Marginal Contrasts and Quasi-Allophones:
Probabilistic Phonological Relationships

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****Note: This is a supplemental handout.****

Two Puzzles About Phonological Relationships:

1. Relationships intermediate between contrast and allophony exist and are widespread in the literature, but not accounted for.

2. Phonological relationships have consequences for perception that are not explained.

Examples of Intermediate Relationships:

- *semi-phonemic* (e.g., Bloomfield 1939; Crowley 1998)
- *semi-allophonic* (e.g., Kristoffersen 2000; Moren 2004)
- *quasi-phonemic* (e.g., Scobbie, Turk, & Hewlett 1999; Hualde 2005; Vajda 2003; Gordeeva 2006; Scobbie & Stuart-Smith 2008)
- *quasi-contrastive* (e.g., Scobbie 2005; Ladd 2006)
- *quasi-allophonic* (e.g., Collins & Mees 1991; Rose & King 2007)
- *quasi-complementary distribution* (e.g., Ladd 2006; Fougeron, Gendrot, & Bürki 2007)
- *deep allophone* (e.g., Moulton 2003)
- *partial contrast* (e.g., Dixon 1970; Austin 1988; Hume & Johnson 2003; Frisch, Pierrehumbert, & Broe 2004; Chitoran & Hualde 2007; Kager 2008)
- *semi-contrast* (e.g., Goldsmith 1995; Bakovic 2007)
- *just barely contrastive* (e.g., Goldsmith 1995)
- *fuzzy contrast* (e.g., Scobbie & Stuart-Smith 2008)
- *mushy phonemes* (e.g., Crowley 1998)
- *crazy contrast* (e.g., Boersma & Pater 2007)
- *marginal contrast/phoneme* (e.g., Vennemann 1971; Wells 1982; Blust 1984; Masica 1991; Goldsmith 1995; Reh 1996; Viechnicki 1996; McMahon 2000; Svantesson 2001; Kiparsky 2003; Matisoff 2003; Anderson 2004; Bullock & Gerfen 2004, 2005; Wheeler 2005; Yliniemi 2005; Labov, Ash, & Boberg 2005; Moreton 2006; Bals, Odden, & Rice 2007; Bermúdez-Otero 2007; Hildebrandt 2007; Padgett & Zygis 2007; Kochetov 2008; Sohn 2008)

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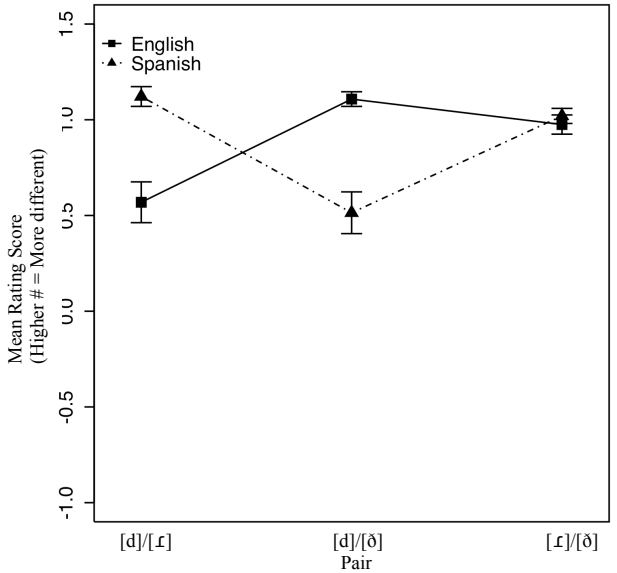
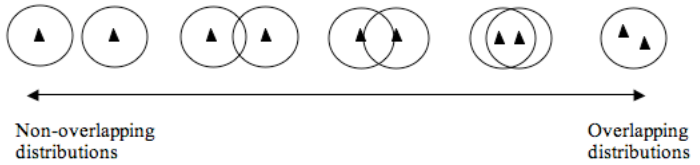
Perception Results (Boomershine, Hall, Hume, & Johnson 2008):



Probabilistic Phonological Relationship Model (PPRM; Hall 2009):



A continuum of phonological relationships, from complete certainty about the choice between two segments (associated with allophony; entropy = 0) on the left to complete uncertainty about the choice between two segments (associated with phonological contrast; entropy = 1) on the right.

Three components of the PPRM:

1. The entropy calculation in a particular environment; ranges from 0 to 1; indicates the uncertainty of the choice between X and Y in a particular environment.

2. The probability of X vs. Y in a particular environment; ranges from 0 to 1 for each segment; indicates the bias toward one segment vs. the other.

3. The weighted conditional entropy across all environments; ranges from 0 to 1; indicates the uncertainty of the choice between X and Y on average across the entire system.

Algorithm for calculating the predictability of distribution of a pair of sounds using the PPRM:

1. Determine the sounds to be compared.
2. Determine the possible sequences or environments that each sound can occur in, given the other sounds in the language and possible conditioning factors (morphological or prosodic boundaries, etc.).
3. Search the language, or its approximation in a corpus, to determine which of the sequences in step (2) actually occur.
4. Search the language/corpus for all of the actually occurring sequences determined in step (3). For each sequence, record:
    a. the number of words/wordforms/morae that the sequence occurs in in a lexicon of the language (= type frequency of the sequence), and
    b. the number of times each of the forms in (4a) occur in a corpus of the language (= token frequency of the sequence).
5. Determine which sequences can be collapsed, based on similarities in their environments that are not expected to have an effect on the appearance of the sounds in question.
    a. Combine the type-frequency counts for all the sequences that can be collapsed.
    b. Combine the token-frequency counts for all the sequences that can be collapsed.
6. Determine the *bias* in the relationship by calculating the probability of each sound in each pair occurring in each environment. Bias is calculated using the following formula: $p(X/e) = N_{X/e} / (N_{X/e} + N_{Y/e})$
    a. $p(X/e)$ is the probability of sound X occurring in environment e
    b. X, Y are the sounds to be compared
    c. e is the environment to be examined
    d. $N_{X/e}$, $N_{Y/e}$ are the number of types or tokens of X or Y occurring in e, from step (5a) or (5b)
7. Determine the amount of uncertainty of the choice between X and Y in a given environment by calculating the entropy of the pair in each environment. Entropy is calculated by applying the following formula: $H(e) = - \sum p_i \log_2 p_i$
    a. $H(e)$ is the entropy of the pair in the environment
    b. p_i is the probability of each sound occurring in the environment ($p(X/e)$ and $p(Y/e)$, from step (6))

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8. Determine the relative importance of each environment to the distribution of the pair by calculating the weight (probability) of each environment using the following formula: $p(e) = N_e / \sum N_{e \in E}$
    a. $p(e)$ is the probability of the environment
    b. N_e is the number of occurrences of the environment, containing either X or Y ($N_e = N_{X/e} + N_{Y/e}$)
    c. $\sum N_{e \in E}$ is the total number of occurrences of any environment that either X or Y occurs in
9. Determine the overall uncertainty of the choice between X and Y across all environments by calculating the weighted average entropy (conditional entropy). This is done by applying the following formula: $H = \sum (H(e) * p(e))$
    a. H is the weighted average entropy (conditional entropy) of the pair
    b. $H(e)$ is the entropy of the pair in each environment, from step (7)
    c. $p(e)$ is the probability of each environment, from step (8)

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