Parallels and divergences in the acquisition and dissolution of language

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SUMMARY

Analyses of the relation between the acquisition and dissolution of language have typically focused on whether or not the forms of language dysfunction that result from brain damage correspond to specific stages of language acquisition: the Regression Hypothesis. These analyses have not met with great success: although there are a number of superficial similarities between aphasic disorders and different stages of the immature linguistic system, there are also important differences. I will suggest that a focus on the behavioral similarities between language acquisition and dissolution is unlikely to be productive. A more productive course would be to focus, instead, on the general principles that constrain the acquisition and dissolution of language.

1. INTRODUCTION

Only rarely has the relation between language acquisition and language dissolution been the focus of experimental investigation or theoretical analysis. On those rare occasions, the focus has been almost exclusively on the Regression Hypothesis. This is the notion that language dissolution following brain damage occurs in the reverse order of acquisition: the last acquired language skills are the first to be lost (Freud 1953; Jakobson 1968; Caramazza & Zurif 1978). The paucity and the narrow focus of these investigations is unfortunate because the two areas have much in common and much to offer to each other, as is apparent from the papers included in this volume. Here, I briefly discuss one domain of language processing where the comparative analysis of acquisition and dissolution of language could profitably inform both areas of investigation. Before doing so, however, I will briefly discuss and dismiss the Regression Hypothesis as too restrictive a framework within which to consider the relation between acquisition and breakdown of language. I will suggest that a focus on the behavioral similarities between these two domains of language processing is unlikely to be productive and that we should instead focus on the general principles that constrain the acquisition and dissolution of language.

2. THE REGRESSION HYPOTHESIS

The comparative analysis of language acquisition and language dissolution has been concerned almost exclusively with the Regression Hypothesis. The earliest clear formulation of the hypothesis is to be found in the writings of Freud (1953) and other neurologists writing at the end of the last century. In Freud's formulation, the hypothesis followed naturally from Hughlings Jackson's views on the evolution and dissolution of function:

> 'In assessing the functions of the speech apparatus under pathological conditions we are adopting as a guiding principle Hughlings Jackson's doctrine that all these modes of reaction represent instances of functional retrogression (...) of a highly organized apparatus, and therefore correspond to previous states of its functional development. This means that under all circumstances an arrangement of associations which, having been acquired later, belongs to a higher level of functioning, will be lost, while an earlier and simpler one will be preserved' (p. 87).

More recently, Jakobson expressed the relation between language acquisition and breakdown as follows: 'the dissolution of the linguistic sound system in aphasics provides an exact mirror-image of the phonological development in child language' (p. 60). In his view, early-acquired phonological contrasts form the basis for the acquisition of later contrasts thereby establishing a one-directional dependence: damage to early-acquired phonological contrasts necessarily affects the later-acquired contrasts but damage to later-acquired phonological contrasts leaves unaffected the earlier-acquired, independent phonological contrasts.

The Regression Hypothesis makes two independent claims: (i) the various forms of language dissolution found in brain-damaged patients correspond to specific forms of language ability at different stages of acquisition – I will call this the 'form constraint';

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and (ii) the language processing abilities most vulnerable to brain damage are the most recently acquired ones – I will call this the 'order constraint'. Although there are aspects of the language performance of brain-damaged subjects which seem to respect the form and/or the order constraints of the Regression Hypothesis, the evidence as a whole does not support a strong version of the hypothesis (see papers in Caramazza & Zurif 1978).

The most commonly cited case of form constraint in language dissolution is the similarity between agrammatic speech in dysphasic patients and the telegraphic speech of young children. Agrammatic speech is characterized by the omission of function words and inflectional morphemes. The patient's utterances may consist of sequences of uninflected nouns and verbs or, in more severe cases, of nouns in isolation as if the patient were simply naming objects or events. For example, patient ML (Caramazza & Hillis 1989) in describing a complex picture produced the following utterances: 'Couple having picnic', 'Boy kite flying', 'Dog watch boy'. This pattern of language production seems similar to the telegraphic speech of young children who produce utterances such as 'mommy sock' or 'mommy throw'.

Despite the striking similarity between the agrammatic speech in dysphasic patients and the telegraphic speech in children, the similarity is only superficial. Detailed investigations comparing the two forms of speech has revealed important qualitative and quantitative differences in the pattern of omissions of function words and inflectional morphemes (e.g. BerkoGleason 1978). Perhaps more damaging to the form constraint of the Regression Hypothesis is the fact that there are many forms of acquired language dysfunction that do not have corresponding forms in acquisition. For example, a common pattern of language production that is not found in language acquisition is that of patients with severe difficulty in producing words of the major lexical classes (nouns, verbs, and adjectives) but who seem to have no difficulty in producing the function words and inflectional morphology needed for the construction of a well-formed sentence (e.g. Butterworth & Howard 1987). Thus, although there are forms of language performance in dysphasic patients that are similar to the performance of young children at some stage of language acquisition, there are many more cases in which the form of language impairment does not correspond to any stage of language acquisition.

There are a number of observations concerning syntactic, lexical and phonological processing disorders that seem to respect the order constraint of the Regression Hypothesis. For example, it has been found that age of acquisition of lexical items predicts relative difficulty in word comprehension and production in dysphasic patients (e.g. Hirsh & Ellis 1994). However, the most detailed and theoretically ambitious analysis of the Regression Hypothesis remains Jakobson's (1968; see also Blumstein 1973) investigation of the relation between phonological universals and the acquisition and dissolution of phonology. Jakobson reviewed evidence showing that among the first phonological oppositions to be lost in dysphasia are those that are relatively rare in the languages of the world and among the last acquired by the child.

Despite these not unimpressive correlations in the order of acquisition and dissolution of language, there are many cases where damage affects those abilities that are acquired early, while leaving largely unaffected abilities that are acquired later in development. Thus, there are patients with progressive degenerative disorders (Alzheimer's disease) who progressively lose the meaning of words while seemingly retaining the ability to produce well-formed if empty sentences (Schwartz *et al.* 1979) even though the acquisition of word meaning precedes the development of sentence production ability; there are patients who have trouble producing nouns but not verbs (Miceli *et al.* 1984) even though nouns are acquired earlier than verbs (Gentner 1982); and so on and so forth for many other dysphasic patterns.

In short, then, neither the form nor the order constraint of the Regression Hypothesis has received unequivocal support: there are patterns of language dissolution that do not correspond to stages of acquisition and there are cases where early-acquired knowledge is damaged while later-acquired knowledge is spared. The Regression Hypothesis, at least in its strong version, does not seem to be correct.

3. THE ACQUISITION AND DISSOLUTION OF SOME ASPECTS OF LEXICAL KNOWLEDGE

The fact that the Regression Hypothesis does not seem to hold up to scrutiny should not be grounds for abandoning the hope for a productive comparison between the acquisition and breakdown of language. Although the strong version of the Regression Hypothesis seems to be false, there are weaker claims about the relation between acquisition and breakdown that are worth exploring. Here I will explore whether there might not be some general principles about the acquisition of lexical knowledge which could inform our understanding of the breakdown of the lexical system in dysphasic patients. I will address this issue by considering semantic and grammatical category-specific disorders in the light of evidence about the acquisition of lexical knowledge. The objective is to explore whether a comparative analysis might not lead to new insights into the nature of category-specific disorders and the organization of lexical knowledge in the normal language processing system.

(*a*) *Category-specific deficits: semantic categories*

One of the most striking forms of language impairment is a disorder in which a category of concepts (e.g. numbers) seems to be selectively damaged. Although not the first to report the existence of category-specific disorders (e.g. Nielsen 1936; Goodglass *et al.* 1966), Warrington, McCarthy & Shallice presented the first compelling evidence and arguments for thinking of the deficit as specifically involving restricted semantic domains. They reported

the performance of several patients who were disproportionately impaired in recognizing and naming living things by comparison to living things (Warrington & Shallice 1984) and other patients with the reverse type of difficulty: greater impairment in recognizing non-living than living things (Warrington & McCarthy 1983, 1987). These deficits are quite striking: a patient may be unable to name or recognize common living things such as horse, chicken, or carrot but show no comparable difficulty with non-living things, even when these are relatively unfamiliar, such as for example sphinx or sextant; and, conversely, a patient may fail to name or recognize common artifacts such as table or pen but show no comparable difficulty with living things. Thus, for example, patient JJ, reported in Hillis & Caramazza (1991), had great difficulty in defining common artifacts such as bench, which he defined as: 'A device you sit on, about 12 inches high with 4 legs. It revolves you around while sitting. Can be made of metal or wood', but showed no difficulty in defining animals including uncommon ones such as heron, which he defined as: 'This bird has a long neck and legs. It lives near water. Stands in the water ... very tall maybe about six feet. Not brown, but white and blue perhaps'.

Since the original studies by Warrington, McCarthy & Shallice, there have been many other reports of category-specific deficits. Some of these also involve the categories living and non-living (e.g. Sartori & Job 1988; Silveri & Gainotti 1988); but others involve more narrowly defined categories: fruits and vegetables (Hart *et al.* 1985; Farah & Wallace 1992), body parts (Dennis 1976), proper names (Semenza & Zettin 1988; Lucchelli & DeRenzi 1992); geographical names (McKenna & Warrington 1978). Despite the large number of reported cases of category-specific deficit, the interpretation of the disorder remains highly controversial.

One criticism has questioned the very existence of semantic category effects. On this view, the putative category-specific deficits are no more than artifacts of poor experimental control of stimuli and other methodological factors. That is, it has been argued that the variation in performance which has been attributed to semantic category distinctions is best accounted for in terms of the non-categorical variables familiarity, frequency, visual complexity, or degree of visual overlap among members of a category (Humphreys & Riddoch 1987; Funnell & Sheridan 1992; Stewart *et al.* 1992). Thus, for example, if the members of a category were to be generally less familiar than the members of other categories, and if the performance of brain-damaged subjects were to be affected by familiarity such that less familiar items were to be more likely to be misnamed, we would then have the appearance of a category-specific deficit where none existed. This criticism has been possible because the most common category-specific deficit has concerned the selective damage of living things. It has also been argued that the members of animate categories are visually less discriminable among themselves and generally less familiar than the members of the contrasting categories of artifacts. Indeed, both Funnel & Sheridan (1992) and Stewart *et al.* (1992) have shown that differences in performance across semantic categories in putative cases of selective deficit of the animate category vanish when category items are matched on such variables as frequency, familiarity and visual complexity.

Although the objection about the possible confounding of processing complexity with semantic categories should not be dismissed lightly, there are several factors which attenuate its impact. It has been shown that in some cases where processing complexity factors were explicitly controlled, the category-specific effect for living things persisted (e.g. Sartori *et al.* 1993). Another factor that undermines the criticism that category-specific effects merely reflect variation in processing difficulty across categories is the report of selective deficits of non-living things. In the measure to which the existence of selective deficits of the animate category is explained by appealing to the greater processing complexity of this category, the existence of selective deficit of the inanimate category cannot be explained by appealing to this same factor. Thus, the reported cases of selective *sparing* of living things (Hillis & Caramazza 1991; Sacchett & Humphreys 1992) further strengthen the empirical basis for interpreting the selective deficit of various semantic categories as true category-specific effects.

Granting that some category-specific deficits are likely to be true category effects, there remains the need to clearly specify the empirical boundaries of the phenomenon. Two issues have emerged as important in this regard. One concerns the seeming preponderance of selective deficits of living over non-living things; the other concerns which taxonomic categories can be selectively damaged. The great majority of reported cases of category-specific deficit have involved the selective deficit of the animate category. However, given the possibility that some of the putative cases of selective impairment of living things might only reflect the effects of greater processing difficulty for members of this category (Funnell & Sheridan 1992; Stewart *et al.* 1992), it is not clear how much weight one should give to the observed discrepancy in the relative occurrence of selective deficit of the living versus non-living category. With respect to the issue of which taxonomic categories can be selectively damaged, here too there is considerable uncertainty. Although there are reports of category-specific deficits involving a number of different categories – fruits and vegetables, body parts, animals, proper names, geographical places – it is possible that many more category-specific effects would be observed if patients were to be tested in a more systematic fashion than is currently the practice. Thus, for all we know, it might be possible to selectively damage the category of writing implements or the category of professions. Although this issue remains to be solved, what is important to note is that some of the observed category-specific deficits do not neatly fit into the categorical distinction living versus non-living. In fact, the reported dissociations of category-specific

deficits are most often complex patterns: impaired identification of living things as well as gemstones and fabrics (Warrington & Shallice 1984); deficit for body parts and artifacts except for large outdoor objects and structures such as ships and bridges (Warrington & McCarthy 1987); deficit for living things and musical instruments (Warrington & Shallice 1984; Silveri & Gainotti 1988); selective sparing of the category animals but not fruits and vegetables (Hillis & Caramazza 1991); and so on and so forth for many other contrasts. It would seem, then, that although the boundaries of the phenomenon of semantic category-specific deficits are still unclear, at the very least the evidence suggests that these deficits can cut across the living/non-living distinction.

(*b*) *Category-specific deficits: grammatical class*

Category-specific deficits have been reported not only for semantic categories but also for grammatical classes. It has been known for some time that brain damage can differentially affect words of different grammatical classes. The earliest reported cases are those of agrammatic speech in which function words are particularly affected and anomia where nouns are typically the most impaired category. More recently, there have been a number of reports that have focused directly on category-specific grammatical class effects in various forms of acquired dyslexia, dysgraphia, and dysnomia (e.g. Andreewsky & Seron 1975; McCarthy & Warrington 1985; Zingeser & Berndt 1988). However, in these reports it was not established whether the category-specific deficit concerned lexical form knowledge or a more central, perhaps semantic, level of representation. It turns out that both types of deficits can occur.

Patient EB (Caramazza & Miceli 1991), who failed to normally process the argument structure of verbs in all tasks tested, provides an example of selective deficit to a central level of representation. He failed to correctly assign nouns their argument positions but was otherwise normal in computing the surface structure of a sentence. For example, he produced the sentence 'La ballerina é applaudita dal pagliaccio' (the ballerina is applauded by the clown) in response to a picture showing a clown applauding a ballerina, and he produced the sentence 'I bambini salutano i dottori' (the children are greeting the doctors) in response to a picture showing doctors greeting children. Note that in both cases, aside from the misassignment of argument positions, the sentences are grammatically flawless. The dissociation between argument structure assignment and other grammatical and morphological processes was not restricted to oral sentence production: EB showed the same pattern of dissociations in spoken and written sentence production, sentence comprehension, grammaticality judgments and sentence anagram tasks. The implication of this pattern of results is that it is possible to damage the argument structure information of a verb while leaving intact the ability to retrieve its phonological or orthographic form.

The most fine-grained grammatical class effects are those involving the selective deficit of one grammatical class in one modality of input or output. Several patients have been reported who are selectively impaired in producing or comprehending either nouns or verbs in either the written or the spoken modality. Thus, there are reports of patients who are selectively impaired in producing verbs in writing (SJD, Caramazza & Hillis 1991; PW, Rapp & Caramazza 1994), patients who are selectively impaired in producing verbs in speaking (HW, Caramazza & Hillis 1991), patients who are selectively impaired in producing nouns in speaking (EBA, Hillis & Caramazza 1994), and patients who are impaired in recognizing written verbs (EBA, Hillis & Caramazza 1994).

Category-specific effects for nouns and verbs can be shown to occur even when the phonological and orthographic forms of the words are identical (i.e. homonyms) in the two grammatical classes. For example, patient SJD was unable to write *play* when it functioned as a verb, as in the sentence 'I like to play tennis', but showed no difficulty in writing *play* when it functioned as a noun, as in the sentence 'I saw the play on Broadway'. By contrast, patient EBA showed the reverse pattern of grammatical class difficulty in speaking: she could produce *play* as a verb but not as a noun. The pattern of dissociations of grammatical categories across and within patients rules out the possibility that the observed modality-specific grammatical class effects merely reflect differences in processing complexity across grammatical categories. Thus, for example, one cannot use the processing complexity argument to explain both SJDs greater difficulty in producing verbs than nouns and EBAs greater difficulty in producing nouns than verbs. Nor can one use the processing complexity argument to explain both EBAs greater difficulty in producing nouns than verbs and her greater difficulty in understanding written verbs than nouns. Other potential confounding factors such as abstractness and frequency were similarly ruled out both by directly controlling these factors in the construction of experimental lists and by the existence of double dissociations across grammatical categories. It would seem, then, that the evidence clearly supports the conclusion that at least some grammatical class effects are true category-specific effects.

What can be concluded about the nature of category-specific deficits from the evidence reviewed here? What are the implications of the existence of semantic and grammatical category-specific deficits for theories of language processing and the organization of lexical knowledge in the brain? Some of the implications would seem to be relatively unproblematic, others much less so.

One clear implication that follows from the existence of modality-specific grammatical class effects is that grammatical knowledge is represented independently and redundantly in modality-specific lexical components (as well as at the level of the lexical semantic component). The fact that grammatical class information is (also) represented at the level of lexical form strongly implies that these lexical

components are organized categorically since there are no phonological or orthographic factors which could function to distinguish among grammatical classes. Thus, the grammatical category-specific effects serve to establish the principle that abstract linguistic information can serve as the basis for the organization of lexical knowledge in the brain.

Less certain implications follow from the existence of semantic category-specific effects, in part because the results are still unclear. Nonetheless, several explanations may be entertained. A first distinction may be drawn between hypotheses that consider the category-specific effects to be secondary to the structure and organization of the semantic primitives which constitute the meaning of words and those that consider the category-specific effects to reflect directly the categorical organization of the semantic system. Two instantiations of the first view are (what I will call) the Sensory Functional Hypothesis (Warrington & Shallice 1984; Warrington & McCarthy 1987) and the Organized Unitary Content Hypothesis (Caramazza *et al.* 1990). The view that category-specific deficits might directly reflect the organization of the semantic system in terms of folk taxonomic categories has not, to my knowledge, been proposed by anyone, despite the fact that it is not obviously false. I will call this last hypothesis the Taxonomic Representation Hypothesis. This hypothesis does not require much explanation. It simply assumes that since lexical knowledge is organized taxonomically in the brain, very fine-grained dissociations of semantic categories are possible.

Warrington *et al.* proposed the Sensory-Functional Hypothesis to account for category-specific deficits. They argued that the sensory-motor attributes of objects play a fundamental role in the organization of semantic information: the semantic system is organized into modality-specific components each representing knowledge acquired through a particular sensory/motor channel. And on the further assumption that living things are defined primarily in terms of visual properties (whereas artifacts are defined primarily in terms of functional attributes), damage to the visual semantic component would result in a category-specific deficit for animate objects.

The Organized Unitary Content Hypothesis (OUCH) (Caramazza *et al.* 1990) also assumes that semantic information is structured, but not along strict sensorymotor dimensions as proposed by the Sensory Functional Hypothesis. Under OUCH, the meaning of a term consists of a set of values on the dimensions of an *n*-dimensional semantic hyperspace. This semantic hyperspace is organized in such a way that related dimensions are close to each other. On this view, category-specific disorders are a consequence of: (i) the fact that damage to a restricted region of the hyperspace will result in damage to related semantic features; and (ii) the fact that members of a semantic category share a number of semantic primitives in common. As a consequence, selective damage to a restricted region of the semantic hyperspace can result in disproportionate difficulty with some semantic categories over others.

Are there clear grounds for choosing among the three proposals about the cause of category-specific deficits? The evidence we have reviewed is not sufficient for an unequivocal choice: all three hypothesis receive some support, but none is entirely satisfactory. The Sensory-Functional Hypothesis provides a natural explanation for the more frequent occurrence of selective damage to the living than the non-living category but does not offer a motivated basis for the existence of category-specific deficits that cut across the living/non-living distinction; OUCH and the Taxonomic Representation Hypothesis can account for the latter fact but do not seem to provide a motivated basis for the (possible) discrepancy in the frequency of occurrence of selective deficits of living versus non-living categories. Can consideration of how children acquire the meaning of words and the ability to categorize objects contribute to a clarification of the issues raised by the existence of category-specific disorders? Can such an analysis shed light on why grammatical class information seems to be represented categorically in the brain?

(*c*) *Category-specific disorders and the acquisition of lexical knowledge*

In considering the relation between the existence of category-specific disorders and language acquisition, one issue can be disposed of quickly: are there stages in the acquisition of language that correspond to the types of category-specific disorders that have been recorded for dysphasic patients? No such correspondences have been noted. This fact further undermines the strong version of the Regression Hypothesis. More importantly, however, it underlines the limitation of any enterprise that would focus on a direct comparison between the performance of brain-damaged subjects and that of children acquiring language. Nonetheless, there are aspects of children's performance that bear on the theoretical implications that follow from the existence of category-specific deficits. Although the results in the acquisition literature are not univocal on the nature and development of lexical knowledge and classification ability, they are suggestive with respect to both semantic and grammatical category-specific disorders.

Consider first the case of semantic category-specific deficits. Two results are particularly relevant here. One concerns the order of acquisition of words and the other concerns the role of perceptual and other properties in the development of category knowledge. There is clear evidence that when children begin to acquire words they predominantly learn nouns (or, more precisely, words that could function as nouns in adult language) (Gentner 1982). There is also evidence that young children initially tend to classify objects on the basis of their salient perceptual properties (see Mansfield 1977). The fact that children first seem to acquire nouns which are likely to refer to perceptually salient parts of the world (Gentner 1982) and the fact that early on children are particularly sensitive to perceptual attributes in their classification of objects could be taken to suggest that an important basis of lexical semantic organization is

the distinction between perceptual and other features of meaning. These observations, although strictly not inconsistent with the OUCH and the Taxonomic Representation Hypothesis, would seem to have a closer affinity with the Sensory Functional Hypothesis which assumes that there are distinct semantic subsystems for visual and functional information. However, this conclusion must be tempered by the fact that young children quickly learn to ignore perceptual information when it is in conflict with category knowledge, even when the latter is of a non-perceptual nature (e.g. Gelman & Markman 1986). This fact would seem to suggest that older children develop a taxonomically-based knowledge structure, or at least one that does not privilege perceptual information over other information in the definition of a category concept.

The results from lexical acquisition are also relevant to the interpretation of grammatical category-specific deficits. In addition to the facts discussed in the context of semantic category-deficits, viz. that children acquire nouns before verbs and that early acquired nouns tend to refer to perceptually salient parts of the world, there is the fact that children seem to bootstrap to knowledge of grammatical relations of verbs from semantic structure involving temporal, causal, and agentive properties (e.g. Gropen *et al.* 1991). In simple verbs, these semantic properties have a rough correspondence to state changes and motion in perceptual/action space. An interesting consequence of this view could be that early-acquired verbs emphasize motor-based components of meaning. Thus, very early in the acquisition of words a major contrast could be established between the semantics of nouns and verbs: the meaning of early nouns would rely principally on perceptual attributes; the meaning of verbs would rely principally on actions or motor plans. This early contrast might affect the representation of semantic predicates in the brain such that those that predominate for nouns would be associated with neural tissue dedicated to the representation and processing of objects (the temporal lobe) whereas those that predominate for verbs would be associated with neural structures dedicated to the processing and representation of actions (the frontal lobe) (Damasio & Tranel 1993; Miceli *et al.* 1984; Caramazza 1994). This neuroanatomical separation in the representation of basic primitives of meaning associated with nouns and verbs would then support the possibility of selective damage to one class of words or the other.

There is another observation from acquisition that is relevant here. Landau & Gleitman (1985) have shown that children rely on syntactic context to bootstrap to the meaning of some verbs. This observation suggests that knowledge of verbs may be more closely linked to knowledge of syntax than is knowledge of nouns. Thus, one might be led to argue that the neural representation of verbs could be determined by its functional proximity to syntactic process. If the latter were to primarily implicate neural structures in the frontal lobe, then, the neural representation of verbs (unlike nouns) might also depend on this area of the brain. Once again, the neuroanatomical separation in the representation of nouns and verbs induced by the order and manner of acquisition could provide the basis for grammatical category-specific deficits.

In conclusion, it is clear that there is no correspondence between category-specific deficits in dysphasic patients and stages of acquisition of lexical knowledge. Nonetheless, there are important similarities and some mutual constraints between the two areas of investigation. The constraints are provided by the relation that each system – the developing one and the damaged one – has to the normally functioning, adult system. When the language system breaks down as a consequence of brain damage, it reflects the structure of the mature system. However, the mature system has the structure it does largely because of the way it is acquired. Thus, there is a clear interdependence between lexical processing performance in acquisition and dissolution, if for no other reason that in both cases performance is ultimately explicable only by reference to the mature system. This dependence, however, is at the level of the principles that govern the general functioning of the two systems and not at the level of specific performance patterns. Despite the lack of detailed correspondence between acquisition and breakdown, it has nonetheless been possible to relate evidence and insights from acquisition to the case of category-specific deficits. Thus, the evidence from acquisition has served to motivate specific hypotheses about the basis for selective damage to grammatical classes and semantic categories. In both cases, the evidence suggests that principles conditioned by sensory-motor aspects of the referents of lexical items play a significant role in the organization of the lexical system. However, this does not necessarily imply support for the Sensory Functional Hypothesis over OUCH and the Taxonomic Representation Hypothesis. All that the evidence from acquisition sanctions is that the categorical distinctions observed in the mature lexical system emerge in part as a consequence of the role played by sensorymotor information in acquisition. Considerably more detailed investigations and analyses will be required in order to determine the specific manner in which semantic and grammatical information is represented and organized.

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REFERENCES

Andreewsky, E. & Seron, X. 1975 Implicit processing of grammatical rules in a classical case of agrammatism. *Cortex* **11**, 379–390.

BerkoGleason, J. 1978 The acquisition and dissolution of the English inflectional system. In *Language acquisition and language breakdown, parallels and divergencies* (ed. A. Caramazza & E. Zurif). Johns Hopkins University Press.

Blumstein, S.E. 1973 *A phonological investigation of aphasic speech.* Janus Linguarum Ser. Minor, Nr. 153. The Hague: Mouton.

Butterworth, B. & Howard, D. 1987 Paragrammatisms. *Cognition* **26**, 1–37.

Caramazza, A. 1994 The representation of lexical knowledge in the brain. *Decade of the brain*, vol.1. (In the press.)

Caramazza, A. & Hillis, A.E. 1989 The dissruption of sentence production: some dissociations. *Brain Lang.* **36**, 625–650.

Caramazza, A. & Hillis, A.E. 1991 Lexical organization of nouns and verbs in the brain. *Nature, Lond.* **349**, 788–790.

Caramazza, A., Hillis, A.E., Rapp, B. & Romani, C. 1990 The multiple semantics hypothesis: Multiple confusions? *Cogn. Neuropsychol.* **7(3)**, 161–189.

Caramazza, A. & Miceli, G. 1991 Selective impairment of thematic role assignment in sentence processing. *Brain Lang.* **41**, 402–436.

Caramazza, A. & Zurif, E. (eds) 1978 *Language acquisition and language breakdown parallels and divergencies.* Johns Hopkins University Press.

Damasio, A.R. & Tranel, D. 1993 Nouns and verbs are retrieved with differently distributed neural systems. *Proc. natn. Acad. Sci. U.S.A.* **90**, 4957–4960.

Dennis, M. 1976 Dissociated naming and locating of body parts after left anterior temporal lobe resection: An experimental case study. *Brain Lang.* **3**, 147–163.

Farah, M. & Wallace, M.A. 1992 Semantically-bound anomia: Implications for the neural implementation of naming. *Neuropsychologia* **30**, 609–622.

Freud, S. 1953 *On aphasia.* Translation E. Stengel. New York: International Universities Press.

Funnell, E. & Sheridan, J. 1992 Categories of knowledge? Unfamiliar aspects of living and nonliving things. *Cogn. Neuropsychol.* **9**, 135–153.

Gelman, S.A. & Markman, E.M. 1986 Categories and induction in young children. *Cognition* **23**, 183–208.

Gentner, D. 1982 Why nouns are learned before verbs: Linguistic relativity vs. Natural partioning. In *Language development: Syntax and semantics* (ed. S. A. Kuczaj II), pp. 301–334. Hillsdale, New Jersey: Erlbaum Assoc.

Goodglass, H., Klein, B., Carey, P. & Jones, K.J. 1966 Specific semantic word categories in aphasia. *Cortex* **2**, 74–89.

Gropen, J., Pinker, S., Hollander, M. & Goldberg, R. 1991 Affectedness and direct objects: The role of lexical semantics in the acquisition of verb argument structure, *Cognition* **41**, 153–196.

Hart, J., Bernt, R.S. & Caramazza, A. 1985 Category-specific naming deficit following cerebral infarction. *Nature, Lond.* **316**, 439–440.

Hillis, A.E. & Caramazza, A. 1991 Category-specific naming and comprehension impairment: A double dissociation. *Brain* **114**, 2081–2094.

Hillis, A.E. & Caramazza, A. 1994 Representation of grammatical knowledge in the brain. *Reports of the Cognitive Neuropsychology Laboratory.* Dartmouth College, Hanover, N.H., U.S.A.

Hirsh, K.W. & Ellis, A. 1994 Age of acquisition and lexical processing in Aphasia: A case study. *Cogn. Neuropsychol.* (In the press.)

Humphreys, G. & Riddoch, M. 1987 On telling your fruit from your vegetables: A consideration of category-specific deficits after brain damage. *Trends Neurosci.* **10**, 145–148.

Jakobson, R. 1968 *Child language, aphasia, and phonological universals.* Translation A.R. Keiler. The Hague: Mouton.

Landau, B. & Gleitman, L.R. 1985 *Language and experience.* Cambridge, Massachusetts: Harvard University Press.

Lucchelli, F. & De Renzi, E. 1992 Proper name anomia. *Cortex* **28**, 221–230.

Mansfield, A.F. 1977 Semantic organization in the young child: Evidence for the development of semantic features systems. *J. exp. Child Psychol.* **23**, 57–77.

McCarthy, R.A. & Warrington, E.K. 1985 Category specificity in an agrammatic patient: the relative impairment of verb retrieval and comprehension. *Neuropsychologia* **23**, 709–727.

McKenna, P. & Warrington, E.K. 1978 Category-specific naming preservation: A single case study. *J. Neurol. Neurosurg. Psychiatry* **41**, 571–574.

Miceli, G., Silveri, M.C., Villa, G. & Caramazza, A. 1984 On the basis of agrammatic's difficulty in producing main verbs. *Cortex* **20**, 217–220.

Nielsen, J.M. 1936 *Agnosia, apraxia, and aphasia: Their value in cerebral localization.* New York: Paul B. Hoeber.

Rapp, B. & Caramazza, A. 1994 The dissociation of grammatical categories in the spoken vs. written production of a single patient. *Reports of the Cognitive Neuropsychology Laboratory.* Dartmouth College, Hanover, N.H., U.S.A.

Sartori, G. & Job, R. 1988 The oyster with four legs: A neuropsychological study on the interaction of visual and semantic information. *Cogn. Neuropsychol.* **5**, 105–132.

Sartori, G., Miozzo, M. & Job, R. 1993 Category-specific impairment? Yes. *Q. J. exp. Psychol.* **46A**, 489–504.

Sacchett, C. & Humphreys, G. 1992 Calling a squirrel a squirrel but a canoe a wigwam: A category-specific deficit for artifactual objects and body parts. *Cogn. Neuropsychol.* **9**, 73–86.

Schwartz, M.F., Marin, O.S.M. & Saffran, E.M. 1979 Dissociations of language function in dementia: A case study. *Brain Lang.* **7**, 277–306.

Semenza, C. & Zettin, M. 1988 Generating proper names: A case of selective inability. *Cogn. Neuropsychol.* **5**, 711–721.

Silveri, M. & Gainotti, G. 1988 Interaction between vision and language in category-specific semantic impairments. *Cogn. Neuropsychol.* **5**, 677–710.

Stewart, F., Parkin, A.J. & Hunkin, N.M. 1992 Naming impairments following recovery from herpes simplex encephalitis: Category-specific? *Q. J. exp. Psychol.* **44A**, 241–284.

Warrington, E.K. & McCarthy, R.A. 1983 Category-specific access dysphasia. *Brain* **106**, 859–878.

Warrington, E.K. & McCarthy, R.A. 1987 Categories of knowledge: Further fractionations and an attempted integration. *Brain* **110**, 1273–1296.

Warrington, E.K. & Shallice, T. 1984 Category-specific semantic impairment. *Brain* **107**, 829–853.

Zingeser, L.B. & Berndt, R.S. 1988 Context effects in a case of pure anomia: implications for models of language production. *Cogn. Neuropsychol.* **5**(4), 473–516.