ON THE STATUS OF THE SEGMENT IN FOUR TYPOLOGICALLY DIVERSE LANGUAGES: RESULTS FROM GLOBAL SOUND SIMILARITY JUDGMENTS

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ABSTRACT

On the basis of the global sound similarity judgment (SSJ) task and linear regression analysis, the phonemic segment is revealed to be a significant phonological unit in Arabic, Taiwanese (Chinese), Korean and Japanese, but with differential weightings in each case based on syllable position. A subsidiary body (CV) unit also emerged in Korean, and in Japanese the mora outranked the segment in prominence.

THE GLOBAL SOUND SIMILARITY JUDGMENT TASK

The research reported here is part of a larger cross-linguistic investigation of phonological units in languages of diverse types. One experimental technique that has proved useful in this investigation is the elicitation of global sound similarity judgments (SSJs). In this task subjects listen to systematically-varied pairs of words or pseudo-words and rate them for overall similarity in sound on some scale, usually ranging from 0 (no similarity) to 9 (identity in sound).

PREDICTING GLOBAL SOUND SIMILARITY JUDGMENTS IN ENGLISH

Following up on Vitz & Winkler's [1] attempt to predict similarity judgments on the basis of a simple phoneme-matching procedure, Derwing & Nearey [2,3] and Bendrien [4] provided strong support for the phoneme as the representational unit in terms of which English sound similarity judgments are made, while also showing a significant independent contribution of a rime (VC) unit.

PREDICTING SSJs IN OTHER LANGUAGES

Arabic

Derwing, Parkinson & Beinert [5] report on a set of SSJ results for Arabic based on a list of 47 CVCVC-CVCVC word-pairs, largely involving one-, two- or three-segment mismatches between the members of each pair (e.g., *s*akan-*m*akan, *r*asal-*r*ikal, d*ar*ab-d*uk*ub). One example each was also provided with four and with five mismatches, and one identity pair with no mismatches (katab-katab). These word-pairs were arranged into a single, randomized list for tape recording and oral presentation to subjects, except that the first six items were purposely selected to illustrate the range of variation, so as to allow subjects to mentally calibrate the zero (least similar) to nine (most similar) scale on which they were asked to rate their judgments. Subjects were 12 residents of Edmonton who were native speakers of Egyptian, Lebanese or Palestinian Arabic. The forms presented were from a "levelled" spoken dialect familiar to all the subjects.

When a series of linear regression analyses were run on the SSJ data, the segment analysis, based on matches (coded 1) or mismatches (coded 0) among the five segments in each word-pair, yielded an r^2 of 92.0%. This surpassed the results based on shared onsets and rimes (88.5%), bodies and codas (71.0%), tiers (where C-tier consists of all the consonants in each word and V-tier both vowels; 70.5%) and whole syllables (44.7%). By adding C-Tier to the variable list along with each of the five segments, the coverage for these word-pairs was increased to 93.4%, showing the significant, additive effect of the C-Tier factor. Adding the V-Tier variable contributed virtually nothing, however. This last analysis is presented in detail in Table 1 below, which shows the coefficients for each variable, as well as the *t*-ratios (all significant at $p < .01$).

We draw the following tentative conclusions from these results for Arabic: (1) Consonants contribute more to SSJ means than vowels do, as indicated by the coefficients. (Note also in this connection that only consonants are ordinarily represented in the standard orthography for this language.)

Table 1. Linear Regression Analysis for Mean SSJ Similarity Ratings in Arabic (47 CVCVC-CVCVC word-pairs)

Variables	Coefficients	*t*-ratios
C1	1.523	6.21
C2	2.038	6.84
C3	1.493	6.17
V1	1.046	5.33
V2	0.651	3.35
C-Tier	1.000	2.91

(2) Of the three consonants represented in CVCVC structures, the middle one (C2) contributes the most, perhaps reflecting the fact that it is only in the middle, intervocalic position where contrasts with consonant geminates and clusters are possible. Furthermore, (3) of the two vowels represented, the first vowel (V1) counts more than the second. (This may be an indication that a rime unit is involved, since the first vowel and the first rime were coextensive for these words, but more research will be required to clarify this point.) Finally, (4) C-Tier (scored as a match only if all three consonants were the same for a given word-pair) makes a significant, independent contribution, in addition to the individual contributions of each separate consonant. While this might be interpreted as evidence in support of the Tier model [6], the lack of relevance of the V-Tier detracts from this. Since C1...C2...C3 corresponds to the root in all of the words in this study, we suspect that this is an ancillary morphological or orthographic effect.

Taiwanese

In the Taiwanese (Chinese) phase of this study, 32 systematically varied CVC-CVC word-pairs were used as stimuli by Wang & Derwing [7], representing contrasts in the first (C1) position (e.g., *b*in33-*c*in33), the vowel (V) (e.g., t*a*n13-t*i*n13) and in final (C2) position (e.g., ci*t*21-ci*n*21), plus multiple combinations of these. (Numerals represent tone contours which were held constant within each word pair.) These items were randomized before recording on audiotape and were presented in one of two fixed orders to subjects; six duplicate items were also inserted at the beginning of each tape to illustrate the range of variation to be encountered on the test. Subjects were 105 native speakers who were recruited from four Freshman English classes at National Tsing Hua University, Hsinchu, Taiwan.

When a linear regression analysis was run on the SSJ mean ratings for these items, using the three segments in each word as variables, over 85% of the variance was accounted for (adjusted r^2=.856). The results of this analysis are shown in Table 2.

Table 2. Linear Regression Analysis for Mean SSJ Similarity Ratings in Taiwanese (32 CVC-CVC word-pairs)

Variables	Coefficients	*t*-ratios
V	4.167	11.88
C1	2.385	6.29
C2	0.780	2.06

Of the three individual segment factors, it can be seen that the vowel made the greatest contribution, followed by the initial consonant, as indicated by the relative sizes of the coefficients, and both were highly significant ($p < .001$). On the other hand, the coefficient on the final consonant factor was very small, and the contribution of that factor was only marginally significant (p =.049). In fact, if we remove the C2 factor from the analysis entirely, the amount of variance accounted for is still 83.5%. This confirms the view that Taiwanese speakers weigh the initial consonants of words more heavily than they do the final consonants, and it is perhaps less than coincidental that the initial consonant position in Taiwanese CVC words permits more than twice the range of consonantal contrasts than does the final consonant position.

Korean

Yoon & Derwing [8] report on an application of the SSJ paradigm to 48 Korean CVC-CVC word-pairs, systematically varied in composition from no phonemes in common (e.g., pin-mut) to full phonemic identity (e.g., pin-pin). These items were randomized before recording as a single list that was presented to all subjects, with four pairs inserted at the beginning of the list to preview the scale. Subjects were 15 native speakers who were students at the University of Alberta.

When a linear regression analysis was run on these data that combined the three segment variables as factors, almost 90% of the variance could be accounted for, suggesting that for Korean, as for English, Arabic and Taiwanese, segments are the most important units for predicting sound similarity. Interestingly, however, adding the CV or "body" variable to the analysis increased the coverage to 93.5%, while adding the rime variable had no significant effect. As shown in Table 3, all four of these factors were highly significant ($p < .001$), making roughly equivalent contributions to the similarity scores.

Combined with the other findings summarized in [8], this result confirms the body as an important sub-component of the Korean syllable, roughly comparable in status to the rime in English.

Table 3. Linear Regression Analysis for Mean SSJ Similarity Ratings in Korean (48 CVC-CVC word-pairs)

Variables	Coefficients	*t*-ratios
C1	0.900	7.85
V1	0.751	7.57
C2	0.710	6.20
Bo	0.756	4.66

Japanese

Finally, following up on preliminary work by Harrison [9] and Derwing & Wiebe [10], a new SSJ study was undertaken in Japanese. Stimuli were 30 real CVCV-CVCV word-pairs that were constructed around a limited set of multi-feature mismatches in one (e.g., *kami*-nami), two (*ka*ko-*ne*ko, *kamo*-*nami*), three (*kage*-*nasa*) or all four segments (*toge*-*misa*), where the segment and moraic analyses could sometimes differ. (Note that the first two examples both illustrate single mora differences, while the last three show a two mora difference.[1]) Subjects were 79 native speakers who were visiting ESL students at the University of Alberta.

When exploratory linear regression analyses were run on the results, the analysis based on the two morae accounted for 92.9% of the variance for the CVCV-CVCV items. Morever, the mora and segment analyses were clearly distinguished, with the latter accounting for only 70.0% of the variance. This large difference is reflected in the fact that, for pairs differing in one C and one V, the effect is much larger if the differences occur in two separate morae (as in pairs like *sake*-*gaka*, *kika*-*kona* or *kasi*-*nagi*), for which the overall mean rating was 0.52, than if these two differences occur within the same mora, (as in *ka*ko-*ne*ko and ta*ko*-t*ani*), for which the overall rating was 3.31. So the mora analysis is the clear winner here, since the latter accounts for more than 20% more variance with a smaller number of variables (two morae vs. four segments). Other analyses, involving units such as the rime or body, did not perform nearly as well as either of these two. However, the best analysis overall (adjusted r^2=.947) is the six-factor model analyzed in Table 4,[2] which takes both morae and all four individual segments into account, and for which five of the six variables show significant independent effects ($p(t_2) < .0001$ for both morae and $p(t_2) < .05$ for all segments except V2, for which $p(t_2)$=.0688; all variables are significant under a one-tailed analysis, which can be motivated *a priori*). In the subject analysis shown in column t_1 in Table 4, all variables are highly significant ($p(t_1) < .0001$).

Table 4. Linear Regression Analysis for Mean SSJ Similarity Ratings in Japanese (30 CVCV-CVCV word-pairs)

Variables	Coefficients	t_1	t_2
M1	3.071	23.75	8.84
M2	3.467	23.37	9.87
C1	0.555	8.19	2.17
V1	0.701	10.36	2.91
C2	0.525	10.38	2.21
V2	0.478	7.25	1.89

SUMMARY AND CONCLUSIONS

The most important finding from this study is the reaffirmation of the segment as a viable phonological unit in each of the four languages investigated. In three of the four cases, in fact (i.e., Arabic, Taiwanese and Korean), the segment clearly predominated, as the regression analyses that involved only the individual segments as factors already accounted for a substantial amount of the variance (greater than 85% throughout) in predicting the mean sound similarity ratings for the word-pairs tested. Even in the exceptional case, Japanese, where the mora unit was predominant, each of the four segments in the CVCV-CVCV comparisons were found to exhibit significant independent effects.

It is also of interest that the Japanese mora was not the only higher-order unit to emerge in this study. Specifically, the SSJ technique has revealed the influence of other sub-syllabic phonological units, in some languages, such as the rime (or VC unit) in English and the body (CV) in Korean.

NOTES

[1]While the mora and syllable units are coextensive for CVCV words in Japanese, results from other word-pairs involving constrasts between four- and five-segments have confirmed that the mora and not the syllable is the operative unit in this language, as the orthography indicates (see also [11]).

[2]Note that two *t*-ratios are provided in Table 4: t_1 reflects the reliability of the coefficients across subjects, while t_2 does the same across items, which is the only analysis done in Tables 1-3 (see Lorch & Myers [12] for discussion). Although individual data could not be processed by press time for the other languages represented here, investigations of other similar data sets have shown that all factors shown to be significant across items have remained significant across subjects.

REFERENCES

[1] Vitz, P.C. & B.S. Winkler (1973), "Predicting the judged similarity of sound of English words," *JVLVB*, vol. 12, pp. 373-388.

[2] Derwing, B.L. & T.M. Nearey (1986), "Experimental phonology at the University of Alberta," in J.J. Ohala & J.J. Jaeger (eds.), *Experimental phonology*, Orlando, FL: Academic Press, pp. 187-209.

[3] Derwing, B.L., T.M. Nearey, R.A. Beinert & T.A. Bendrien (1992), "On the role of the segment in speech processing by human listeners: Evidence from speech perception and from global sound similarity judgments," *Proc. of ICSLP 92*, vol. 1, pp. 289-292.

[4] Bendrien, B.A (1992), *Sound similarity judgements in English CVC's*, B.A. Honors Thesis, University of Alberta.

[5] Derwing, B.L., D.B. Parkinson & R.A. Beinert (in press), "Experimental investigations of Arabic syllable structure," in J. McCarthy & M. Eid (eds.), *Perspectives on Arabic linguistics* VII, Amsterdam: John Benjamins.

[6] McCarthy, J. (1981), "A prosodic theory of nonconcatenative morphology," *Linguisic Inquiry*, vol. 12, pp. 373-418.

[7] Wang, H.S. & B.L. Derwing (1993), "Is Taiwanese a 'body' language?", *Toronto Working Papers in Linguistics*, pp. 679-694.

[8] Yoon, Y.B. & B.L. Derwing (in press), "The sound similarity judgement of Korean CVC's by Korean and English speakers," *Proc. of 1994 Canadian Linguistic Association*, Toronto University Press.

[9] Harrison, K. (1992), *Syllable internal structure in Japanese phonology: Syllable, mora or segment?*, B.A. Honors Thesis, University of Alberta.

[10] Derwing, B.L. & G.E. Wiebe (in press), "Syllable, mora or segment? Evidence from global sound similarity judgements in Japanese," *Proc. of 1994 Canadian Linguistic Association*, Toronto University Press.

[11] Otake, T., G. Hatano, A. Cutler & J. Mehler (1993), "Mora or syllable? Speech segmentation in Japanese," *J. of Memory and Language*, vol. 32, pp. 258-278.

[12] Lorch, R.F., & J.L. Myers (1990), "Regression analyses of repeated measures data in cognitive research," *J. Exper. Psychology: Learning, Memory and Cognition*, vol. 16, pp. 149-157.

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