

Minimal Pairs and Hyperarticulation of Singleton and Geminate Consonants as Enhancement of Lexical/Pragmatic Contrasts

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Synopsis: Recent studies in Message Oriented Phonology (MOP) have provided increasing evidence that informativity plays a non-trivial role in linguistic behavior (Aylett and Turk 2004; Hume and Bromberg 2005; Bell et al. 2009; Jaeger 2010; Cohen Priva 2012; Shaw et al. 2014; Hall, Hume, Jaeger and Wedel 2016; Kawahara 2016). This study provides a case study of MOP focusing on the durational contrast between singleton and geminate consonants in spoken Japanese. Based on the assumption that lexical competition induces synchronic, phonetically specific hyperarticulation of phonemic contrasts (Wedel 2016), this study examined the hypothesis that the durations of minimally contrasting singletons and geminates are hyperarticulated to provide more information to distinguish their host words from their minimal pair counterparts (competitors). This study confirmed that (i) minimally contrastive singletons and geminates are both hyperarticulated (singletons become shorter and geminates longer); (ii) in addition to the lexical contrasts, the pragmatic (non-phonemic) contrasts are also subject to the hyperarticulation; and (iii) the degree of durational contrast or hyperarticulation follows from the informativity of contrasts as represented by Shannon's entropy. The results suggest that the hyperarticulation of phonetic cues promotes maintenance of phonemic contrasts over time.

Background: Modern Japanese has a variety of length contrasts, including contrasts in consonant length. Among consonants contrasting in length, short consonants are called singletons, while long consonants are called geminates or *sokuon*. The contrastive nature of these consonants is exemplified in such minimal pairs as /k_{ata}/ 'frame' vs. /k_{atta}/ 'bought' and /h_{ato}/ 'dove' vs. /h_{atto}/ 'hat.' Differences in phonetic duration can also produce a pragmatic effect, which is called emphatic lengthening, in such pairs as /s_{ugoi}/ 'great' vs. /s_{uggoi}/ 'super-great' (Arisaka 1940; Hashimoto 1950; Hattori 1960; Koizumi 1978; Vance 1987, 2008; Kawagoe 2015; Kawahara 2015; Itô 2016). A very large number of studies have attempted to identify the cues or factors contributing to differences between singletons and geminates. Among many of these cues and factors, the difference in constriction duration is argued to be the primary acoustic correlate of the singleton-geminate contrast (Han 1962, 1994; Homma 1981; Beckman 1982; Kawahara 2006; Idemaru and Guion 2008; Ridouane 2010). This provides a useful test of the assumption of MOP. In MOP, information transfer or message transmission is defined by (1).

$$(1) P(\text{message} | \text{signal}, \text{context}) = P(\text{message} | \text{context}) * P(\text{signal} | \text{message})$$

In (1), the posterior probability of a message given a phonological form (signal) in a context, $P(\text{message} | \text{signal}, \text{context})$, is a multiplicative function of the predictability of the message in context, $P(\text{message} | \text{context})$, and the signal specificity, $P(\text{signal} | \text{message})$, the degree to which the speech signal differentiates the intended message from competitors. It follows that if the predictability of a message is high, then the signal specificity is low, and vice versa. This study applies (1) to give a message-based account of the gemination patterns observed in a speech corpus of Japanese. In this study, (i) the ratio of the mean duration of singletons and geminates (SG ratio) is regarded as measuring the degree of durational contrast between singletons and geminates; (ii) the SG ratio is an estimate of the signal specificity, i.e., how clearly the speech signal conveys geminacy in message transmission. To quantify the informativity of singleton/geminate (binary) contrasts, this study uses Shannon's entropy $H(x)$, which is defined as: $H(x) = -\sum P(x) * \log_2(P(x))$.

Method: Data were retrieved from the CSJ-RDB (Corpus of Spontaneous Japanese-Relational Database, NINJAL 2012), among which the present study targeted 12 speech samples. The data were collected using MySQL, which implements the SQL programming language (<http://www.navicat.com>), with reference to the phonological and morphological information annotated in the CSJ-RDB. An exhaustive search of the data in the CSJ-RDB resulted in 12,583 tokens, of which 10,717 (85.2%) were singletons and 1,866 (14.8%) were geminates. For the whole dataset, the mean duration of the singletons is 34.4 msec, the mean duration of the geminates is 88.1 msec, and the singleton-geminate ratio (SG ratio) is 2.56.

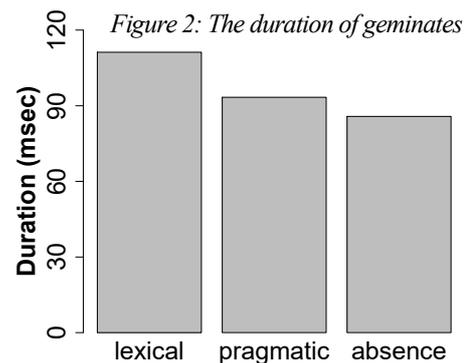
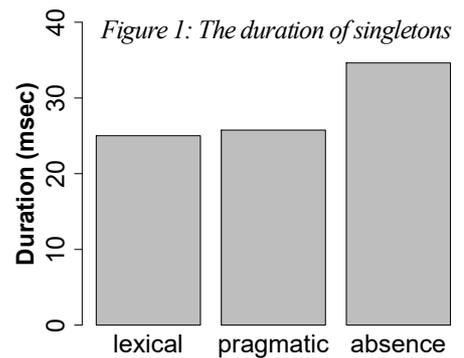
In addition to minimal pairs that are lexically contrastive, some pairs are pragmatically contrastive, that

is, pairs in which one item shows gemination due to emphasis or allophonic pairs differing due to extra-linguistic factors, such as speaking style or register (e.g. /mina/ vs. /minna/ ‘everyone,’ and /fakusu/ vs. /fakkusu/ ‘fax’). Thus, this study examined the durations of singletons and geminates in three categories: (i) lexically contrastive minimal pairs, (ii) pragmatically contrastive minimal pairs, and (iii) absence of minimal pairs. If a member of a pair is a proper noun, jargon, an archaic form, a dialectal form, or one that differs from its counterpart in accent and/or grammatical category, the pair is not regarded as minimal.

Each token was analyzed in terms of the presence/absence of minimal pairs (lexically or pragmatically contrastive) with the durations of singletons and geminates being dependent variables. All distributional skews discussed below were tested by the linear mixed-effects model (Barr 2013; Barr et al. 2013) using R (R development Core Team 1993–) with speakers and items being random effects.

Results: The duration of singletons and geminates differed according to the presence/absence of minimal pairs: the duration was shorter for minimally contrastive singletons than for non-contrastive ones ($t = 2.315, p < 0.05$), while for minimally contrastive geminates, the duration was longer than for non-contrastive ones ($t = -2.364, p < 0.05$). Furthermore, the duration of singletons/geminates was shorter/longer in both lexically contrastive minimal pairs and pragmatically contrastive minimal pairs than in the absence of contrast (*singleton* (Figure1): lexically contrastive, pragmatically contrastive < absence, $p < 0.01$, *geminate* (Figure2): lexically contrastive, pragmatically contrastive > absence, $p < 0.05$ by multiple comparisons with Tukey’s method). The SG ratio was highest in lexically contrastive followed by pragmatically contrastive, and lowest in absence in accord with Shannon’s entropy of lexically contrastive > pragmatically contrastive > absence (Table 1).

Table 1	lexical	pragmatic	absence
SG ratio	4.45	3.62	2.48
Shannon’s entropy	1	0.66	0.58



Discussion & Conclusion: These observed patterns bear out the hypothesis that the durations of singletons and geminates in a minimal pair show the effects of hyperarticulation to provide more information to distinguish their host word from its minimal pair competitor. The presence of a minimal pair competitor makes the predictability with which a target segment is identified lower, and thus requires the signal specificity to be more informative/salient to differentiate the target from other competitors. This is manifested by the hyperarticulation of phonetic cues that provide more information to distinguish their host word from its minimal pair competitor. Furthermore, the degree of durational contrast between singletons and geminates (or hyperarticulation) that is reflected in the SG ratio follows from the informativity of singleton/geminate contrasts represented by Shannon’s entropy. Another finding this study offers is that the hyperarticulation of durational contrast is observed both in lexical minimal pairs and pragmatic minimal pairs, which emphasizes the role of non-lexical/non-phonemic information in linguistic behavior.

The results provide supporting evidence for the diachronic assumption that phonological contrasts that carry high functional loads are less likely to neutralize (Martinet 1952; Hockett 1967). The results predict that synchronically informative contrasts are hyperarticulated, and thus their phonetic implementation is perceptually salient. This results in diachronic stability, whereby informative contrasts tend to be preserved. Thus, the hyperarticulation of individual sounds induced by lexical (pragmatic) competition can influence long-term change in the system of phonemic contrasts (Wedel 2016).