# Production of Estonian quantity contrasts by native speakers of Finnish

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## Abstract

Estonian and Finnish are closely related languages both exploiting duration cues contrastively; however, the quantity systems in the two languages are different. The Estonian quantity system involves three contrastive patterns referred to as short (Q1), long (Q2) and overlong (Q3) quantity degrees. These contrasts are manifested by a complex interaction of durational and tonal cues in a disyllabic foot. In Finnish, the quantity contrast is binary and phonologically clearly segmental.

Research has shown that L2 subjects with Finnish language background failed to produce the Estonian Q2 vs. Q3 contrast in vowel-peaked structures (CVVCV vs. CVV:CV) not distinguished in the orthography. In order to test the effect of L2 orthographic input on L2 pronunciation target words involving consonant-peaked quantity contrast (CVCCV vs. CVC:CV) have been used in the current study; in the case of plosives between the first and second syllable vowels, the quantity contrast is manifested orthographically.

The results confirm the role of L2 orthographic input in L2 pronunciation – in the case of target words with plosives L2 subjects produced different patterns for Q2 and Q3 structures, but not in the case of target words with non-plosives.

**Index Terms**: Estonian, Finnish, quantity contrasts, L2 speech

## 1. Introduction

Estonian and Finnish are typical examples of quantity language both exploiting the duration cue for manifesting phonological contrasts. However, the quantity systems in the two languages are different: ternary in Estonian and binary in Finnish.

The Estonian quantity degrees, referred to as short (Q1), long (Q2) and overlong (Q3), are manifested in monopthongs and diphthongs of the stressed syllable, e.g. Q1 *sada* /sa.ta/ 'hundred', nom.sg.; Q2 *saada* /saa.ta/ 'to send', sg.imperat.; Q3 *saada* /saa:.ta/ 'to get'; Q2 *koera* /koe.ra/ 'dog', gen.sg.; Q3 *koera* /koe:.ra/ 'dog', part.sg., or in consonants and consonant clusters between the first and second syllable vowels, e.g. Q1 *kala* /ka.la/ 'fish', nom.sg.; Q2 *kalla* /kal.la/ 'arum', nom.sg.; Q3 *kalla* /kal:.la/ 'pour', 2.sg. imperat.; Q2 *lehma* /leh.ma/ 'cow', gen.sg.; Q3 *lehma* /leh:.ma/ 'cow', part.sg. In the orthography, most Q2 and Q3 words are not distinguished, excluding words with plosives between first and second syllable vowels (see examples later in the text). The vowel quantity contrast is possible only in the stressed syllable. There are several studies showing that the domain of the Estonian quantity degrees is a disyllabic foot – a sequence consisting of the stressed syllable and the following unstressed syllable, e.g. [1], [2], [3], [4], [5].

The Finnish quantity system [6] differs from the Estonian system in several ways:

(1) the quantity contrast is binary and phonologically clearly segmental – long segments are interpreted as sequences of two identical (single) phonemes. It is also reflected in the orthography, e.g. *tuli* /tu.li/ 'fire', nom.sg.; *tuuli* /tuu.li/ 'wind', nom.sg.; *tulli* /tul.li/ 'customs', nom.sg.; *kiitä* /kii.tä/ 'thank!', 2. pers.sg.imp.; *kiitää* /kii.tää/ 'to dash';

(2) the vowel quantity contrast is possible also in unstressed syllables;

(3) the consonant quantity contrast is not possible in word-final positions.

In both languages the consonant quantity contrast is not possible word-initially.

Recent studies have shown that the complexity of Estonian quantity system is difficult to acquire for L2 learners with Russian-language background (L2-RU) and also for L2 subjects with Finnish-language background (L2-FI) [7], [8], [9]. In the latter study [9], both L2 subject groups failed to distinguish the Estonian Q2 vs. Q3 contrast in their production despite the fact that Finnish has duration based phonological contrasts and Russian does not. This could not be predicted by the Feature Hypothesis [10] according to which Estonian quantity contrast should be easier to acquire for L2-FI subjects than for L2-RU subjects due to different roles of duration in the subjects' native languages.

However, these rather surprising results emerged in the experiment involving the production of vowel-peaked quantity contrasts only, i.e. the target words with structures CV.CV (Q1), CVV.CV (Q2), and CVV:.CV (Q3). In these structures Q2 and Q3 words are not distinguished orthographically, e.g.

(1) *Meie <u>kooli</u> poisid...* 'Boys of our school ...' (*kooli* in Q2: /koo.li/ 'school', gen.sg.),

(2) *Lähen <u>kooli</u> ....* 'I go to school ...' (*kooli* in Q3: /koo:.li/ 'school', illat.sg.).

Thus, it might be the orthography of the target words that leads L2 subjects to use the same production pattern for both Q2 and Q3 despite different syntactic roles of the target words in sentence context. Diverse evidence of the L2 orthographic input on L2 pronunciation has been reported in several studies; see e.g. [11].

The aim of the current study is to explore the effect of the L2 orthographic input on the production of Estonian quantities by focusing on target words manifesting the Q1 – Q2 – Q3 contrast orthographically. This is the case only in words with plosives between first and second syllable vowels, e.g.: Q1: *kade* /ka.te/ 'envious', nom.sg., Q2: *kate* /kat.te/ 'cover', nom.sg., Q3: *katte* /kat:.te/ 'cover', gen.sg.; Q1: *lugu* /lu.ku/ 'story', nom.sg., Q2: *luku* /luk.ku/ 'lock', gen.sg., Q3: *lukku* /luk:.ku/ 'lock', part.sg.; Q1: *leba* /le.pa/ 'lay', 2.pers.sg.imperat., Q2: *lepa* /lep.pa/ 'alder', gen.sg., Q3: *leppa* /lep:.pa/ 'alder', part.sg. Notice that, in Estonian orthography, the letters <bdg> and <ptk> denote short and long voiceless plosives, respectively.

## 2. Methods

### 2.1. Subjects

The L2-FI group involved twelve (6 male and 6 female; age 21-49, median 36) subjects with Finnish-language background originating from the Helsinki, Turku and Oulu areas (2 male and 2 female from each area). They were born in monolingual Finnish speaking families and started to study Estonian at the age 18 – 35 at university. In self-assessment one subject rated his/her proficiency in Estonian as "elementary", seven subjects as "intermediate", three as "advanced" and one as "proficient"; six subjects use Estonian frequently (daily or weekly) and the other six more rarely.

As the reference group, ten (5 male, 5 female) native speakers of Estonian were involved. L1 subjects (age 21-54, median 26.5) came from monolingual Estonian-speaking families and represent the pronunciation of standard Estonian.

### 2.2. Corpus and material

A subset (48 target words in read sentences) of the Estonian Foreign Accent Corpus [12] was used in the study. L2-FI subjects from Helsinki and Oulu were recorded in the recording studios of Helsinki and Oulu universities, the subjects from Turku in a quiet lecture room at Turku University. L1 subjects were recorded in the recording studio of the Laboratory of Phonetics and Speech Technology, Tallinn University of Technology. For all recordings the same microphones (Audio-Technica ATM33a and Sennheiser ME3) and high quality recording equipment (sampling frequency 44.1 kHz, resolution 16 bit) were used.

The analyzed speech material involved seven triplets of segmentally identical disyllabic target words in the quantities Q1, Q2 and Q3 (representing consonant-peaked quantity contrasts in structures CV.CV, CVC.CV and CVC:.CV, respectively). Among these, three triplets involved plosives /k/, /p/ and /t/ between first and second syllable vowels, in the other triplets consonants /m/, /n/, /s/, and /l/ were present. In addition, nine triplets of vowel-peaked quantity contrasts (structures CV.CV, CVV.CV and CVV:.CV) used in earlier studies [8], [9] were involved for comparison. All target words have been manually segmented and labeled on word and phone levels using Praat [13].

### 2.3. Measurements

The durations of all constituent segments (C1, V1, C2, V2) in each target word were measured using a Praat-script and syllable duration ratio as a characteristic feature distinguishing the three quantity degrees (proposed by Lehiste [14]) was calculated. In native speech, the typical duration ratio for Q1 varies in the range 0.6 – 0.9, for Q2 1.4 – 2.0, and for Q3 2.0 – 3.9 as pooled across different studies [15]. The syllable duration ratio is calculated as the duration of the first (stressed) syllable rhyme divided by the duration of the second (unstressed) syllable nucleus [16] (syllable-initial consonants do not participate in quantity opposition). In the case of vowel-peaked quantity contrast (i.e. target words CV.CV, CVV.CV and CVV:.CV) the characteristic duration ratio is calculated as the duration of the stressed syllable vowel (V1) divided by the duration of the unstressed syllable vowel (V2). In the case of consonant-peaked target words (CVC.CV and CVC:.CV) the calculation of duration ratio is more complicated since it involves the splitting of the word-medial geminate consonant into two segments: the coda of the first syllable and the onset of the second syllable. For splitting a simple approach from [16] has been adopted – in CVC.CV-structures (Q2) the word-medial geminate has been divided into two components of equal duration, in CVC:.CV-structures (Q3) the splitting is based on the following consideration. Assuming that syllable onset does not participate in quantity contrasts, the lengthening of intervocalic consonant in Q3 (when compared to Q2) can be attributed to the first syllable coda only. From this follows that the second syllable onset can be taken to have a duration equal to that of the onset of the second syllable in the Q2 structure, and the rest of geminate's duration can be taken to belong to the first syllable coda.

## 3. Results

### 3.1. Segment durations

Table 1 provides average duration data of all constituent segments of the 462 target words (22 subjects x 21 words (in 7 triplets)) representing the word structures CV.CV (Q1), CVC.CV (Q2), and CVC:.CV (Q3). In the C2 position the consonants /k/, /p/, /t/, /l/, /m/, /n/, and /s/ occur; the quantity contrast is manifested orthographically in the case of the plosives, but not in the case of the other consonants. Depending on the consonant type in the C2 position, the two sets of target words are denoted as Plosive (C2 = plosive) and Non-plosive (C2 = non-plosive) sets.

In the analysis of variance (ANOVA) three grouping variables (factors) were defined: Word set (Plosive and Non-plosive), Subject group (L1 and L2) and Quantity (Q1, Q2 and Q3); where applicable, TukeyHSD post-hoc tests were used.

Table 1. *Average duration (in ms) and standard deviation (in parenthesis) of C1, V1, C2 and V2 in the three word structures representing the quantity contrasts Q1, Q2 and Q3 read by L1 and L2-FI subjects.*

| Word set | Subject group | Qs | C1 | V1 | **C2** | V2 |
|---|---|---|---|---|---|---|
| C2 = plosive (n = 198) | L1 | Q1 | 57 (15.4) | 72 (17.1) | **75 (12)** | 98 (26.7) |
| | | Q2 | 59 (19.8) | 67 (10.5) | **134 (13.8)** | 79 (22) |
| | | Q3 | 50 (17.3) | 65 (12.3) | **200 (24.3)** | 57 (15) |
| | L2 | Q1 | 60 (20.4) | 65 (13.9) | **92 (23.8)** | 105 (38.7) |
| | | Q2 | 58 (16.5) | 61 (11.4) | **147 (56.9)** | 77 (33) |
| | | Q3 | 56 (15.7) | 66 (16.9) | **196 (43)** | 64 (22.5) |
| C2 = non-plosive (n = 264) | L1 | Q1 | 89 (17.6) | 86 (13.8) | **63 (20.3)** | 95 (31.9) |
| | | Q2 | 81 (18.6) | 97 (15.8) | **111 (20.1)** | 77 (18.2) |
| | | Q3 | 79 (20.1) | 101 (20.7) | **147 (28.4)** | 62 (14.4) |
| | L2 | Q1 | 106 (20.3) | 73 (16.1) | **68 (17.7)** | 97 (23.7) |
| | | Q2 | 98 (17.1) | 86 (23.6) | **134 (38.5)** | 73 (26.3) |
| | | Q3 | 96 (19.3) | 87 (21.5) | **139 (41.2)** | 64 (17.5) |

In L1, there are minor and mostly non-significant duration differences of C1 and V1 among the different quantity degrees in the case of both word groups. Quantity has an effect on C1 duration [$F(2, 117) = 3.6$; $p < 0.05$] and on V1 duration [$F(2, 117) = 8.4$; $p < 0.05$] in the Non-plosive set only. As expected, Quantity has the largest effect on C2 duration in the Plosive [$F(2, 87) = 381.3$; $p < 0.001$] and in the Non-plosive [$F(2, 117) = 129.8$; $p < 0.001$] sets, as well as on V2 duration in the Plosive [$F(2, 87) = 27.3$; $p < 0.001$] and in the Non-plosive [$F(2, 117) = 20.7$; $p < 0.001$] sets.

When comparing L1 segment durations between the two word groups, differences in most segments (except V2) emerge. However, these differences reflect natural variability due to variable phonemic identities of the segments. What is most important is that in both word groups segment durations manifest similar quantity related patterns: C2 duration is proportional to the quantity degree (shortest in Q1 and longest in Q3) and V2 duration is inversely proportional (longest in Q1 and shortest in Q3). The post-hoc test revealed that the durations of both C2 and V2 differ significantly ($p < 0.001$) in all quantity degrees.

In the L2-FI group, for the segments C1 and V1, the results are rather similar to those of the L1 group: Quantity has an effect on C1 duration [$F(2, 141) = 3.6$; $p < 0.05$] and on V1 duration [$F(2, 141) = 7.3$; $p < 0.001$] only in the Non-plosive set. Also in the L2 group Quantity has an effect on C2 and V2 durations, yet, in a manner different from L1 group. In the case of C2, Quantity affects duration in both the Plosive [$F(2, 105) = 51.6$; $p < 0.001$] and the Non-plosive [$F(2, 141) = 64.4$; $p < 0.001$] sets. However, the post-hoc test showed that C2 duration differs significantly ($p < 0.001$) in all quantity degrees in the Plosive set only, but not in Non-plosive set: in the latter set, the C2 duration difference is significant between Q1 and Q2 ($p < 0.001$), but not between Q2 and Q3 ($p = 0.79$). V2 duration has similar patterns in Plosive [$F(2, 105) = 14.96$; $p < 0.001$] and Non-plosive [$F(2, 141) = 27.2$; $p < 0.001$] sets, contrasting between Q1 and Q2 ($p < 0.001$), but not between Q2 and Q3 words ($p = 0.2$).

### 3.2. Duration ratios

In Table 2 the average durations of the first syllable rhyme and the second syllable nucleus are given. The characteristic duration ratio has been computed using these measures as explained above. To compare the data from consonant-peaked word structures, the data from vowel-peaked word structures [11] are given as a reference.

In the L1 group, Quantity has a strong effect on the duration of the first syllable rhyme in both the Plosive [$F(2, 87) = 305.8$; $p < 0.001$] and in the Non-plosive [$F(2, 117) = 167$; $p < 0.001$] sets; the duration is different in all quantity degrees ($p < 0.001$). (For the second syllable nucleus, hence V2, see the analysis above). Consequently, the duration ratio is heavily dependent on Quantity in both the Plosive [$F(2, 87) = 248.7$; $p < 0.001$] and the Non-plosive [$F(2, 117) = 154.5$; $p < 0.001$] sets and results in three clearly distinct patterns for Q1, Q2 and Q3 in both word sets (Figure 1, top).

For the Plosive set, the L2-FI subjects show results similar to those of the L1 subjects: Quantity has an effect on the duration of the first syllable rhyme [$F(2, 105) = 126.2$; $p < 0.001$] and the duration differences are significant in all quantity degrees ($p < 0.001$). Consequently, also the duration ratios in the Plosive set show strong dependence on Quantity [$F(2, 105) = 58.2$; $p < 0.001$] and the post-hoc test confirmed the contrasts in all quantity oppositions ($p < 0.001$).

For the Non-plosive set, Quantity affects the duration of the first syllable rhyme [$F(2, 141) = 110.6$; $p < 0.001$], but the post-hoc test confirmed the contrast between Q1 and Q2 ($p < 0.001$), but not between Q2 and Q3 ($p = 0.63$). Similarly, the duration ratio in the Non-plosive set occurs dependent on Quantity [$F(2, 141) = 95.9$; $p < 0.001$]; the post-hoc test reveals that the difference between Q1 and Q2 is highly significant ($p < 0.001$), and also the difference between Q2 and Q3 almost reaches the significance level ($p = 0.051$) (Figure 1, mid). However, an additional pair-wise comparison (using Two Sample t-test) indicated that there is no difference in Q2 duration ratios between the Plosive and the Non-plosive sets ($p = 0.45$), but Q3 duration ratios in the two word sets differ significantly ($p < 0.05$).

Table 2. *Average duration (in ms) and standard deviation (in parenthesis) of Syllable 1 rhyme, Syllable 2 nucleus and Duration ratio in target words representing the consonant-peaked (Plosive and Non-plosive sets) and vowel-peaked quantity contrasts Q1, Q2 and Q3 read by L1 and L2-FI subjects.*

| Word set | Subject group | Qs | Syllable 1 rhyme | Syllable 2 nucleus | Duration ratio |
|---|---|---|---|---|---|
| Consonant-peaked words C2 = plosive (n = 198) | L1 | Q1 | 72 (17.1) | 98 (26.7) | 0.8 (0.19) |
| | | Q2 | 134 (12.3) | 79 (22) | 1.8 (0.54) |
| | | Q3 | 198 (26.8) | 57 (15) | 3.6 (0.66) |
| | L2 | Q1 | 65 (13.9) | 105 (38.7) | 0.7 (0.27) |
| | | Q2 | 134 (34.8) | 77 (33) | 2.1 (1.11) |
| | | Q3 | 188 (43.1) | 64 (22.5) | 3.3 (1.31) |
| Consonant-peaked words C2 = non-plosive (n = 264) | L1 | Q1 | 86 (13.8) | 95 (31.9) | 1.0 (0.28) |
| | | Q2 | 153 (19.1) | 77 (18.2) | 2.1 (0.48) |
| | | Q3 | 192 (38.9) | 62 (14.4) | 3.2 (0.82) |
| | L2 | Q1 | 73 (16.1) | 97 (23.7) | 0.8 (0.22) |
| | | Q2 | 153 (36.2) | 73 (26.3) | 2.3 (0.76) |
| | | Q3 | 159 (38.3) | 64 (17.5) | 2.6 (0.91) |
| Vowel-peaked words (n = 594) | L1 | Q1 | 82 (15.6) | 112 (28.3) | 0.8 (0.2) |
| | | Q2 | 144 (29) | 85 (25) | 1.8 (0.4) |
| | | Q3 | 174 (26.7) | 61 (12.2) | 2.9 (0.6) |
| | L2 | Q1 | 74 (22) | 114 (35.8) | 0.7 (0.2) |
| | | Q2 | 170 (48.2) | 66 (25.7) | 2.8 (1.0) |
| | | Q3 | 173 (44.8) | 66 (27.6) | 2.8 (0.9) |

In the case of vowel-peaked quantity contrasts (reported earlier in [9]), L1 subjects exploit both V1 and V2 for signaling the quantity oppositions, which results in three distinct V1/V2 durational ratios. Quantity has an effect on the duration of both V1 [$F(2, 267) = 330.4$; $p < 0.001$] and V2 [$F(2, 267) = 112.9$; $p < 0.001$], as well as on the V1/V2 duration ratio [$F(2, 267) = 520.7$; $p < 0.001$]; the post-hoc test confirmed significant differences in V1 and V2 durations and V1/V2 ratio in all of the quantity oppositions ($p < 0.001$).

Also in the L2-FI group, Quantity had an effect on V1 and V2 duration, and on V1/V2 ratio – V1: [$F(2, 322) = 213.6$; $p < 0.001$]; V2: [$F(2, 322) = 88.3$; $p < 0.001$]; V1/V2 ratio: [$F(2, 322) = 249.8$; $p < 0.001$]. However, according to the post-hoc test, V1 and V2 durations and V1/V2 ratio differ between Q1 and Q2 ($p < 0.001$), but not between Q2 and Q3 ($p < 1$) (Figure 1, bottom).

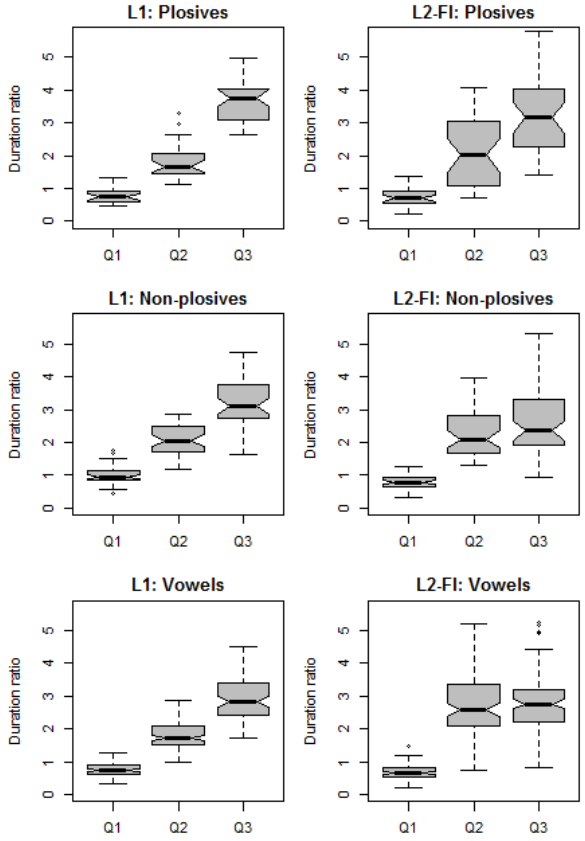


Figure 1: *Boxplots of duration ratios for L1 (left) and L2-FI (right) in target words with plosives (top), non-plosives (mid), and vowels (bottom).*

## 4. Discussion

According to a survey on teaching Estonian at the universities in Finland [17], for the adult learners of Estonian with Finnish-language background the most difficult topics in Estonian phonetics-phonology are the quantity oppositions, the phoneme /õ/ (a vowel category missing in Finnish), palatalization (missing in Finnish), and the relationship between the orthography and pronunciation, especially in the case of plosives.

The results reported in this study confirm the experience-based claim of Estonian language teachers in Finland and provide experimental evidence on the difficulties of L2-FI subjects to produce contrasts between Q2 and Q3 words. Our L2-FI subjects succeeded to produce a reliable contrast between Q2 and Q3 words only in the case of plosives in the intervocalic position (at the boundary of first and second syllable) of consonant-peaked word structures, i.e., in word structures where quantity contrasts are explicitly expressed in the orthography. This is an example of a positive effect of L2 orthographic input leading to a more target-like pronunciation. It was expected to take place in L2-FI subjects since in Finnish the phonemic distinctions are rather systematically indicated in the orthography [6].

In the case of other consonant-peaked word structures containing non-plosives and also in the case of vowel-peaked words (in both sets Q2 and Q3 words are not distinguished orthographically), the main problem for the L2-FI subjects lies in choosing the right temporal patterns for the pronunciation of Q2 words. In the case of Estonian Q2 structures the conflict between the prosodic systems of the native (binary and segmental in Finnish) and the target language (ternary and foot-based in Estonian) conspicuously emerges. In Finnish, there are frequent CVC.CV and CVV.CV patterns [18] which are phonetically closer to the Estonian Q3 (consonant-peaked and vowel-peaked patterns, respectively) than to Q2 [19]. In order to get Estonian Q2 words right, it is crucial to get the duration of the second-syllable vowel right. To achieve that, Finnish learners of Estonian should pronounce Estonian Q2 words of the structures CVV.CV and CVC.CV as quick versions of the Finnish structures CVV.CVV and CVC.CVV, respectively [20]. However, L2-FI subjects do not use the native CVC.CVV and CVV.CVV patterns for Estonian Q2 words because, to them, L2 orthography suggest that there must be a single vowel in the unstressed syllable of Q2 words.

The results of the current study show that the Feature Hypothesis [10], originally proposed to explain the role of L1 transfer in vowel perception in a situation in which both spectral and duration cues are involved in the perception and production of non-native contrasts, cannot easily explain L2 production of non-native phonological quantity contrasts, at least in the case of a target language in which the duration cue is simultaneously exploited in several phonetic segments to signal the quantity oppositions.

## 5. Conclusions

In the paper we tested the effect of L2 orthographic input on L2 pronunciation of a consonant-peaked quantity contrast (CVCCV vs. CVC:CV) using two sets of target words. In the Plosive set the quantity contrasts are explicitly expressed in the orthography, unlike the Non-plosive set. The results confirmed the role of L2 orthographic input on L2 pronunciation – in the Plosive set the L2-FI subjects produced different patterns for Q2 and Q3 structures, but not in the Non-plosive set, in which the L2-FI subjects showed results similar to the production of a vowel-peaked quantity contrast.

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