Brain and Language **68,** 347–354 (1999)
Article ID brln.1999.2066, available online at http://www.idealibrary.com on IDEAL®

Rule-Based versus Associative Processes in Derivational Morphology

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The present article examines whether derivational morphology shows evidence of an associative memory structure. A distributional analysis of stems of attested derivational forms revealed evidence of clustering around phonological properties (gangs) for all nonneutral affixes but only a few neutral affixes. Subjects' acceptability ratings for novel complex words revealed sensitivity to the gang structure associated with the relevant derivational affixes. Results suggest that, like inflectional morphology, derivational morphology shows dissociations between rule-based and associative generalization mechanisms. © 1999 Academic Press

Key Words: morphology; gang effects; derivation; connectionism; dual model; associative memory.

One of the most hotly debated issues in recent years is whether certain linguistic processes can be captured within single associative networks that eschew symbolic representations and rules (e.g., Bybee, 1995; Rumelhart & McClelland, 1986; Skousen, 1992; Stemberger, 1995). Much of the debate has been addressed to the distinction between regular and irregular inflections. Challenging the single-network models, Pinker (1991) presented evidence that regular and irregular inflections show multiple dissociations that support a distinction between rule-based and associative processes for regular and irregular inflections respectively.

According to Pinker's dual model, a rule-based process is a default operation that concatenates an affix, such as *-ed*, with a variable standing for syntactic category of the stem. It thus applies freely to any item of the right category, regardless of phonological form. Irregular inflections involve the storage of stems and inflected forms in an associative memory structure. Productive generalizations exploit similarities to patterns of stored forms. These are known as ''gang effects'' (Stemberger & MacWhinney, 1988). For example, the gang represented by *ring–rang*, *sing–sang* generalizes to

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spling–splang (Bybee & Moder, 1983; Prasada & Pinker, 1993). In contrast to single-network connectionist models, Pinker's dual model predicts that gang effects should only be found for irregular forms, not for regular forms, which appears to be the case (Bybee & Moder, 1983; Prasada & Pinker, 1993).

Unlike inflectional morphology, derivational morphology does not have a clear distinction between regular and irregular processes. There is no sense in which derivational functions have a default form and a more idiosyncratic form. However, there are differences in the degree of productivity between various derivational processes. For example, the agentive -*er* suffix occurs with most verb stems, whereas -*ist* is much more selective. Along with differences in productivity, there are also differences in the phonological effects that derivational affixes may have on their stems. Morphological processes have traditionally been divided into neutral and nonneutral (Chomsky & Halle, 1968). Neutral affixation does not trigger changes in the internal phonology of the stem, and therefore the stress pattern and vowel quality of the stem remains intact upon affixation. Nonneutral affixation may cause changes to the internal stem phonology in the form of stress shifts and vowel changes (e.g., *tèlegraph* vs *telègraphy*).

How does the derivational distinction between neutral and nonneutral map onto the distinction between rule-based and associative processes? Since nonneutral derivations share many characteristics of irregular inflections (limited productivity, phonological deformation of stems), one might expect them to generalize based on redundancy patterns in associative memory and therefore show gang effects. Neutral derivations, on the other hand, show properties that are somewhat in between those of regular and irregular processes. While neutral derivations seem to attach to stems in a similar manner to regular inflections, they are rarely considered to be default processes and may sometimes have quite limited application to stems.

Many psycholinguistic studies have equated the status of derivational affixes with regular inflectional affixes in that both are said to involve morphological decomposition for lexical access. This contrasts with irregular inflections, which are found to be stored as whole words. Several studies have found that base forms are activated when either regularly inflected or derived words are processed, but not when irregular inflections are processed (Stanners, Neiser, Hernon, & Hall, 1979; Laudanna, Badecker, & Caramazza, 1992; Cole, Beauvillain, & Segui, 1989). However, such results do not distinguish between Pinker's (1991) dual model and single-network models. This is because single-network models account for stem activation phenomena by either having superimposed representations (Bybee, 1995) or by having whole word representations cluster together in the lexicon around a nucleus represented by the stem (Lukatela, Gligorijevic, & Kostic, 1980). In addition, Alegre and Gordon (1999) have shown that even regularly inflected forms may exhibit whole-word storage and yet not show gang effects in their generalization patterns (Prasada & Pinker, 1993). Finally, these papers have also tended to ignore the distinction between neutral and nonneutral derivations, which could be significant in exploring these issues.

To investigate how derivational representations might be structured, we used two procedures. In the first study, we explored whether different derivational forms are organized in gangs, thus providing evidence of storage in an associative memory structure. For this, we performed a distributional analysis on 11 derivational affixes. We searched for recurring patterns that could be considered to constitute gangs. In the second study, we used acceptability ratings to examine how these patterns generalize to novel forms and whether the presence or absence of gangs plays a role in such generalizations.

STUDY 1: DISTRIBUTIONAL ANALYSIS OF DERIVATIONAL AFFIXES

Method

We used Francis and Kucera (1982), Marchand (1969), *Walker's Rhyming Dictionary* (1985), and *Chambers Back-Words for Crosswords* (1987) for the distributional analysis. Twelve affixes were selected: six nonneutral affixes (*-ion, -al*$_N$, *-al*$_V$, *-ity, -ous,* and *-ic*) and six neutral affixes (*-ize, -en, -ness, -able, -ment,* and *-er*). We identified all English words ending in these affixes whose stems were of the right syntactic category (e.g., only adjectives for *-en*) and showed clear evidence of being multimorphemic (i.e., contained a base form that either existed as an independent word or could be found in other derived items). We also excluded those forms that involved multiple affix combinations (e.g., items where *-ic* attached to a multimorphemic word ending in *-ist*). We then searched for three types of regularities among base forms: (1) number of syllables, (2) recurring stress patterns, and (3) recurring sound sequences at the beginnings and endings of the base forms.

Results

The results are shown in Table 1. Beginnings of stems turned out to be less diagnostic of gang clustering than stem endings. Therefore, items were classified as belonging to a gang if they shared a pattern of length in syllables, stress, and ending with at least 10 other items or over 10% of attested forms. Partial overlap was credited for forms that shared length, stress, and initial sound sequences with well-defined gangs plus had a common ending with at least two other forms.

From Table 1, it can be seen that all nonneutral affixes display a strong gang organization. The same is true for two neutral affixes: *-en* and *-ize.* A few recurring patterns were identified for *-able, -ness, -er,* and *-ment,* but these accounted for less than 20% of attested forms often distributed over five or six different gang types. Thus, while some degree of phonological overlap between forms was observed, these forms cannot be considered to display a clear gang structure.

In summary, the existence of gang clusters overlaps with the neutral/nonneutral distinction, but is not coextensive with it. It appears that being nonneutral is a sufficient but not necessary condition to attract gang clustering.

TABLE 1
Gang Structure in Derivational Forms

Affix	Type	No. of types analyzed	No. of gangs identified	% of types in gangs	% of types with partial overlap	% of types with no associative support
-ion	Nonneutral	477	9	87	10.5	2.5
-al$_{N}$	Nonneutral	389	15	89	4	7
-al$_{V}$	Nonneutral	36	5	89	5.5	5.5
-ity	Nonneutral	195	9	90	3	7
-ous	Nonneutral	85	3	77	6	17
-ic	Nonneutral	167	4	86	9	5
-en	Neutral	30	1	100	—	—
-ize	Neutral	76	5	70	22	8
-ness	Neutral	318	5	17		83
-able	Neutral	302	6	20		80
-ment	Neutral	246	5	20		80
-er	Neutral	516	3	11		89

STUDY 2: GENERALIZATION OF DERIVATIONAL MORPHOLOGICAL PATTERNS

Are productive generalizations sensitive to clustering of phonological similarities? Both dual models and single-network models predict gang effects for items that have gangs. However, only the single-network models predict generalization for the No-Gang items. For example, a nonce form like *kriller*, with a base that resembles dozens of forms that take *-er*, should be more acceptable than a form like *trilber*, which has a base form ending in *-lb*, a sequence not found in any English verb coda.

In the present study, participants were presented with pairs of novel base and affixed forms to see if the existence of gang organization predicts similarity-based generalization (cf. Prasada & Pinker, 1993).

Participants

Forty-four undergraduate students from the psychology subject pool at the University of Pittsburgh participated in the experiment.

Materials

We constructed a questionnaire containing 69 novel derived words and their base forms. Derivational forms included four Gang affixes (*-ion*, *-al*$_{N}$, *-al*$_{V}$, and *-en*) and three No-Gang affixes (*-er, -ness,* and *-able*). There were three kinds of items for each affix based on similarity to attested forms. (1) Near items had base forms that resembled items from the gangs identified in the previous section, capturing every common phonological element that we could find within the gang (e.g., **dissumption*). (2) Intermediate items resembled no more than five attested forms. They either partially matched gang patterns or resembled forms previously classified as ‘‘types with partial overlap’’ (e.g., **femension*). (3) Distant items did not resemble any attested forms and violated any observed gang patterns (e.g., *mipation*). We tried to make all novel forms as natural-sounding as possible and did not include any sequences that violated English phonotactic constraints. Naturalness ratings obtained on the base forms for this task allowed us to control for any differences at this level.

For the No-Gang items, the near-intermediate-distant metric was also based on similarity of items to phonological properties of clusters of attested forms. The difference was that such clusters did not figure prominently in the overall distribution of base forms (see Table 1).

For each affix there were three items for each of the three similarity levels (near, intermediate, distant)—except for *-ion,* which had five items in each cell to test the larger variety of gang types for this affix.

Procedure

The novel items were embedded in simple sentences and presented in a paper-and-pencil questionnaire. Participants first rated the naturalness of the base form on a 7-point scale and then rated the likelihood that the base form would take a particular affix. For example:

(a) You can DISART it.
Poor 1 2 3 4 5 6 7 Good

You can do a DISARTION.
Unlikely 1 2 3 4 5 6 7 Very likely

Results

Ratings for the three similarity types are presented in Fig. 1 for the base forms and in Fig. 2 for the derived forms, both contrasting Gang and No-Gang items. Only the Gang items showed evidence of similarity to attested forms resulting in a strong Gang $\times$ Similarity interaction [$F1(2, 43) =$

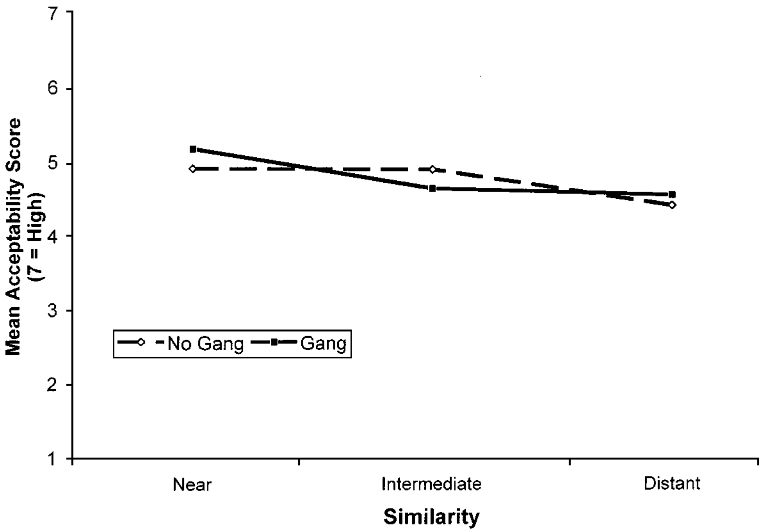

FIG. 1. Acceptability ratings for base forms.

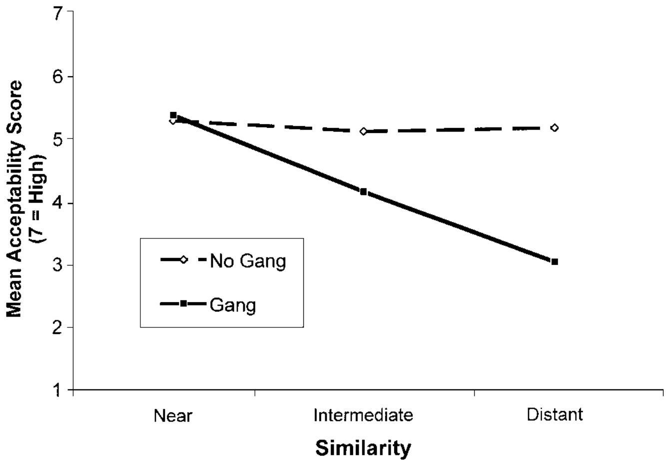

FIG. 2. Acceptability ratings for derivational forms.

136.73, $p < .0001$; $F2(2, 68) = 36.1$, $p < .0001$]. Although there was an effect of similarity for base forms [$F1(2, 43) = 57.84$, $p < .0001$; $F2(2, 68) = 9.74$, $p < .005$], there was no interaction with Gang [$F1(2, 43) = 0.67$, $p = .52$; $F2(2, 68) = 0.12$, $p = .88$]. Figures 3 and 4 show that these effects were consistent across all of the affixes tested. In particular, the similarity effect for derived forms was significant for all four Gang affixes (-*ion*, -al_{N}, -al_{V}, and -*en*; $p < .05$) and not for any of the No-Gang affixes (-*er*, -*ness*, and -*able*; $p > .05$).

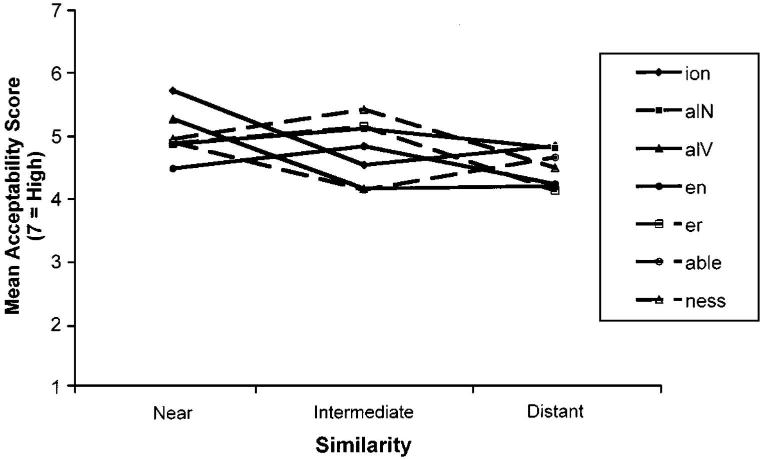

FIG. 3. Acceptability ratings for base forms for individual affixes.

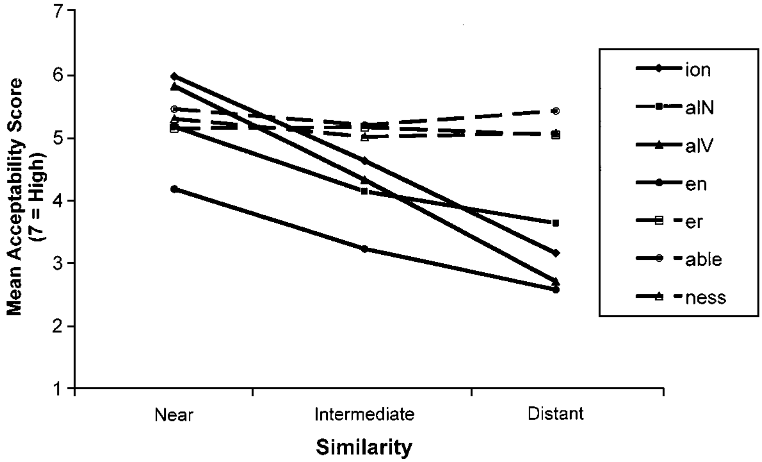

FIG. 4. Acceptability ratings for derivational forms for individual affixes.

GENERAL DISCUSSION

The distributional analysis of base forms that take specific derivational affixes has shown that some of these forms organize into clusters or gangs and others do not. Furthermore, the existence of gangs for any particular affix has strong effects on judgments of acceptability for novel forms. The more similar an affixed form is to members of the cluster, the more acceptable it is. The gang effect is not simply due to generalization from attested forms since clusters for No-Gang items did not show such effects.

For affixes that do not show gang effects, it is tempting to suggest that such affixes promote generalization on the basis of abstract rules in much the same way that has been proposed for regular inflection (Pinker, 1991). It is unlikely, though, that many existing derivational forms are created via rule processes at every turn. Words like *teacher*, *likeable*, and *neatness* are more than likely to be stored as whole words even though they may not give rise to phonological clustering. However, this is also true for high-frequency regular inflections (Alegre & Gordon, 1999; Gordon & Alegre, 1999, this volume). The primary difference between Gang and No-Gang affixes seems to be primarily one of how generalization occurs in the creation of unattested complex forms.

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