice's conjecture ... that a specific system for identification of man-made objects has evolved in the human brain; if Warrington and Shallice's conjecture were correct, monkeys would show relatively greater difficulty in discriminating among inanimate objects than among living things, compared to human observers." It is not apparent, however, how such a comparison can be made because the tasks carried out were so different. Moreover, for the monkeys, most of the stimuli would presumably be meaningless objects; therefore what should be critical would indeed be raw discriminability. If, however, discriminability were a key factor underlying the performance of both the monkeys and the patients, then one would expect a positive correlation within each of the living and nonliving sets of stimuli between the results of the two group of subjects. In fact, there was no correlation between the items the monkeys found difficult and those the patients found difficult in either the living or the nonliving sets.

Gaffan and Heywood's work, like that in the other critical studies, used the Snodgrass and Vanderwart (1980) stimuli, for which norms are available on a number of relevant variables. In this set of stimuli the animals, in particular, tend to be rather similar to other members of their category. Warrington and Shallice (1984), however, also used the so-called Ladybird stimuli, large clear colored pictures designed for preschool children, with three of their patients. Shallice and Cinan have obtained ratings of structural complexity, familiarity, and discriminability from normal subjects for the Ladybird stimulus set and used these to reanalyze the findings of Warrington and Shallice. With these ratings, no difference was found between all three categories of stimuli (animals, artefacts, foods) for either familiarity or discriminability, but the animals remained structurally more complex than the other two categories. Because the task the patients carried out with this stimulus set had involved word-picture matching using a four-alternative forced-choice task, the relevant degree of discriminability on the Gaffan-Heywood hypothesis was that within each set of five; this is what the subjects of Shallice and Cinan rated. However, with these stimuli two of the three original Warrington and Shallice patients on whom the test had been used performed significantly more poorly on foods than on artefacts with the third showing a strong trend in the same direction. Moreover, on a regression analysis using the ratings obtained by Shallice and Cinan, all three patients showed a significant effect cf category and no effect of the other three variables. Thus it would appear that these category specificity findings cannot just be reduced to some combination of differences in word frequency, visual familiarity, structural complexity, and within-category discriminability.

In this respect, the work of Shallice and Cinan corroborated an earlier finding of Farah, McMullen, and Meyer (1991), who used the Snodgrass and Vanderwart (1980) stimuli with two patients exhibiting the standard category-specific dissociations. In a regression analysis on picture recognition performance, Farah, McMullen, and Meyer showed that neither name frequency, name specificity, similarity to other objects, structural complexity, nor object familiarity had any significant effect. The only factor to have such an effect was category membership. The absence of a significant effect of other factors in the presence of a significant effect of category makes implausible even one final convoluted artifactual explanation put forward by Gaffan and Heywood (1993). These authors suggested that the category difference arises through performance on items differing in a way dependent upon some other dimension; following Snedecor and Cochran (1967), they pointed out that *measurement* errors on the other dimension can lead to an apparent difference in performance across categories even when the differences on the other variables are allowed for as a covariate. However, what would then be expected is that there would be a basic effect of some other dimensions; this was not in fact found in either study.

Thus it would appear that the basic category-specific effects cannot be reduced just to an artifact of some combination of differences in word frequency, visual familiarity, structural complexity, and within-category discriminability across categories. A second type of finding that supports the conclusion that all neuropsychological dissociations in this domain cannot simply be attributed to some artifact of differences in presemantic factors is the existence of the complementary phenomenon, namely a superior performance in some subjects of living things (and in two studies foods) over artefacts (Warrington and McCarthy 1983, 1987; Hillis and Caramazza 1991; Sacchett and Humphreys 1992). The first two studies involved global aphasics who could only be tested by word-picture matching using, for instance, the Ladybird stimuli discussed above. However, the subjects in the last two studies were not globally aphasic; thus naming to visual confrontation could be used (for instance, C.W. in Sacchett and Humphreys 1992 scored 19/20 on naming animals; but only 7/20 on naming artefacts). Interestingly, the location of C.W.'s lesion (left frontoparietal) differed from that characteristic of the herpes simplex encephalitis cases (for all of whom the left temporal lobe was involved).

Much the most plausible conclusion is that the category-specific effects do not arise at a presemantic level due to some difference in difficulty between the categories but reflect some qualitative difference in the semantic representations of the categories. When the herpes encephalitis syndrome was first described, it was explained in terms of a contrast between stimuli primarily differentiable in terms of their sensory qualities and those more saliently differentiable in terms of their function.

Unlike most plants and animals, man-made objects have clearly defined functions. The evolutionary development of tool using has led to finer and finer functional differentiations of artefacts for an increasing range of purposes. Individual inanimate objects have specific functions and are designed for activities appropriate to their function. Consider, for instance, chalk, crayon, and pencil; they are all used for drawing and writing, but they have subtly different functions.... Similarly, jar, jug, and vase are identified in terms of their function, namely, to hold a particular type of object, but the sensory features of each can vary considerably. By contrast, functional attributes contribute minimally to the identification of living things (e.g., lion, tiger, and leopard), whereas sensory attributes provide the definitive characteristics (e.g., plain, striped, or spotted). (Warrington and Shallice 1984, 849)

A closely related position was taken to explain the complementary syndrome to be discussed later (see Warrington and McCarthy 1983.)

Dector, Bub, and Chertkow (in press) take a somewhat related position based on their study of a patient, E.L.M., who suffered from bilateral temporal lobe strokes. On tests of perceptual knowledge of objects he performed normally, but he was grossly impaired at many tests involving the perceptual characteristics of animals. Dector, Bub, and Chertkow argue that the difference between the superiority of artefacts over animals arises because different tokens of the same man-made object may show a considerable variation in the shape of its parts but a consistent function that allows for a unique interpretation, thus echoing the Warrington-Shallice position. However, they then argue that artefacts "can be uniquely identified at the basic level through a functional interpretation of their parts" and this is why they are relatively preserved (see De Renzi and Lucchelli 1994 for a related position). Many artefacts with a unique function do indeed have a unique organization of distinctly functioning parts; take a lamp, for example. However, others, such as a table tennis ball, do not. As yet it remains unclear to what extent the relative sparing of artefacts depends upon their unique organization of distinctly functioning parts or on the unique functions of the whole.

14.2 Sensory Quality and Functional Aspects of Different Categories

The position just developed attributes differences in performance across different categories to the way that identification in some categories depends critically on sensory quality information but for others functional information is more critical. One can, however, consider how well different semantic aspects of the same category are understood by patients who show this category-specific pattern. When this is done, knowledge of functional aspects of biological categories tends to be much better preserved than knowledge of sensory quality aspects (Silveri and Gainotti 1988). In a related fashion, Dector, Bub, and Chertkow's (in press) patient E.L.M. was much better at answering "encyclopedic" questions about animals such as "Does a camel live in the jungle or the desert?" (85%) than visual ones such as "Does a camel have horns or no horns'?" where he was at chance (55%). However, the effects are not completely clear-cut. The performance of E.L.M., say, on functional aspects of animals was still well below that of normal controls, who scored 99%. This was not due just to a general problem with carrying out semantic operations on concrete objects; when asked to identify artefacts he performed at ceiling.

A more dramatic example is given by De Renzi and Lucchelli's (1994) herpes encephalitic patient, Felicia. In explaining the perceptual difference between pairs of animals, for example, goat and sheep, or paired fruits or vegetables, for example, cherry and strawberry, she performed far worse than the worst controls (15% vs. 90%; 49% vs. 85%). However, in explaining the *visual* difference between paired objects, for example, lightning rod and TV antenna, she was somewhat better than the normal mean (90% vs. 85 %). Analogous results have been reported in a number of other studies (e.g., Silveri and Gainotti 1988; Sartori and Job 1988; Farah et al. 1989) although at least one patient, Giuletta (Sartori et al. 1993), answered nonvisual questions about animals almost perfectly (see also Hart and Gordon 1992), while at the other extreme S.B. (Sheridan and Humphreys 1993) performed almost as poorly on visual as on nonvisual questions about animals (70% and 65%, respectively).

Why should the category-specific impairment generally recur if in a milder form when the patient is responding to questions about animals or foods which appear not to be based on accessing sensory qualities? Does it not undermine the explanation of category-specific effects outlined earlier, namely, that they arise from damage affecting sensory quality representations? If one articulates the theory developed thus far in a connectionist form, then the problem can be resolved. Farah and McClelland (1991) investigated a model (see figure 14.1) in which some semantic units represented the functional roles taken by an item, while others represented its visual qualities. Each of the semantic units was connected (bidirectionally) to the others, to units representing structural descriptions, and to units representing phonological word-

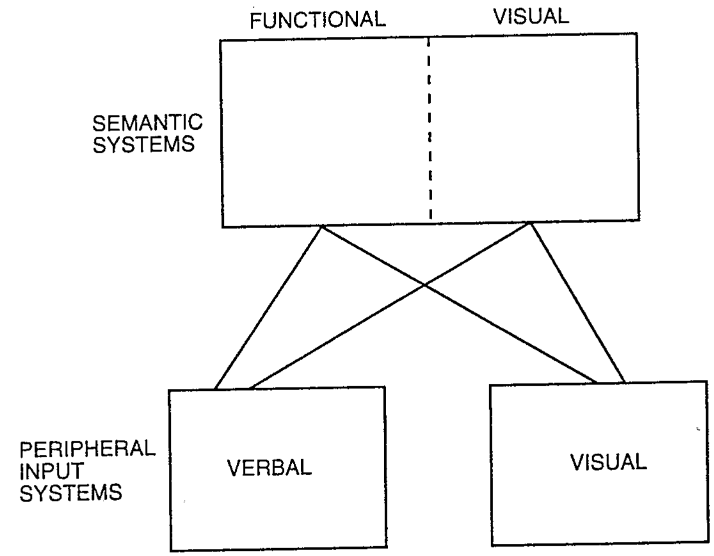

Figure 14.1
Farah and McClelland's (1991) model for explaining category-specific preservation of artefact comprehension and naming (reproduced by permission from Farah and McClelland 1991).

forms. The number of units in the two subsets of semantic representations was determined through an experiment on normal subjects. Subjects rated the description of each item in definitions of both living and nonliving things in the *American Heritage Dictionary* as to whether it described the visual appearance of the item, what the item did, or what it was for. On average there were 2.13 visual descriptions and 0.73 functional ones, but the ratio between the two types was 7.7:1 for living things and only 1.4:1 for the nonliving things. These values were then realized in the representations of living things and artefacts used for training. The network was trained using an error correction procedure based on the delta rule (Rumelhart, Hinton and McClelland 1986) applied after the network had been allowed to settle for ten cycles following presentation of each input pattern. In each of four additional variants of the basic network, one particular parameter was altered so as to establish the robustness of any effect obtained.

The most basic finding was that lesioning the "visual" semantic units led to greater impairment for living things than for artefacts with the opposite pattern shown for the lesioning of the functional semantic units. Thus the standard double dissociation was obtained due to "identification" of living things relying more on the visual semantic units and "identification" of artefacts depending more on the functional semantic units. More interestingly, if one examines how close a match occurs over the *functional* semantic units when a lesion is made to the *visual* semantic units, then there is a difference between the two types of item. The *functional* representations of the living things were less adequately retained than those of artefacts. In the original learning process, the attainment of the representation in one of the semantic "subsystems" helps to support the learning of the complementary representation in the other; the richer the representation is in one of the systems, the more use is made of it in learning the complementary representation. Thus the most typical relation between functional and visual impairments with living things is explained. Whether the full range of relations observed can be explained remains to be investigated.

There are two uncomfortable findings that the model would appear well designed to explain. First, the living/nonliving distinction is not absolute. Thus Y.O.T. was one of the global aphasic patients who performed very much better on word-picture matching with living things and foods than with artefacts (Warrington and McCarthy 1987). In Y.O.T.'s case, the impairment did not extend to large man-made objects such as bridges or windmills. Patient J.J. of Hillis and Caramazza (1991), who had a selective sparing of animal naming like Y.O.T., also had the naming of means of transportation spared. Complementarily, the problems of herpes encephalitic patients extended to gemstones and fabrics. The semantic representation of all these subcategories may well consist more of visual units than of functional ones, especially if function has to be linked with a specific action.

Second, the living/nonliving distinction is graded. Thus patients have been described in whom the deficit is limited, say, to animals alone (e.g., Hart, Berndt, and Caramazza 1985; Hart and Gordon 1992). The sensory quality/function contrast would seem likely to be more extreme for animals than foods, say, so that for more minor damage to sensory quality units only the least functional of the semantic categories would be affected.

Overall, this group of category-specific disorders fits with the idea that knowledge of the characteristics of objects is based on representations in more than one type of system. Realizing the different systems as sets of units in a connectionist model allows certain anomalies in the basic subsystem approach to be explained. The nature of the representations mediated by each of the systems remains unclear, however. The deficit appears not to correspond simply to damage to visual units. Thus one of the patients studied by Warrington and Shallice (1984) was unable to identify foods by taste as well as by sight. Moreover, in three of the patients where it has been assessed (Michaelangelo in Sartori and Job 1988; E.L.M. in Dector, Bub, and Chertkow, in press; and S.B. in Sheridan and Humphreys 1993), relative size judgments could be

made fairly accurately, suggesting that even the visual deficit does not extend to all visual characteristics. The issue remains open.

14.3 Optic Aphasia

A second syndrome that suggests the need to refine the conceptual/structural description contrast of Jackendoff (1987) is optic aphasia. First described by Freund (1889), optic aphasia refers to an impairment where the patient is unable to name objects presented visually but at the same time gives evidence of knowing what these objects are, for instance, by producing an appropriate mime. Moreover, the problem is not just one of naming; the patient is able to produce the name to a description or on auditory or tactile presentation. A considerable number of patients have been described who roughly fit the pattern (see Beauvois 1982; Iorio et al. 1992; Davidoff and De Bleser 1993 for reviews). If one limits consideration to patients who do not appear to have any impairment in accessing the structural description because stimulus quality does not affect naming ability, Davidoff and De Bleser (1993) list fourteen patients who have been formally described. Certain of these patients performed perfectly in gesturing the use of visually presented stimuli they could not name (Lhermitte and Beauvois 1973; Caplan and Hedley-White 1974; Gil et al. 1985).

This apparent preservation of knowledge of the visually presented object when it cannot be named has been explained most simply by assuming that the optic aphasic suffers from a disconnection between "visual semantics" and "verbal semantics," with the name only being accessible from verbal semantics (Beauvois 1982; Shallice 1987). The distinction between subsystems at the semantic level appears to differ from the one drawn in the previous section between systems representating functional and visual or sensory quality types of information. I will address this issue in more detail later. In any case, a number of authors have contested the claim (see Riddoch and Humphreys 1987; Garrett 1992; Rapp, Hillis, and Caramazza 1993), holding that the miming could simply be based on an affordance, that is, an action characteristically induced by the shape of the object, or a cross-modal association of sensory and motor schemas, either of which might in turn be based only on an intact structural description. Alternatively, miming might require accessing only restricted parts of the semantic system, in particular those parts most strongly realized from the structural description because they are also represented in it explicitly, for example, the tines of forks; this is the privileged access theory account of Caramazza et al. (1990) and Rapp, Hillis, and Caramazza (1993). A similar explanation might also be given for the preserved drawing from memory shown in patients such as J.F. (Lhermitte and Beauvois 1973).

However, access to other types of information can be present in these patients when they cannot name. For instance, Coslett and Saffran (1992) gave their patient EM2 a task based on one devised by Warrington and Taylor (1978) in which the patient has to judge which of three items are functionally similar, for example, zipper, button, coin (see also patient C.B. in Coslett and Saffran 1989). EM2 scored at 97% on this task, with the control mean being 94%. Because the affordances of a zipper and a button are not similar, it is difficult to see how the use of affordances might be the basis for this good performance; indeed, there are no subcomponents of the two structural descriptions that are related. Rapp, Hillis, and Caramazza (1993), in confronting the argument that such a pattern of performance presents a difficulty for their privileged access position (Shallice 1993), merely respond by saying, "difficulty naming visually presented items in the face of demonstrated intact comprehension of some aspect of the visual structures, however, indicates that the full semantic description required to support naming has not been activated from a 3-D representation of the stimulus." This argument presupposes that normal performance on the function-matching test can be obtained when activation of the relevant semantic representation is reduced. This claim is merely asserted by Rapp, Hillis, and Caramazza. However, because the task is a three-alternative forced-choice test, with rather basic semantic information being required about each item—concerning its function—the assertion has some plausibility.

Similar results have, however, been obtained by Manning and Campbell (1992) on patient A.G. on semantic tasks which appear to be much more demanding. Two types of test were used with these patients. The first was the Pyramids and Palm Trees test of Howard and Patterson (1992). In a typical item of this test, the patient has to decide which tree (palm, fir) goes best with a pyramid. The stimuli can be presented either visually, verbally, or in mixed visual-verbal format. In the second test, the patient has to answer sets of questions about each item, (e.g., What is it made of?) both when the item is presented visually and when it is presented auditorily. A.G. performed at only 40%–50% in naming objects from drawings, but at 100% in naming to description and at 91% in naming tactilely presented stimuli, thus showing a specific naming defect with visual stimuli. However, A.G.'s performance on the Pyramids and Palm Trees test, while not at ceiling, was virtually identical across the visual and verbal modalities of presentation (82% vs. 84%) and in both cases was within one standard deviation of the mean of normal control subjects. A similar pattern was observed for the question-answering test (88% vs. 91%). Druks and Shallice's (1995) patient L.E.W. behaved in the same way for both types of test. That patients showed no difference and were not at ceiling on tests of auditory and verbal comprehension seems impossible to account for in Rapp, Hillis, and Caramazza's (1993) version of the privileged access theory, which involves a unitary semantics. By contrast, these results fit well with the multiple semantic system position.

Coslett and Saffran (1992), on the other hand, present an interesting variant of the multiple store position. They agree that two semantic stores do exist and that one is disconnected from the language production mechanisms in optic aphasic patients, but they argue that the stores are primarily distinguished by hemisphere, with the right-hemisphere semantic system being disconnected from the language production systems in the left hemisphere. However, the patients described by Manning and Campbell (1992) present a difficulty for this position. In the acute condition immediately after a sudden onset lesion (e.g., vascular), the right hemisphere is supposed by right-hemisphere theorists such as Coslett and Saffran not to have access to any phonological lexicon, although they hold that over time a phonological lexicon becomes available to a semantic system in the right hemisphere (Coslett and Saffran 1989). This semantic system or the variety of output phonological word-forms that can be accessed from it is then seen to have an effective content corresponding to that of the words readable in deep dyslexia (Coltheart 1980a; Saffran et al. 1980; Coslett and Saffran 1989). In deep dyslexia, however, concrete nouns can be read reasonably well but verbs present severe problems (Coltheart 1980b). Yet while patients A.G. and L.E.W. were severely impaired in naming objects, which they could identify nonverbally, they could name actions very well. Thus A.G. was 95% correct at naming actions—the same level as controls—but worse than 50% at naming objects. This contrast in ease of accessing output phonological word-forms from an intact semantic representation is the opposite of what would be expected according to the right-hemisphere theory, where one would assume that objects should be more easily nameable than actions. The basic multiple semantic store position can perhaps explain the obtained effect by assuming the existence of another semantic subsystem—one controlling actions (Druks and Shallice 1995); being an essentially high-level output system but accessible from perceptual input, it would have connections to verbal semantics distinct from those used by the visual semantic representations of objects. This, however, remains a highly speculative account.

There remains one other counterintuitive aspect of optic aphasia. Many of the patients characterized as optic aphasic through their pattern of success and failure on naming and comprehension tests exhibit a strange set of errors when they fail to name correctly. Of the optic aphasic patients reviewed by Iorio et al. (1992), who generally correspond with Davidoff and De Bleser's (1993) group 2 optic aphasics, nearly all made both semantic and perseverative errors, with less than half also making visual errors. Moreover, in the most detailed analysis of such errors—that of Lhermitte and Beauvois (1973) of their patient J.F.—the authors consider the interaction between

Table 14.1
Errors Made by J. F. in Two Experiments

Type of error	Example	100 pictures	30 objects
Horizontal errors			
Semantic	*shoe* ⇒ "hat"	9	3
Visual	*coffee beans* ⇒ "hazel nuts"	2	1
Mixed visual-and-semantic	*orange* ⇒ "lemon"	6	1
Vertical errors			
Item and coordinate perseveration	T26 . . . ⇒ "wristwatch"		
	T27 *scissors* ⇒ "wristwatch"		
	T44 . . . ⇒ "newspaper"		
	T45 *case* ⇒ "two books"	8	2
Mixed horizontal/vertical errors			
	T43 . . . ⇒ "chair"		
	T47 *basket* ⇒ "cane chair"		
	T53 *string* ⇒ "strand of weaved cane"	3	0

Source: Lhermitte and Beauvois 1973.

what they call "horizontal errors," understood strictly in terms of the processes (temporally) intervening between presentation of the stimulus and the responses, and what they call "vertical errors," where effects of preceding stimuli or responses occur. It is clear from this analysis that the perseverative and the semantic errors combine in a complex way (see table 14.1).

Why might such a strange combination of errors be characteristic of optic aphasia? Again a possible answer can be given by adding a connectionist dimension to the models. Plaut and Shallice (1993a) considered a network which had a direct pathway mapping visual representations into semantic ones. It also had a "cleanup" pathway that involved recurrent connections from the semantic units to the "cleanup" units and back (see figure 14.2). The network used an iterative version of the backpropagation learning algorithm known as backpropagation through time (Rumelhart, Hinton, and Williams 1986). Training with an algorithm of this type in such a recurrent network leads to its developing a so-called attractor structure; the effect of the operation of the cleanup pathway is to move a noisy first-pass representation at the semantic level toward one of the representations it has been trained to produce as an output, given that the initial representation is in the vicinity of the trained one.

The network contained one other major difference from other networks well known in cognitive psychology, such as Seidenberg and McClelland's (1989). In

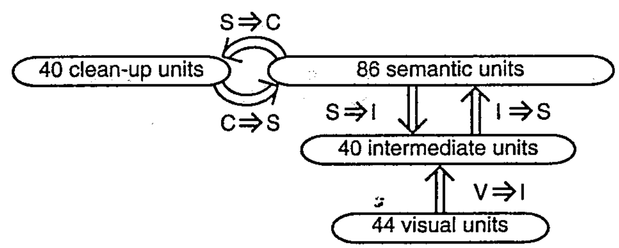

Figure 14.2
Plaut and Shallice's (1993) model for explaining the typical error pattern found in optic aphasia (reproduced from Plaut and Shallice 1993a by permission).

the nervous system, changes in synaptic efficiency at a single synapse occur at many different time scales (Kupferman 1979). The incorporation of additional connection weights that change much more rapidly in training than those standardly used in connectionist modeling is also computationally valuable; it allows for temporal binding of neighboring elements into a whole (e.g., von der Marlsburg 1988) and facilitates recursion (Hinton, personal communication described in McClelland and Kawamoto 1986). Each connection in the network therefore combined a standard, slowly changing, long-term weight with a rapidly altering, short-term weight based on the correlation between the activities of its input and output units.

A network having both types of weights tends to reflect in its behavior both its long-term reinforcement history and its most recent activity; it contains the analogue of both long-term learning and of priming. The network was trained to respond appropriately at the semantic level to the structural representations of forty different objects. Wherever the network was lesioned, it produced a few visual errors but considerably more semantic errors and typically more with both visual and semantic similarity to the stimulus. More critically, there was a strong perservative aspect to the responses. The previous response or one of its semantic associates could well occur as an error to the present stimulus. This corresponds well to the error pattern occurring in optic aphasia.

Adding a connectionist dimension to the model therefore allows the error pattern of the syndrome to be explained. The information-processing model we used as a basis for the connectionist simulations corresponds to those of Riddoch and Humphreys (1987) and Caramazza et al. (1990), which were held to be unsatisfactory earlier in this chapter. However, the essence of the simulation is that if short- and long-term weights are combined, the errors will reflect both perseverative influences and the level of representation at which strong attractors occur.[1] Thus the obtained error pattern would also be expected if an analogous connectionist dimension were added to the multiple semantic system models, provided that one or more of the semantic systems had analogous attractor properties.

14.4 Conclusion

In the sections 14.1 and 14.2 certain syndromes were discussed involving category-specific impairments, particularly those associated with herpes simplex encephalitis, where large differences in performance exist between identification of man-made artefacts on the one hand and of living things and foods on the other. Explanations in terms of differences between the categories on a number of potentially confounding dimensions were considered and rejected. The favored explanation assumes that partially separable systems underlie the semantic representations of the functional and of the sensory quality properties of stimuli. In section 14.3 another syndrome—optic aphasia—was considered; here it was argued that the most plausible explanation involved disconnecting "visual" and "verbal" or "lexical" semantic representations.

The evidence presented in all three sections poses difficulties for the view that a single conceptual system, together with a structural description system that can also be addressed from above, is a sufficient material base for representing semantic operations. The sensory quality component of the semantic system cannot be conflated with the structural description system because variables relevant to disorders of the latter system, for example, presentation of items from unusual views (Warrington and Taylor 1978), do not predict the stimuli that are difficult for patients with impairments to the former system (Warrington and Shallice 1984; Dector, Bub, and Chertkow in press). The issue is even clearer from the perspective of the second set of disorders. In certain optic aphasic patients much more semantic information appears to be accessible from vision than could be based on the structural description alone; yet it would appear not to be available in a generally accessible conceptual system because it cannot be used to realize naming.

By contrast, the accounts presented for these disorders fit naturally with those beginning to be developed within developmental psychology for image schemas at a level of abstraction higher than the structural description and yet not simply subsumable within verbal knowledge (see Mandler, chapter 9, this volume). However, to argue that the such visual semantic processes should be limited to what is required for visual identification alone—in Chertkow and Bub's (1990) visual identification procedure subsystem—and that this is the only system lying between the structural description system and an amodal core semantic system does not fit well for either syndrome. In the herpes encephalitis condition what is lost are the sensory quality aspects of the item, while identification procedures, according to Miller and Johnson-Laird (1976), require primarily functional property information as well as structural analysis. Turning to optic aphasia, one possibility to explain the syndrome might be to view it as arising from a disconnection between the visual identification procedures and the core semantic system. However, a task like Pyramids and Palm Trees involves the utilization of shared context. The Bub and Chertkow theory holds that inferred context is stored in the amodal core semantic system, so that an optic aphasic would be not expected to perform well on such tasks for words that could not be named. Patients A.G. (Manning and Campbell 1992) and L.E.W. (Druks and Shallice 1995) show the opposite pattern, namely, intact performance on this task, together with grossly impaired naming.

There are, however, certain problems in explaining the two types of syndrome in terms of the functional/sensory quality and visual/verbal dichotomies. The concepts are orthogonal. The information available in a visually or sensory quality–based semantic system, as inferred by the information lost in the herpes encephalitic patient is not the only information *accessible* from the visual modality in the optic aphasic patient. Certain optic aphasic patients, for example, A.G. and L.E.W., can access types of information from vision that would be in the functional or encyclopedic parts of the semantic system on a simple all-or-none multiple store view. Moreover, within the semantic dementia literature there are striking echoes of this visual input predominance extending outside the purely sensory quality domain in the performance of patient T.O.B. (McCarthy and Warrington 1988).[2] When a picture was presented to T.O.B. his identification was more than 90% accurate for both types of material, but he identified verbal input artefacts much better than living things (89% vs. 33%). Thus when the word *dolphin* was presented, the patient could say only, "A fish or a bird," but when presented with the picture, he said, "Lives in water ... they are trained to jump up and come out.... In America during the war they started to get this particular animal to go through to look into ships." McCarthy and Warrington have argued that this patient has an impairment that affects the stored information itself rather than an input pathway because of the consistency with which particular items were or were not identifiable (see for rationale Warrington and Shallice 1979; Shallice 1987). Thus contrasting both optic aphasia and semantic dementia with herpes simplex encephalitis, it would appear that the putative lines of cleavage within the semantic system suggested by the syndromes differ.

One possibility is to postulate category-specific systems that are themselves specific to particular modalities (McCarthy and Warrington 1988). However, explanations provided for certain secondary aspects of the syndromes suggest an alternative direction in which a more economical solution might lie. A connectionist simulation of Farah and McClelland (1991) can account for certain otherwise most recalcitrant findings about category-specific disorders. For optic aphasia, the counterintuitive error pattern associated with the disorder is in turn explicable on a connectionist simulation of Plaut and Shallice (1993a). Thus adding a connectionist dimension to the theoretical framework used to account for the characteristics of the syndromes enables a much fuller explanation of the detailed nature of the deficits to be provided. Adding such a connectionist dimension to a subsystem approach provides an account closely related to presimulation suggestions made over the last ten years or so, that the semantic system has as its material basis a large associative neural network with different concepts being represented in different combinations of its subregions, depending on the specific subset of input and output systems generally used to address them (see Allport 1985; Warrington and McCarthy 1987; Shallice 1988b; and Saffran and Schwartz 1994). How the rule-governed aspects of semantic processing would be dealt with on this type of account has not been addressed by neuropsychologists. However, the use of a connectionist network framework for explaining aspects of neuropsychological disorders does not preclude the possibility of explaining rule-governed aspects of semantic processing, provided additional elements are added to the basic network (see Touretsky and Hinton 1988; Derthick 1988; and Miikkulainen 1993). On this account the semantic/conceptual system postulated by Jackendoff would need to be realized as a complex neural network. As yet, though, no implementation adequately explains the rich and highly counterintuitive evidence that detailed study of individual neurological patients provides.

Notes

1. This is especially the case if the mapping from the visual to the semantic level is not orthogonal, as it is in language (see Plaut and Shallice 1993a); for visual presentation of objects, the visual and the semantic representations are correlated.

2. A simple peripheral explanation of the phonological word-form being damaged can also be excluded.

References

Allport, D. A. (1985). Distributed memory, modular subsystems and dysphasia. In S. K. Newman and R. Epstein (Eds.), *Current perspectives in dysphasia*. Edinburgh: Churchill Livingstone.

Beauvois, M. F. (1982). Optic aphasia: A process of interaction between vision and language. *Philosophical Transactions of the Royal Society, London, B298*, 33–47.

Bub, D., Black, S., Hampson, E., and Kerkesy, A. (1988). Semantic encoding of pictures and words: Some neuropsychological observations. *Cognitive Neuropsychology*, *5*, 27–66.

Caplan, L., and Hedley-White, T. (1974). Cueing and memory dysfunction in alexia without agraphia: A case report. *Brain*, *97*, 251–262.

Caramazza, A., Berndt, R. S., and Brownell, H. H. (1982). The semantic deficit hypothesis: Perceptual parsing and object classification by aphasic patients. *Brain and Language*, *15*, 161–189.

Caramazza, A., Hillis, A. E., Rapp, B. C., Romani, C. (1990). The multiple semantics hypothesis: Multiple confusions? *Cognitive Neuropsychology*, *7*, 161–189.

Charcot, J. W. (1883). Un cas de suppression brusque et isolée la vision mentale des signes et des objets (formes et couleurs). *Progrès Medical*, *11*, 568–571.

Chertkow, H., and Bub, D. (1990). Semantic memory loss in dementia of Alzheimer's type. *Brain*, *113*, 397–417.

Coltheart, M. (1980a). Deep dyslexia: A right hemisphere hypothesis. In M. Coltheart, K. E. Patterson, and J. C. Marshall (Eds.), *Deep dyslexia*. London: Routledge.

Coltheart, M. (1980b). Deep dyslexia: A review of the syndrome. In M. Coltheart, K. E. Patterson, and J. C. Marshall (Eds.), *Deep dyslexia*. London: Routledge.

Coslett, H. B., and Saffran, E. M. (1989). Preserved object recognition and reading comprehension in optic aphasia. *Brain*, *112*, 1091–1110.

Coslett, H. B., and Saffran, E. M. (1992). Optic aphasia and the right hemisphere: Replication and extension. *Brain and Language*, *43*, 148–161.

Davidoff, J., and De Bleser, R. (1993). Optic aphasia: A review of past studies and a reappraisal. *Aphasiology*, *7*, 135–154.

Dector, M., Bub, D., and Chertkow, H (in press). Multiple representations of object concepts: Evidence from category-specific aphasia. *Cognitive Neuropsychology*.

De Renzi, E., and Lucchelli, F. (1994). Are semantic systems separately represented in the brain? The case of living category impairment. *Cortex*.

Derthick, M. (1988). Mundane reasoning by parallel constraint satisfaction. Ph.D. diss., Carnegie Mellon University, Pittsburgh.

Druks, J., and Shallice, T. (1995). Preservation of visual identification and action naming in optic aphasia. Paper presented at the Annual British Neuropsychological Society Conference, London, March.

Farah, M. J., Hammond, K. H., Mehta, Z., and Ratcliff, G. (1989). Category specificity modality specificity in semantic memory. *Neuropsychologia*, *27*, 193–200.

Farah, M. J., and McClelland, J. L. (1991). A computational model of semantic memory impairment: Modality specificity and emergent category specificity. *Journal of Experimental Psychology: General*, *120*, 339–357.

Farah, M. J., McMullen, P. A., and Meyer, M. M. (1991). Can recognition of living things be selectively impaired? *Neuropsychologia*, *29*, 185–194.

Freund, D. C. (1889). Über optische Aphasie und Seelenblindheit. *Archiv für Psychiatrie und Nervenkrankheiten*, *20*, 276–297.

Funnell, E., and Sheirden,J. (1992). Categories of knowledge? Unfamiliar aspects of living and nonliving things. *Cognitive Neuropsychology*, *9*, 135–153.

Gaffan, D., and Heywood, C. A. (1993). A spurious category-specific visual agnosia for living things in normal human and nonhuman primates. *Journal of Cognitive Neuroscience*, *5*, 118–128.

Garrett, M. (1992). Disorders of lexical selection. *Cognition*, *42*, 143–180.

Gil, R., Pluchon, C., Toullat, G., Michenau, D., Rogew, R., Lefevre, J. P. (1985). Disconnexion visuo-verbale (aphasie optique) pour les objects, les images, les couleurs, et les visages avec alexie abstractive. *Neuropsychologia*, *23*, 333–349.

Hart, J., Bérndt, R. S., and Caramazza, A. (1985). A category-specific naming deficit following cerebral infarction. *Nature*, *316*, 439–440.

Hart, J., and Gordon. B. (1992). Neural systems for object knowledge. *Nature*, *359*, 60–64.

Howard, F., Patterson, K. E. (1992). *Pyramids and palm trees: A test of semantic access from pictures and words*. Thames Valley.

Iorio, L., Falango, A., Fragassi, N. A., and Grossi, D. (1992). Visual associative agnosia and optic aphasia: A single case study and a review of the syndromes. *Cortex*, *28*, 23–37.

Jackendorff, R. (1987). On beyond zebra: The relation of linguistic and visual information. *Cognition*, *26*, 89–114.

Kupferman, I. (1979). Modulatary actions of neurotransmitters. *Annual Review of Neuroscience*, *2*, 447–465.

Laurent, B., Allegri, R. F., Michel, D., Trillet, M., Naegele-Faure, B., Foyatier, N., and Pellat, J. (1990). Encéphalites herpétiques à prédominance unilatérale: Étude neuropsychologique au long cours de 9 cas. *Revue Neurologique*, *146*, 671–681.

Lhermitte, F., and Beauvois, M. F. (1973). A visual-speech disconnexion syndrome: Report of a case with optic aphasia, agnosic alexia, and colour agnosia. *Brain*, *96*, 695–714.

Manning, L., and Campbell, R. (1992). Optic aphasia with spared action naming: A description and possible loci of impairment. *Neuropsychologia*, *30*, 587–592.

Marr, D. (1982). *Vision*. San Francisco: Freeman.

McCarthy, R. A., and Warrington, E. K. (1988). Evidence for modality-specific meaning systems in the brain. *Nature*, *334*, 428–430.

McClelland, J. L., and Kawamoto, A. H. (1986). Mechanisms of sentence production: Assigning roles to constituents of sentences. In J. L. McClelland and D. E. Rumelhart (Eds.), *Parallel distributed processing: Explorations in the microstructure of cognition*. Vol. 2, 272–325. Cambridge, MA: MIT Press.

Miikkulainen, R. (1993). *Subsymbolic case-role analysis of sentences with embedded clauses*. Technical report AI 93-202. Austin: University of Texas Press.

Miller, G. A., and Johnson-Laird, P. N. (1976). *Language and perception*. Cambridge: Cambridge University Press.

Pietrini, V., Nertempi, P., Vaglia, A., Revello, M. G., Pinna, V., and Ferro-Milone, F. (1988). Recovery from herpes simplex encephalitis: Selective impairment of specific semantic categories with neuroradiological correlation. *Journal of Neurology Neurosurgery and Psychiatry*, *51*, 1984–1293.

Plaut, D. C., and Shallice, T. (1993a). Perseverative and semantic influences on visual object naming errors in optic aphasia: A connectionist account. *Journal of Cognitive Neuroscience*, *5*, 89–117.

Plaut, D. C., and Shallice, T. (1993b). Deep dyslexia: A case study of connectionist neuropsychology. *Cognitive Neuropsychology*, *10*, 377–500.

Rapp, B. C., Hillis, A. E., and Caramazza, A. (1993). The role of representations in cognitive theory: More on multiple semantics and the agnosias. *Cognitive Neuropsychology*, *10*, 235–249.

Riddoch, M. J., and Humphreys, G. W. (1987). Visual object processing in a case of semantic access agnosia. *Cognitive Neuropsychology*, *3*, 201–224.

Rumelhart, D. E., Hinton, G. E., and Williams, R. J. (1986). Learning internal representations by error propagation. In D. E. Rumelhart and J. L. McClelland (Eds), *Parallel distributed processing: Explorations in the microstructure of cognition*, vol. 1. Cambridge, MA: MIT Press.

Sacchett, C., and Humphreys, G. W. (1992). Calling a squirrel a squirrel but a canoe a wigwam: A category-specific impairment for artefactual objects and body parts. *Cognitive Neuropsychology*, *9*, 73–86.

Saffran, E. M., Bogyo, L. C., Schwartz, M. F., and Marin, O. S. M. (1980). Does deep dyslexia reflect right hemisphere reading. In M. Coltheart, K. E. Patterson, and J. C. Marshall (Eds.), *Deep dyslexia*. London: Routledge.

Saffran, E. M., and Schwartz, M. F. (1994). Of cabbages and things: Semantic memory from a neuropsychological perspective. In C. Umiltà and M. Moscovitch (Eds.), *Attention and performance*, vol. 15, 507–536. Cambridge, MA: MIT Press.

Sartori, G., and Job, R. (1988). The oyster with four legs: A neuropsychological study of the interaction of visual and semantic information. *Cognitive Neuropsychology*, *5*, 105–132.

Sartori, G., Job, R., Miozzo, M., Zagu, S., and Machiori, G. (1993). Category-specific form-knowledge deficit in a patient with herpes simplex encephalitis. *Journal of Clinical and Experimental Neuropsychology*, *15*, 280–299.

Sartori, M., Miozzo, M., and Job, R. (1993). Category-specific naming impairments? Yes. *Quarterly Journal of Experimental Psychology*, *46a*, 489–504.

Seidenberg, M. S., and McClelland, J. L. (1989). A distributed, developmental model of word recognition and naming. *Psychological Review*, *96*, 523–568.

Shallice, T. (1987). Impairments of semantic processing: Multiple dissociations. In R. Job, G. Sartori, and M. Coltheart (Eds.), *The cognitive neuropsychology of language*. London: Erlbaum.

Shallice, T. (1988a). *From neuropsychology to mental structure*. New York: Cambridge University Press.

Shallice, T. (1988b). Specialization within the semantic system. *Cognitive Neuropsychology*, *5*, 133–142.

Shallice, T. (1993). Multiple semantics: Whose confusions? *Cognitive Neuropsychology*, *10*, 251–261.

Sheridan, J., and Hymphreys, G. W. (1993). A verbal-semantic category specific recognition impairment. *Cognitive Neuropsychology*, *10*, 143–184.

Silveri, M. C., and Gainotti, G. (1988). Interaction between vision and language in category-specific semantic impairment. *Cognitive Neuropsychology*, *3*, 677–709.

Snedecor, G. W., and Cochran, W. G. (1967). *Statistical methods*. 6th ed. Ames: Iowa State Press.

Snodgrass, J. G., and Vanderwart, M. (1980). A standardized set of 260 pictures: Norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of Experimental Psychology: Human Learning and Memory*, *6*, 174–215.

Stewart, F., Parkin, A. J., and Hunkin, N. M. (1992). Naming impairment following recovery from herpes simplex encephalitis: Category-specific? *Quarterly Journal of Experimental Psychology*, *44a*, 261–284.

Swales, M., and Johnson, R. (1992). Patients with semantic memory loss: Can they relearn lost concepts? *Neuropsychological Rehabilitation*, *2*, 295–305.

Von der Marlsburg, C. (1988). Pattern recognition by labeled graph matching. *Neural Networks*, *1*, 141–148.

Warrington, E. K. (1975). The selective impairments of semantic memory. *Quarterly Journal of Experimental Psychology*, *27*, 635–657.

Warrington, E. K., and McCarthy, R. (1983). Category-specific access dysphasia. *Brain*, *106*, 859–878.

Warrington, E. K., and McCarthy, R. (1987). Categories of knowledge: Further fractionation and an attempted integration. *Brain*, *110*, 1273–1296.

Warrington, E. K., and Shallice, T. (1979). Semantic access dyslexia. *Brain*, *102*, 43–63.

Warrington, E. K., and Shallice, T. (1984). Category-specific semantic impairments. *Brain*, *107*, 829–854.

Warrington, E. K., and Taylor, A. M. (1978). Two categorical stages of object recognition. *Perception*, *7*, 695–705.

Wernicke, C. (1886). Die neuren Arbeiten über Aphasie. *Fortschritte der Medizin*, *4*, 371–377.

Zingeser, L. B., and Berndt, R. S. (1988). Grammatical class and context effects in a case of pure anomia: Implications for models of language production. *Cognitive Neuropsychology*, *5*, 473–516.

Chapter 15

Space and Language

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15.1 Introduction

Functioning effectively in space is essential to survival, and sophisticated spatial cognitive systems are evident in a wide range of species. In humans, the emergence of language adds another level of complexity to the organization of spatial cognition. We use language for many purposes, not least of which is the conveying of information about where important things are located (food, safety, enemies) and how to get to and from these places (for discussion of these evolutionary issues, see O'Keefe and Nadel 1978, Pinker and Bloom 1990). Given the fundamental nature and importance of spatial cognition, it is of considerable interest to determine the ways in which it connects to language. The hope that study of such connections might shed light on both the spatial cognitive faculty and on the language faculty has generated considerable interest in the domain of "language and space."

We are interested in how people talk about space and what they can and do choose to say about it. By exploring the boundaries of these cognitive domains, we hope to uncover their structure and to elucidate the ways in which they can relate to one another. By considering the role of development and culture in shaping the language-space interaction, we hope to discover the extent to which fundamental aspects of spatial cognition are given a priori and the extent to which spatial cognition can be altered by experience. And by analyzing the ways in which neural systems organize spatial and linguistic knowledge, we hope to shed light on how these two capacities relate to one another.

In the present chapter we analyze what we take to be the consensually accepted framework within which the relations between language and space have been considered. Based on this framework, we critically discuss some influential proposals as to the precise nature of this relationship. Finally, we return to the set of issues and questions with which we began, and reach some tentative conclusions.