

Harmonic Gradience in Greek Rap Rhymes

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1 Introduction

Phoneme similarity judgments are based on differences assessment (Bailey & Hahn, 2005). The naïve native speaker’s intuition on rhyming offers an open window to the speaker’s perception of featural (dis)similarity. This is especially true in oral traditions, like rap music, as rappers are not formally trained to create rhyming pairs (hence naïve), yet perceive similarity and its gradient nature.

This preliminary study investigates phonological (dis)similarity in Greek rap rhyme for the first time. Rhyming makes use of the “innate human impulse to recognize patterns and to anticipate what will follow” (Bradley, 2009, p. 50). According to Bradley (ibid.), rap lyrics are the most significant collection of rhyming pairs today. The rap genre dictates that rappers try to minimize differences and achieve perfect rhyme, while listeners also anticipate to hear rhyming pairs. In addition, rhyming is important in rap because it is the only thing, alongside the beat, that poses a constraint to the rapper’s creative freedom (Bradley, ibid.), thus posing a challenge to be met. As a result, rhyme is so central to rap that it defines it (Bradley, ibid., p.80). Successful rhyming while, at the same time, telling a coherent story is an essential skill for a rapper, to the point that there are also instances of forced rhymes (which Bradley (ibid.) terms *transformative rhymes*), where one or more phonemes in a line-final word are substituted in order to achieve a rhyming pair. For example, Tupac Shakur substitutes /r/ with [l] in the word **fire** in the following verse: “My life is in **denial**, and when I die / Baptized in eternal **fire**.” (*So Many Tears*, 1995), in order to force the words ‘denial’ and ‘fire’ to rhyme: [dɪˈnaɪəl]-[ˈfaɪəl] (cf. Bradley, ibid., p. 71).

For these reasons, rap rhyme is an excellent opportunity to study the intuition that (at least a subset of) the native speakers of a said language (rappers) have, regarding perceptual similarity of phonemes. We anticipate that rappers will always aim for rhyming pairs with identical correspondents. When this is impossible, due to lexicon restrictions, they will select the rhyming pair with the greatest similarity possible. In this case, high frequency of occurrence implies high similarity.

2 Background

2.1 Perfect and Imperfect Rhyme Especially in Old-School rap (Bradley, 2009), rhyming fellows form a pair of correspondents between the line-final domain of the first rhythmic group and the line-final domain of the subsequent rhythmic group (end-rhymes) (Katz, 2008, p. 9). The end of a line, i.e. the corresponding (rhyming) syllable(s), is positioned on the downbeats, following the music and its harmonic changes, (Adams, 2008; cf. also Katz, 2008; 2015, for a more detailed overview of rhyme alignment in hip-hop).

Following Holtman (1994), we assume that a rhyme domain includes the rightmost stressed syllable and the syllable(s) that follow(s); i.e. the rime¹ (nucleus and coda in closed syllables, nucleus in open syllables) of the line-final stressed syllable, plus the syllable(s) that follow(s) it. The rhyme domain can coincide with the line-final morphological word, or be a smaller or a larger unit. The onsets of the corresponding stressed

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¹ As a convention and for purposes of clarity, in this paper, we use the orthography *rime* to indicate the sub-syllabic constituent (nucleus and coda) and the orthography *rhyme* to refer to rhyming pairs.

syllables must not be identical (e.g. Holtman, 1994), and we do not include them in our rhyme domain definition. Holtman (1994) defines the relevant stressed syllable as the rightmost syllable bearing lexical stress. This is not always predicted by the lexicon in the case of rap, at least for Greek rap, where rappers may move the position of the rightmost stressed syllable in order to achieve rhyme, so the lexical stress position in a given word might differ from the stress position in the same word, when used in rap lyrics.

Perfect Rhyme (henceforth PR) is the default rhyme type, where two line-final phonological elements, in two consecutive lines (rhyming pair or rhyme fellows) rhyme, i.e. they have identical nuclei and codas within the rhyme domain; e.g. (1), where [a.'sti.o]-[erya.'li.o] is the rhyming pair and [i.o] is the rhyme domain.

- (1) [a.'sti.o]-[erya.'li.o] ‘joke’ - ‘tool’ (Afezz, *Neos serifis stin poli*)

Meanwhile, *Imperfect Rhyme* (henceforth IR), defines two not completely identical rhyme fellows where the stressed nuclei are identical², while at least one of the succeeding consonants differs in one or more (or all) distinctive features. The mismatching consonant(s) can be attested in various positions. For Greek, they can be found in the following positions (marked with an underscore character): C_V, V_C, V_#, V_V). For example, intervocalic consonant(s) (V_V) in the rhyme domains of a rhyming pair may differ in the Place of Articulation (PoA) feature, as seen in (2), where [mi.ti]-[li.ci] is the rhyming pair and [i.ti], [i.ci] are the rhyme domains, mismatching in the intervocalic [t] and [c], respectively.

- (2) [mi.ti]-[li.ci] ‘nose’ - ‘wolves’ (Dodekatos Pithikos, *Ta Vradja*)

Standard Modern Greek (henceforth SMG) is a language with a vowel system consisting of only five vowels, with syllable timing, and lexical stress (e.g. Revithiadou, 1999). ATR and vowel length are not relevant in the description of SMG vowels either. In addition, open syllables are the prominent syllable type (86.2%; cf. Protopapas et al., 2012). In closed syllables, the native final coda is restricted to [s], [n], while the native word-medial coda is restricted to the CORONAL SONORANTS [n], [l], [r] (e.g. Malikouti-Drachman, 1987, i.a.)³.

As a result, PR is easily achieved in Greek rap lyrics. When the stress is on the final syllable, the codas are expected to match and, as the frequency of open syllables in SMG indicates, they will, probably, be missing. It, therefore, suffices to have matching nuclei for the rhyme domains to match e.g. (3-5).

- (3) [u.ra.'ni] – [zo.da.'ni] ‘skies’ - ‘alive.PL.’ (Detro, *Adikrizo ti morfi mou*)
 (4) [per.'nas] – [ko.'las] ‘pass.PR.2SG’ – ‘stick.PR.2SG’ (Dodekatos Pithikos, *Ipirchan Pragmata*)
 (5) [pa.li] – [ce.'fa.li] ‘again’ – ‘head’ (Vasilis-Tri Pa Crew, *Taratses*)

As seen in (3)-(5), each rhyming pair includes a part that is dissimilar at the beginning, followed by a part characterized by identity. For example, in (5), the parts that are not included in the rhyme [p] in [pali] and [cef] in [ce'fali] bear no similarity: in their number of syllables, in number of segments, or in the segments that are realized. The second, line-final, parts of the pair (rhyme domains), which stand in correspondence forming the rhyme, are completely identical: [a.li] – [a.li]; i.e., two identical, stressed vowels, followed by a pair of identical onset consonants and a pair of identical vowels, parsed into two syllables. As Holtman (1994) proposes, this is an instance of *reduplication*, where elements of the first rhyme domain (from the line-final stressed syllable onwards), which is the *Base* (B), are copied in the second rhyme fellow, which acts in a way similar to *Reduplicants* (R). In (5), the first rhyme domain [ali] in 'p(al)i_B is the Base and the second rhyme domain [ali] in ce'f(al)i_R is the Reduplicant. However, as Holtman (ibid.) stresses, different kinds of rhyme are acceptable (as she puts it, grammatical), and rhyme acceptability may be attested at

² It can also be the case that vowels mismatch in IR. This is not the case in our data; thus, we narrow down our definition of IR to exclude mismatching nuclei.

³ Of course, additional segments are allowed in coda position in loanwords.

varying degrees, which is not the case in other types of reduplication.

The perceptibility of the salience of mismatches in rhyme is deemed to be in proportion with their likelihood (e.g. Steriade, 2003a, on Romanian verse; Kawahara, 2007, on Japanese rap). In American rap, Katz (2015) observes context-dependent asymmetries in the probability of IR patterns, that cannot be attributed to “shared features or natural classes” (ibid., p. 3).

Nevertheless, Steriade’s (2001; 2003a; 2003b; 2008, i.a.) P-Map claims that speakers recognize the perceptual distance between two corresponding phonological elements, and pursue minimizing salient psychoacoustic mismatches. In this frame, Steriade (ibid.) observes that voicing mismatches are the least perceptually salient, a claim that is backed up by psycholinguistic empirical findings (e.g. Wang & Bilger, 1973; Bailey & Hahn, 2005; i.a.).

2.2 Previous studies on rhyme Phonology of rhyme has long been studied. Studies have focused on rhyming in songs in African languages (Greenberg, 1960) and English (doggerel and Mother Goose rhymes; Maher, 1969), where rhyming pairs differ, in principle, only in one distinctive feature (PoA), American and British rock (Zwicky, 1976), where mainly PoA in nasals mismatches (39.8%, followed by mismatches in Manner of Articulation (MoA), and only 16 instances of voicing mismatch, namely 6.8%), German folk songs (Maher, 1972), Irish verses (Malone, 1987), as well as in poetry, through the study of Turkish poems (Malone, 1988), Romanian half-rhymes (Imperfect Rhymes) (Steriade, 2003a; 2003b), Dutch poetry (Holtman, 1994), 18th and 19th-century Russian verses (Holtman, 1996).

Studies on IR in rap lyrics are extremely limited and more recent. Kawahara (2007) analyzed IR in Japanese rap songs, concluding that voicing mismatches are the least salient, hence the most frequent in Japanese rap, while PoA mismatch in NASALS (m-n) is also very frequent. It should be noted, however, that he argues that acoustic information is used by Japanese rappers, in addition to the number and the type of shared features. Katz (2015) studies American English rap. His findings show that, similarly to Japanese rap, voicing distinctions are frequent, and they are more frequent than mismatches in nasality and in continuancy. Mismatches in PoA are more frequent between NASALS, than between VOICELESS OBSTRUENTS, and even more frequent than between VOICED OBSTRUENTS. Schelde (2020) investigates IR patterns in Dutch rap. She found effects of both featural mismatches and acoustic similarity, and showed that, in Dutch rhyme, stridency, continuancy and major PoA mismatch more frequently than sonority, voice, nasality, and [anterior] features, where mismatches are less tolerated. Her data also show that mismatches are more frequently observed between unmarked segments (VOICELESS CORONAL OBSTRUENTS), as well as between consonants that are “easily weakened or vowel-like” (ibid., p. 60).

All the above studies have concluded that speakers (rappers) seem to have an unconscious knowledge of perceptual (dis)similarity and that similarity correlates with rhymability. Additionally, an important finding is that mismatches in American English, Japanese, as well as in Dutch rap are context-dependent, and that they cannot be described by solely the use of distinctive features, as acoustic factors seem to also play a role.

Furthermore, a key observation is made by Kawahara (2007), who claims that rhymability in Japanese rap is gradient, whereas in poetic traditions of other languages rhymability is categorical; i.e. there is threshold for similarity, and dissimilar corresponding pairs beyond that threshold are not accepted as rhyming pairs. It remains to be known whether this is a language-specific difference, as he hypothesizes, or rather, a genre-specific characteristic, since the creation of rap lyrics does not follow formal guidelines, being restricted only by perceived similarity.

3 Present Study

3.1 Focus of the study For the purposes of this study, we investigated IR patterns in the rhyme fellows of 42 Greek rap songs, written and performed by 25 different rap artists who use the Standard variety of Modern Greek (apart from the use of certain lexical items from different varieties). The artists are situated in major cities of both Northern (e.g. Thessaloniki, Aleksandroupoli) and Southern Greece (e.g. Crete), while our corpus also included rappers living in the capital city, Athens. The artists were selected based on their preference for ‘Old School’ rap style. An early style defined by metered, rhyming verse, where the rhyme is aligned to the right-edge of the line, while it is also aligned to the salient metrical pulse, with a certain periodicity (cf. §2.1). Other rappers, who create a freer verse were excluded.

In this set of lyrics, we pinpointed a total of 182 line-final IR pairs, which were phonologically transcribed and analyzed to pinpoint and investigate the mismatching distinctive features and the prevalence (frequency) of each mismatch type.

In the present study, mismatch only occurs between singleton, intervocalic, onsets. Mismatch that results from segmental substitution (segment insertion or deletion in the Reduplicant (second rhyme domain)), or mismatch between corresponding consonantal sequences/clusters is beyond the scope of this paper.

In the rhyming pairs under investigation, the relevant stress (the line-final stress which is salient, according to the rhythmic properties of the song) falls on the nucleus of the penultimate or the antepenultimate.

The rhyme domain under investigation includes the (faithfully matching) rimes of the 2-3 last syllables of two rhyme domains, alongside a pair of corresponding mismatching consonants, while the onset of the stressed syllable is irrelevant (e.g. (7-8)). Interestingly, the type of mismatch studied here seems to be found only in a posttonic position. In Greek rap, the rhyme domain includes the pronominal clitics⁴ [mu] ‘my’, [su] ‘yours’, etc. which function as complements to nouns, so the domain spans the phonological word (PWd). For example, in (8), the rhyme domain starts from the stressed [a] onwards. The Base is: ['a.ri.mu] and the Reduplicant is ['a.li.mu]. In both cases, the last syllable [mu] is a clitic.

(7) ['pa.da]_{PWd} - ['fra.ga]_{PWd} ‘always’-‘dough’ (=cash) (Ianos-Vromikos Notos, *Krifokitame*)

(8) [to.'ma.ri.mu]_{PWd} - [ce.'fa.li.mu]_{PWd}
 hide CLT.1:SG.GEN. - head CLT.1:SG.GEN.
 ‘my hide’ - ‘my head’ (Monimos katikos, *I foni*)

The consonants were categorized in 4 PoA groups: CORONAL, LABIAL, PALATAL and VELAR; in 6 MoA groups: STOP, FRICATIVE, AFFRICATE, NASAL, RHOTIC, and LATERAL; and in two voicing groups: [+voice] and [-voice].

Like in previous research on rap rhyme (e.g. Kawahara, 2007), the hypothesis is that the greater the similarity between two consonants, the more frequently they are found in IR rhyming pairs. The research question is: In case of featural mismatch, is there any preference (better/worse mismatch): (i) in features that mismatch, (ii) in number of mismatching features?

4 Results

The data in our corpus confirmed that, in Greek rap, there is a very strong tendency towards PR, which seems to be the default, unmarked pattern, as we recorded a ratio of $\approx 87\%$ PR in the corpus, e.g. (6).

(6) ['vi.ma]-['ci.ma] ‘step’ – ‘wave’ (Afezz, *Skandalo*)

The phonological and the descriptive statistical analysis showed that the perceived similarity of corresponding segments (manifest as frequency of occurrence) is inversely proportional to the number of mismatching distinctive features. This means that mismatch in only one distinctive feature (PoA, MoA, or voicing) is by far more frequent than mismatches in two distinctive features, while a mismatch in all three distinctive features is rare (Table 1)⁵.

⁴ In SMG, the weak pronouns like [mu] ‘my’, [su] ‘yours’, [tu] ‘his’ etc. are pronominal clitics, prosodically dependent on an adjacent host and function as complements to nouns. These clitics also function as complements to adjectives, determiners, adverbs, and as (in)direct objects to verbs (Holton et al. 1997, pp. 303-307).

⁵ All values in Tables (1)-(7) are rounded to the second decimal place

Futures no.	Frequency %
1 feature	75.65
2 features	19.13
3 features	5.22

Table 1. Number of mismatching futures and their frequency in the corpus

Apart from the preference in the number of distinctive features that mismatch, when there is mismatch in only one feature, there is gradience in the distinctive features that mismatch: PoA mismatch is the preferred, most frequent pattern, MoA mismatch is far less frequent, while a mismatch in voicing is avoided by rappers (Table 2).

1 feature mismatch	% IR	% corpus
PoA	42.61	4.19
MoA	28.70 ⁶	2.65
voicing	4.35	0.43

Table 2. Types of mismatch, 1 mismatching feature (% of total IR, % of total corpus of Greek rap rhyme studied)

In cases where there is a mismatch in two distinctive features between the two corresponding consonants, a mismatch in PoA and MoA (i.e. corresponding consonants agree in voicing) is more accepted than a mismatch in PoA and voicing (i.e. corresponding consonants agree in MoA) or in MoA and voicing (i.e. corresponding consonants agree in PoA). We observe, again, here, that mismatches in voicing are highly avoided in Greek rap, even when voicing is not the only mismatching feature.

2 features mismatch	%
PoA + MoA	63.64
PoA + voicing	22.73
MoA + voicing	13.64

Table 3. Types of mismatch, 2 mismatching features (% of mismatch in 2 features)

In the case of PoA mismatch (corresponding consonants have identical MoA and voicing), which, as we said above, is the most frequent mismatch in our corpus, there is further gradience (Table 4). The mismatches are mainly observed between CORONAL and LABIAL segments, at a frequency ratio of 63.26% (which follows from the sum of the frequency ratio of a CORONAL in the Base with a LABIAL correspondent in the Reduplicant, plus the frequency ratio of a LABIAL in the Base with a CORONAL correspondent). The ratios

⁶ The ratio includes difference in stridency

imply no preference for directionality; i.e., CORONALS in the Base can have a corresponding LABIAL in the second rhyme domain (Reduplicant) (32.65%); likewise, LABIALS in the Base can have a corresponding CORONAL in the Reduplicant, to a comparable extent (30.61%).

C_{RED} \ C_{BASE}	CORONAL	LABIAL	PALATAL	VELAR
CORONAL		32.65 ['o.non]-['o.mon]	4.08 ['i.tis]-['i.cis]	8.16 ['a.da]-['a.ga]
LABIAL	30.61 ['a.pi]-['a.ti] ⁷		2.04 ['i.pis]-['i.cis]	2.04 ['o.vo]-['o.ɣo]
PALATAL	6.12 ['a.çi]-['a.θi]	0		0
VELAR	8.16 ['o.xos]-['o.θos]	6.12 ['a.ksa.me]-['a.psa.me]	0	

Table 4. Types of PoA mismatch. % in the total of PoA mismatches. Grey cells denote non applicable mismatches. Zero (0) denotes no instance of mismatch in question in this corpus.

The majority of corresponding segments that mismatch in their PoA (Table 5) are OBSTRUENTS (65.31% of PoA mismatches, including STOPS plus FRICATIVES), while the remaining PoA mismatches are observed between nasals (34.69%). Nevertheless, the highest frequency is noted between corresponding STOPS, followed by NASALS, while FRICATIVES are the least frequently mismatching segments. It should be noted that there are no instances of PoA mismatches between AFFRICATES and LIQUIDS. This is due to the fact that all AFFRICATES ([tʃ], [dʒ]) and all LIQUIDS ([l], [r]) of SMG are CORONALS, they are, thus, physically unable to mismatch for PoA (change their PoA).

MoA Frequencies in PoA Mismatches		
MoA	%	<i>example rhyme</i>
STOPS	44.90	['ada]-['aga]
NASALS	34.69	['imi]-['ini]
FRICATIVES	20.41	['aɣus]-['avus]

Table 5. Frequencies of MoA of correspondents mismatching for POA. % in the total of PoA mismatches

In all IR where solely the PoA feature mismatches, voicing of non-sonorant consonants that mismatch seems to be irrelevant; i.e., half mismatches are observed between VOICED OBSTRUENTS, and the other half between VOICELESS OBSTRUENTS.

In the case of mismatches in MoA (corresponding consonants have identical PoA and voicing), which are less frequent than PoA mismatches, the preferred pattern is a mismatch within a natural class (OBSTRUENTS, NASALS, LIQUIDS) (Table 6). Namely, a mismatch between two OBSTRUENTS is most frequently attested (29.03%, as a sum of a FRICATIVE in the Base with a STOP correspondent plus a STOP in the Base with a FRICATIVE correspondent), at a frequency similar to that of the mismatch frequency between LIQUIDS (25.81%, as a sum of a LATERAL in the Base with a RHOTIC correspondent plus a RHOTIC in the

⁷ In Tables 4-8, the example pairs presented include only the rhyme domains.

Base with a LATERAL correspondent). Like in the case of PoA mismatches, the ratios imply no preference for directionality in MoA mismatches.

C_{BASE} \ C_{RED}	STOP	FRICATIVE	AFFRICATE	NASAL	LATERAL	RHOTIC
STOP		12.90 [<i>'i.ces</i>]- [<i>'i.çes</i>]	3.22 [<i>'a.da</i>]- [<i>'a.dza</i>]	0	0	0
FRICATIVE	16.13 [<i>'e.çis</i>]- [<i>'e.cis</i>]		0	9.68 [<i>'i.ðes</i>]- [<i>'i.nes</i>]	0	3.22 [<i>'a.ðes</i>]- [<i>'a.res</i>]
AFFRICATE						
NASAL	3.22 [<i>'a.no.sa</i>]- [<i>'a.ji.ksa</i>]	3.23 [<i>'o.pa</i>]- [<i>'o.ðja</i>]	0		6.45 [<i>'e.nos</i>]- [<i>'e.los</i>]	6.45 [<i>'o.non</i>]- [<i>'o.ron</i>]
LATERAL	0	0	0	3.22 [<i>'o.lis</i>]- [<i>'o.nis</i>]		19.35 [<i>'i.no.la</i>]- [<i>'i.no.ra</i>]
RHOTIC	0	0	0	6.45 [<i>'a.ru.ne</i>]- [<i>'a.nu.ne</i>]	6.45 [<i>'a.ros</i>]- [<i>'a.los</i>]	

Table 6. Types of MoA mismatch. % in the total of MoA mismatches. Grey cells are not applicable mismatches. Zero (0) denotes no instance of mismatch in question in this corpus.

Mismatches in MoA are predominantly observed between CORONALS (77.42%), while they are not that frequent between PALATALS (19.35%), and are avoided between VELARS (only 3.23% of MoA mismatches are mismatches between two corresponding VELARS) (Table 7).

Interestingly, LABIALS are absent from this table of MoA mismatches (Table 7). In our corpus, there is not a single case of corresponding LABIALS that mismatch solely in their MoA. In a total of 104 IR pairs that involve a LABIAL as a mismatching segment (either in the Base or as a correspondent in the Reduplicant), half of them are a PoA mismatch, while MoA mismatches in LABIALS include only cases of a mismatch in both PoA and MoA (9.62%) or in all three distinctive features (PoA, MoA, voicing) (3.85%).

PoA Frequencies in MoA Mismatches		
PoA	%	<i>example rhyme</i>
CORONALS	77.42	[<i>'iθos</i>]-[<i>'itos</i>]
PALATALS	19.35	[<i>'eçis</i>]-[<i>'ecis</i>]
VELARS	3.23	[<i>'ixus</i>]-[<i>'ikus</i>]

Table 7. Frequencies of MoA of correspondents mismatching for POA. % in the total of PoA mismatches

Like in the case of PoA mismatches, in the data where only the MoA feature mismatches (i.e. corresponding consonants agree in PoA and voicing), the voicing value of mismatching non-sonorant consonants seems to be irrelevant; i.e., half mismatches are observed between VOICED OBSTRUENTS, and the other half between VOICELESS OBSTRUENTS.

Voicing is a feature that can take only two values in SMG (binary feature): [\pm voice]. As also seen in the cases of PoA and MoA mismatches, the directionality of voicing mismatches (voiced Base-voiceless Reduplicant vs. voiceless Base-voiced Reduplicant) is almost equally distributed, indicating no preference. Voicing mismatches (corresponding consonants have identical PoA and MoA) are observed between FRICATIVES, with only one case of a voicing mismatch between STOPS ([$'$ ata]-[$'$ ada]).

Voicing mismatch			
C _{BASE}	C _{RED}	%	example rhyme
[+voice]	[-voice]	40	[$'$ i.zo.me]-[$'$ i.so.me]
[-voice]	[+voice]	60	[$'$ a.ta]-[$'$ a.da]

Table 8. Directionality of voicing mismatch. % in the total of voicing mismatches

5 Discussion

The majority of consonants that are involved in IR are CORONAL OBSTRUENTS, mainly CORONAL STOPS, regardless of their voicing value: PoA mismatches are mainly allowed between OBSTRUENTS (STOPS for the most part), with the corresponding consonants being CORONAL and LABIAL, while MoA typically mismatches between CORONALS, with the correspondents being OBSTRUENTS (FRICATIVES and STOPS). In general, the preferred IR pattern in Greek rap involves a mismatching PoA between two OBSTRUENTS. The voicing has to be identical in the two correspondents, despite its value ([\pm voice]).

Therefore, we observe that (un)markedness (a notion introduced by Trubetzkoy, 1931/1968; for a detailed account on markedness in the phonological theory cf. Rice, 2007, and references therein) seems to play a decisive role in the feature values that mismatch, a rather unsurprising finding, as unmarked segments are considered to be perceptually less salient in the phonological literature (cf. Rice, 2007). The CORONAL PoA is considered to be universally less marked than the LABIAL and the DORSAL PoA (e.g. Paradis and Prunet, 1991). In addition to the low perceptual salience that CORONALS and, to a lesser extent, LABIALS seem to exhibit in Greek rap, a fact in support of their unmarked status in SMG, findings are in parallel to Consonant Harmony data from phonological acquisition in SMG as ambient language (e.g. Tzakosta, 2007), which point toward a relatively marked status of VELARS, in comparison to LABIALS, which are, in turn, more marked than CORONALS, resulting in the following dominance ordering regarding (un)markedness: VELAR >> LABIAL >> CORONAL (>>: more marked than) (cf. also Prince & Smolensky, 1993/2004).

PoA mismatches between corresponding OBSTRUENTS and, to a lesser extent, between NASALS (which are the most unmarked SONORANTS; e.g. Rice & Avery, 1991). The unmarked [-continuant] STOPS are frequently involved in Greek rap IR, i.e. they are one of the two correspondents in MoA mismatches. Sonority also seems to play a role. Taking into account the Sonority Scale proposed for SMG by Kappa (1995) in (7), it is evident that mismatches in MoA are allowed between consonants with a similar sonority. Mismatches in MoA between corresponding STOPS and FRICATIVES, and between corresponding LIQUIDS (LATERALS and RHOTICS), are the main patterns in the data, indicating some acoustic (phonetic) basis in the IR mismatches preference.

- (7) STOPS < voiceless FRICATIVES < voiced FRICATIVES < s < z < NASALS < LIQUIDS

(Note : < less sonorous than).

As described in the results section (cf. §4), the main finding, which agrees with findings in other languages (Kawahara, 2007; Katz, 2015; Schelde, 2020) is that, in IR, corresponding consonants are mainly allowed to mismatch in only one distinctive feature; in SMG, preferably in PoA.

It is, thus, observed that the markedness ranking of IR, which is gradient, dictates that mismatch in 1

feature is the least marked and most commonly accepted IR pattern, while mismatch in 2 features is more marked, and mismatch in 3 features is marginally accepted, hence extremely marked.

Focusing on IR which is due to a sole feature mismatch, mismatch in PoA is a mismatch pattern more allowed than mismatch in MoA, which is more allowed than mismatch in voicing. In like manner, in IR which is a consequence of mismatch in 2 distinctive features, mismatch in both PoA and MoA is tolerated more than a mismatch in both PoA and voicing, while a mismatch in MoA and voicing is the least frequent pattern in the case of IR mismatch in 2 features. Moreover, a mismatch in all 3 distinctive features between two correspondents is the least accepted pattern, with the lowest frequency. Accordingly, the following ranking in (8) describes the gradient acceptability (or, to put it differently, similarity) of IR in Greek rap:

$$(8) \quad \text{IR}_{\text{PoA}} > \text{IR}_{\text{MoA}} > \text{IR}_{\text{voi}} > \text{IR}_{\text{PoA, MoA}} > \text{IR}_{\text{PoA, voi}} > \text{IR}_{\text{MoA, voi}} > \text{IR}_{\text{PoA, MoA, voi}}$$

(Note: > more acceptable than)

In order to account for the gradience observed in the asymmetries of IR patterns that are allowed or disallowed in Greek rap rhyme (8), we couch our formal analysis in the theoretical framework of *Harmonic Grammar* (Legendre, Miyata, & Smolensky, 1990; Smolensky & Legendre, 2006), a version of *Optimality Theory* (OT; Prince & Smolensky, 1993/2004, i. a.) where the candidate output forms are evaluated through violable weighted (and not ranked, as they would be in OT) constraints, each carrying an individual weight w_k (w : real number, $w \geq 0$; Coetzee & Pater, 2008, i. a.). The number of violations (n_k) of any constraint C_k ($k=1, \dots, K$) (e.g. Pater, 2009, i. a.) by a candidate results in a Violation Score s_k (s_k : negative integer, Legendre et al., 2006; Pater, 2009, i. a.), where $s_k = n_k * (-1) = -n_k$. The Harmony Score (H) of each candidate is based upon the sum of its violation scores s_k for every constraint, each multiplied by the constraint weight w_k , as seen in (9), where w_k = weight of constraint C_k ; s_k = violation score of a candidate (Pater, 2009, p.1006).

$$(9) \quad H = \sum_{k=1}^K s_k w_k$$

The lower the violation score, the highest the Harmony. The optimal candidate is the one with the highest Harmony, but the other candidates are not excluded. They are less harmonic, and they can be realized, albeit less frequently, with a frequency that decreases in proportion to their Harmony.

Following Holtman (1994), we claim that the rhyme fellows stand in a Base-Reduplicant relationship, hence they are realized in a relation of Output-Output correspondence (McCarthy, 1995, i. a.; cf. also McCarthy & Prince, 1993, for a detailed discussion on reduplication), where the first member of the pair (i.e. the correspondent uttered first) acts as the Base and the second one (i.e. the correspondent uttered second) acts as a Reduplicant. In our analysis, we build on Holtman (1994), using constraints she puts in use to analyze rhyme as reduplication within the framework of OT with ranked violable constraints, and within (generalized) Correspondence Theory, as proposed by McCarthy & Prince (1995), which models faithfulness relations, including correspondence relations between Output-Output correspondents (Base-Reduplicant).

The IDENT(F) constraint family (McCarthy & Prince, 1995, p. 16) requires corresponding segments to be identical for a feature F. Specifically, we employ the IDENT-BR(F) instantiation, which requires the correspondents of Base segments in the Reduplicant to be identical. In our case, this is analyzed as:

IDENT-BR[SEGM.]	requires segmental identity in PoA, MoA, and voicing features, between the correspondents. This constraint is satisfied only by PR; any IR type violates it
IDENT-BR(voi.)	assigns one violation for every Reduplicant segment that differs in voicing value to its correspondent segment at the Base
IDENT-BR(PoA)	assigns one violation for every Reduplicant segment that differs in PoA to its correspondent segment at the Base
IDENT-BR(MoA)	assigns one violation for every Reduplicant segment that differs in MoA to its correspondent segment at the Base

The grammar that constrains the likelihood of rap rhyme is constructed by constraints that dictate identity

between the two correspondents. Markedness in (rap) rhyme arises from the violation of identity.

Perfect rhyme is attested in about 87% of the rhyming pairs studied, we thus assume a weight of $w_{\text{segm}}=87$ for the IDENT-BR[SEGM.] constraint, which carries the highest weight, considerably higher than the weights of IR-related constraints. To decide on the weights of the IR-related IDENT-BR(F) constraints, we calculate the ratio of each mismatch pattern (PoA, MoA, voicing mismatch) in the corpus (cf. Table 2. in §4). We assume that:

$$(10) \quad w_{(F)} = \log(\text{PR}/\text{IR}_{(F)})$$

where: $w_{(F)}$: the weight assigned to the IDENT-BR(F) constraint, that requires identity for the distinctive feature F, PR: the percentage of PR in the corpus, and $\text{IR}_{(F)}$: the percentage of IR where mismatch is observed solely in feature F in the corpus.

This results in weights that increase gradually, from the IDENT-BR(PoA) constraint where the smaller weight $w_{(\text{PoA})}$ is assigned, to the IDENT-BR(voice) constraint where the greatest weight $w_{(\text{voice})}$ is assigned.

Taking into account all of the constraints we have assumed, the constraint weights in this analysis are ranked as following (11):

$$(11) \quad w_{\text{segm}} > w_{(\text{voi.})} > w_{(\text{MoA})} > w_{(\text{PoA})}$$

The highest Harmony is attested in IR candidates with a single IDENT-BR(F) violation. More violations add to the negative sum, leading to reduced Harmony. Violations in constraints with greater weight result in reduced Harmony, hence the infrequency of mismatch(es). More constraints violated simultaneously have a cumulative effect: as the absolute value of sum increases the Harmony decreases, reflecting the IR gradience.

A simple illustration of this can be seen in Table 9. Assuming a rhyme where the rhyme domain of the Base is [-'i.θa]⁸, candidate Reduplicants (a)-(f) illustrate the various mismatches that can be observed between two corresponding consonants. They all violate IDENT-BR[SEGM.] with one violation, while each violates one (a-c) or more (d-f) additional constraints. Candidate (a) [-'i.fa] is the most harmonic Reduplicant. It violates IDENT-BR[SEGM.] and IDENT-BR(PoA), so its Harmony is the sum of its 1 violation of IDENT-BR[SEGM.] multiplied by the constraint weight ($w_{\text{segm}}=87$), plus its 1 violation of IDENT-BR(PoA) multiplied by the weight of this constraint ($w_{\text{PoA}}=1.32$). Similarly, (b) [-'i.ta] violates IDENT-BR[SEGM.] and IDENT-BR(MoA), and is evaluated as less harmonic than (a), and (c) [-'i.ða] violates IDENT-BR[SEGM.] and IDENT-BR(voi.) and is evaluated as even less harmonic. In candidates (d) and (e), where 2 features mismatch with the features of the corresponding segment in the Base, violations in 3 constraints accumulate, resulting in even lower Harmony, while the last candidate (f) [-'i.ma] violates every IDENT-BR(F) constraint, thus being evaluated as the least harmonic candidate in the set (a-f).

Weights	87	2.31	1.49	1.32	\mathcal{H}
Base: -'i.θa	IDENT-BR [SEGM.]	IDENT-BR (voi.)	IDENT-BR (MoA)	IDENT-BR (PoA)	
☞ (a) -'i.fa	-1			-1	-88.32
(b) -'i.ta	-1		-1		-88.49
(c) -'i.ða	-1	-1			-89.31
(d) -'i.va	-1	-1		-1	-90.63
(e) -'i.la	-1	-1	-1		-90.80
(f) -'i.ma	-1	-1	-1	-1	-92.12

Table 9.

6 Conclusion and future directions

IR reveals phoneme similarity judgments of rappers in a naturalistic setting. According to our analysis

⁸ For reasons of simplicity, clarity, and economy of space, only the relevant rhyme domain is given in the examples, while the preceding segments are omitted.

on Greek rap IR, Output-Output (Base-Reduplicant) correspondents can mismatch to any extent, but there is gradience in the preference (in the Harmony of the Reduplicant). Similarity in rap rhyming pairs (rhyme fellows) is gradient in SMG, constrained by the number of features that diverge from the Base, in line with previous studies on other languages (Japanese, American English, Dutch).

However, our results differ to a great extent from what has been claimed for American English (Katz, 2015) and Japanese (Kawahara, 2007), where differences in voicing are less marked, as they are frequent and are considered to be less perceptually salient than mismatches in PoA or MoA. In our study, voicing mismatches are found to be highly marked. They are avoided by Greek-speaking rappers to a great extent; hence we claim that, in Greek rap, voicing mismatches are salient. The apparent salience of voicing is of interest for an additional reason, as it is a sign that perception of voicing in SMG might be based on more than psychoacoustic (non)salience as, if that was the case, voicing mismatches should be allowed in Greek rap, since, psychoacoustically, voicing mismatches are hardly salient (e.g. Steriade, 2001; 2008).

The frequencies observed in feature values that mismatch indicate that, in Greek rap, mismatch is mainly allowed between unmarked consonants, as PoA mismatches mainly between OBSTRUENTS, preferably STOPS, and MoA mismatches, to a great extent, between CORONALS. In both cases (PoA and MoA mismatch), mainly CORONAL OBSTRUENTS are involved. This is an indication that, in SMG, differences in more unmarked consonants are less salient, a finding that is, again, in incongruence with findings in American English and Japanese, but resembles findings in Dutch (Schelde, 2020) where mismatches are frequent between (voiceless) CORONAL OBSTRUENTS (although the voicing value is of no importance in Greek rap, as long as it remains unchanged between the two corresponding segments). Nevertheless, PoA in Greek can mismatch not only between OBSTRUENTS, but also between NASALS, which is a finding shared by all studies on IR similarity to date.

We, hence, argue that perceptual similarity of segments is rather language specific. In SMG, it is not purely phonetic and it can be based on phonological features, motivated by phonetics, to an extent that remains to be further investigated. The language-specific differences observed in rap IR, are an indication that perceptual similarity is not purely based on acoustic factors, hence the language specific phonological grammar plays some part in it. Future studies on (dis)similarity in Greek rap rhyme should also be directed to the investigation of rates of cluster dissimilarity, rates of segment insertion or deletion in the Reduplicant, and cumulative rates to test and expand on the present preliminary findings, reaching an overall conclusion.

References

- Adams, Kyle (2008). Aspects of the music/text relationship in rap. *Music Theory Online*, 14(2), 1–12.
- Bailey, Todd M., & Hahn, Ulrike (2005). Phoneme similarity and confusability. *Journal of Memory and Language*, 52(3), 339–362.
- Bradley, Adam (2009). *Book of rhymes: The poetics of Hip Hop*. Basic Civitas.
- Coetzee, Andries W., & Joe Pater (2008). Weighted constraints and gradient restrictions on place co-occurrence in Muna and Arabic. *Natural Language & Linguistic Theory*, 26(2), 289–337.
- Greenberg, Joseph Harold (1960). A survey of African prosodic systems. In Stanley Diamond (Ed.), *Culture in history: Essays in honor of Paul Radin* (pp. 925–950). Octagon Books.
- Holtman, Astrid (1994). A constraint-based approach to rhyme. *Linguistics in the Netherlands*, 11(1), 49–60.
- Holtman, Astrid (1996). *A generative theory of rhyme: An optimality approach*. PhD dissertation, Utrecht University. Utrecht Institute of Linguistics.
- Holton, David, Mackridge, Peter & Philippaki-Warbuton, Irene (1997). *Greek: A comprehensive grammar of the modern language*. Routledge.
- Kappa, Ioanna (1995). *Silbenphonologie im Deutschen und Neugriechischen [Syllable phonology in German and Modern Greek]*. [Unpublished doctoral dissertation]. University of Salzburg.
- Katz, Jonah (2008). *Towards a Generative Theory of Hip-Hop* [Conference Handout]. Music, Language, and the Mind, Tufts, Medford MA. <https://community.wvu.edu/~jokatz/KatzGTHH.pdf>
- Katz, Jonah (2015). Hip-hop rhymes reiterate phonological typology. *Lingua*, 160, 54–73.
- Kawahara, Shigeto (2007). Half rhymes in Japanese rap lyrics and knowledge of similarity. *Journal of East Asian Linguistics*, 16(2), 113–144.
- Legendre, Géraldine, Miyata, Yoshiro, & Smolensky, Paul (1990). Harmonic Grammar-A formal multi-level connectionist theory of linguistic well-formedness: Theoretical foundations. In *Proceedings of the 12th annual conference of the Cognitive Science Society* (pp.884–891). Erlbaum.

- Legendre, Géraldine, Sorace, Antonella, & Smolensky, Paul (2006). The Optimality Theory-Harmonic Grammar connection. In Paul Smolensky & Géraldine Legendre (Eds.), *The harmonic mind: From neural computation to optimality theoretic grammar* (vol. 2: Linguistic and philosophical implications, pp. 339–402). MIT Press.
- Maher, J. Peter (1969). English-speakers' awareness of distinctive features. *Language Sciences*, 5, 14.
- Maher, J. Peter (1972). Distinctive feature rhyme in German folk versification. *Language Sciences*, 16, 19–20.
- Malikouti-Drachman, Angeliki (1987). Syllables in Modern Greek. In Wolfgang U. Dressler, Hans C. Luschützky, Oskar E. Pfeiffer & John R. Rennison (Eds.) *Phonologica 1984: Proceedings of the Fifth International Phonology Meeting*, Eisenstadt, 25–28 June 1984 (pp. 181–187). Cambridge University Press.
- Malone, Joseph L. (1987). Muted euphony and consonant matching in Irish. *Germanic Linguistics*, 27, 133–144.
- Malone, Joseph L. (1988). Underspecification theory and Turkish rhyme. *Phonology*, 5, 293–297.
- McCarthy, John J. (1995). Extensions of faithfulness: Rotuman revisited. In *Linguistics Department Faculty Publication Series*. 36.
- McCarthy, John J., & Prince, Alan (1993). *Prosodic morphology: Constraint interaction and satisfaction*. Linguistics Department. Faculty Publication Series. 14. Retrieved from https://scholarworks.umass.edu/linguist_faculty_pubs/14
- McCarthy, John J., & Prince, Alan (1995). Faithfulness and reduplicative identity. *Papers in Optimality Theory*. 10. Retrieved from https://scholarworks.umass.edu/linguist_faculty_pubs/10
- Paradis, Carole, & Prunet, Jean-François (Eds.) (1991). *Phonetics and phonology. The special status of coronals: internal and external evidence* (vol. 2). Academic Press.
- Pater, Joe (2009). Weighted constraints in generative linguistics. *Cognitive Science*, 33(6), 999–1035.
- Prince, Alan, & Smolensky, Paul (1993/2004). *Optimality theory: constraint interaction in generative grammar*. Blackwell.
- Protopapas, Athanassios, Tzakosta, Marina, Chalamandaris, Aimilios, & Tsiakoulis, Pirros (2012). IPLR: an online resource for Greek word-level and sublexical information. *Language Resources and Evaluation*, 46(3), 449–459.
- Revithiadou, Anthi (1999). *Headmost accent wins*. [doctoral dissertation]. Leiden University/HIL.
- Rice, Keren (2007). Markedness in phonology. In Paul De Lacy (Ed.), *The Cambridge handbook of phonology* (Cambridge Handbooks in Language and Linguistics, pp. 79–98). Cambridge University Press.
- Rice, Keren, & Avery, Peter (1991). On the relationship between laterality and coronality. In Carole Paradis and Jean-François Prunet (Eds.) *Phonetics and phonology. The special status of coronals: internal and external evidence* (vol. 2, pp. 101–124). Academic Press.
- Schelde, Jona Van Der (2020). *Phonological and phonetic similarity as underlying principles of imperfect rhyme*. [Master's Thesis]. University of Amsterdam.
- Smolensky, Paul, & Legendre, Géraldine (2006). *The harmonic mind: From neural computation to optimality theoretic grammar*. MIT Press.
- Steriade, Donca (2001). Directional asymmetries in place assimilation. In Elizabeth Hume & Keith Johnson (Eds.), *The role of speech perception in phonology* (pp. 219–250). Academic Press.
- Steriade, Donca (2003a). Knowledge of perceptual similarity and its phonological uses: evidence from half-rhymes. In Maria-Josep Solé, Daniel Recasens & Joaquin Romero (Eds.), *Proceedings of the 15th International Congress of Phonetic Sciences* (pp. 363–366). Causal Productions.
- Steriade, Donca (2003b). Knowledge of similarity and narrow lexical override. In *Proceedings of the Twenty-Ninth Annual Meeting of the Berkeley Linguistics Society: General Session and Parasession on Phonetic Sources of Phonological Patterns: Synchronic and Diachronic Explanations*, 29 (pp. 583–598).
- Steriade, Donca (2008). The phonology of perceptibility effects: The P-map and its consequences for constraint organization. In Kristin Hanson & Sharon Inkelas (Eds.), *The Nature of the Word: Essays in Honor of Paul Kiparsky*. MIT Press.
- Trubetzkoy, Nikolaj Sergeevič (1931/1968). *Die phonologischen systeme*. Travaux du Cercle Linguistique de Prague, 4 (pp. 96–116). [Reprint: Nendeln, 1968]
- Tzakosta, Marina (2007) Genetic and environmental effects in L1 phonological acquisition. The case of consonant harmony in Greek child speech. *Journal of Greek Linguistics*, 8(1), 5–30.
- Wang, Marilyn D., & Bilger, Robert C. (1973). Consonant confusions in noise: A study of perceptual identity. *Journal of Acoustical Society of America*, 54, 1248–1266.
- Zwicky, Arnold M. (1976). Well, this rock and roll has got to stop. Junior's head is hard as rock. In Salikoko S. Mufwene, & Carol A. Walker (Eds.), *Papers from the 12th Regional Meeting, Chicago Linguistic Society 3, (12)* (pp. 676–697).