"Potizo" or "Potizw"?
The influence of morphology in the processing of Roman-alphabeted Greek*

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Abstract

This paper investigates word-recognition in Greeklish, a spelling variation of Greek with Latin characters that follows a phonological (*ποτίζω=potizo*) or a visual/orthographic transliteration-pattern (*ποτίζω=potizw*). 22 Greek speakers underwent a lexical-decision task in Greek and Greeklish involving verbs with the character omega in the stem or suffix, and provided a sample of written production in Greeklish. Results showed that word-recognition is not influenced by the participants' transliteration preferences. Words with omega on the stem showed shorter reaction times for the phonological transliteration, while the opposite was attested for words with omega on the suffix, demonstrating that inflectional morphology impacts on word-recognition.

Keywords: Greeklish, reading, word-recognition, inflectional morphology, lexical decision task, phonological, visual/orthographic

1. Introduction

During the last decade, a novel type of spelling has emerged in Greek-to-Greek computer-mediated communication. Technological limitations that often obstruct compatibility between different computer platforms often oblige Greek users to resort to the use of Roman characters to spell Greek. This way of spelling Greek has come to be known as *Greeklish*.

Greeklish is characterised by spelling variation. It can follow either the phonological representation of the word, attempting to represent the Greek phonemes with Latin characters (ποτίζω=potizo), or it can attempt to maintain the Greek orthographic conventions by representing Greek characters with visually similar Latin characters (ποτίζω=potizw) or numbers (κάθε=ka8e). These two transliteration types can be broadly categorised as *phonological* versus *visual/orthographic*.

Research in Greeklish has been primarily conducted from a sociolinguistics perspective (Ανδρουτσόπουλος 1999, 2000; Koutsogiannis & Mitsikopoulou 2003). Tseliga (2004) was the first to investigate how Greek adult readers process Greeklish on-line, and using a sentence verification task showed that at the sentence level, readers of Greeklish process both transliteration types almost equally fast. However, the

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sentences in Tseliga's experiment contained several characters and numbers, and thus, it is not clear whether these results reflect that word recognition of Greeklish is equally fast in both transliteration types or whether specific characters or numbers contributed to this effect. To address this issue, we investigated how adult readers process Greeklish on-line at the *word-level* focusing on only one letter of the Greek alphabet, the letter 'ω' omega.

2. Word-recognition in skilled readers and the Greek orthographic system

One of the most influential models in word-recognition is the Orthographic Depth Hypothesis (ODH) (Katz & Frost 1992). This hypothesis draws on the consistency of grapheme-phoneme correspondences. Languages that have consistent grapheme-phoneme mappings are classified as languages with a *shallow orthography* (e.g. Finish); languages with inconsistent and opaque grapheme-phoneme mappings are classified as languages with a *deep orthography* (e.g. English). According to the strong version of this theory, word-recognition in shallow orthographies relies primarily on phonemic cues generated pre-lexically by grapheme-to-phoneme conversion, whereas in deep orthographies, lexical access relies strongly on visual/orthographic cues and phonology is derived from the lexicon (Frost et al. 1987) – but cf. Ziegler and Goswami (2005) for a different approach.

The Greek orthographic system is characterised by relatively regular and consistent grapheme-to-phoneme correspondences, and thus, within the ODH, Greek is placed towards the shallower orthographies (Porpodas 1989; Seymour et al. 2003). However, phoneme-to-grapheme correspondences are less consistent, as some of the vowels can be spelled in several ways – e.g. the phoneme /i/ can be spelled with one of the single letters ι, η, υ, or with the digrams ει, οι, υι, as in τραπέζ**ι** = /trapezi/ (table), **ει**ρ**ή**ν**η** = /irini/ (peace), κ**οι**λιά = /kilja/ (belly), and the phoneme /o/ with the letters ω or ο, as in φ**ω**ς = /fos/ (light), π**ό**ν**ο**ς = /ponos/ (pain). Taking into consideration that very specific rules regulate the pronunciation of these inconsistencies (Aidinis & Nunes 2001), a word's pronunciation in Greek is most of the times easily predicted based on the information of the word's spelling/written form, and thus, Greek is easier to read than to spell.

A further characteristic of Greek is that it has a rich inflectional morphology. Inflectional suffixes on nouns encode gender, number and case, and inflectional suffixes on verbs encode person and number. For example, in the noun άνθρωπ-ος = /anthropos/ (human) the suffix –ος encodes masculine, singular, nominative, and in the verb ποτίζ-ω = /potizo/ = (I water), the suffix -ω encodes 1st person singular.

The issue of reading development in Greek children has drawn a lot of attention in the last decades, originating from the pivotal work of Porpodas (1989, 1999) and Porpodas et al. (1990). Considerable less research has been conducted in word-recognition by adult skilled readers of Greek and especially in how syntactic information encoded in inflectional morphology impacts on word-recognition. To our knowledge, only two studies have addressed this issue comparing word-recognition in English and Greek monolinguals (Chitiri & Willows 1994) and bilinguals (Chitiri & Willows 1997). The main results from those two studies concerning word-recognition in Greek that are relevant for our study are that: (a) both phonological and visual/orthographic routes are involved in word-recognition of Greek, and (b) Greek readers seem to attend more to the last syllable of nouns which carries inflectional suffixes. This is consistent with studies in other languages with a rich morphology, such as Serbo-Croatian (Feldman & Fowler 1987) and Italian (Jarvella et al. 1987).

The present study investigates word-recognition in adult skilled readers of Greek and Greeklish by using a lexical decision task. To address the impact of inflectional morphology and frequency effects, the letter omega was used in the stem, at the penultima of verbs ending in -ωνω, and in the suffix. Finally, to investigate the relationship between word-recognition and written production, we compared the results from the lexical decision task with the participants' written transliteration preferences in Greeklish.

3. Method

3.1 Participants

Twenty-two native speakers of Greek (12 female) aged 20-29 years (mean age: 23.7, SD: 2.28) participated in this study. All participants were skilled readers of Greek, born and educated in Greece, and they did not have any history of language or reading disorder. At the time of testing they were undergraduate or postgraduate students in the UK, and the average time they had spent in the UK was 40 months (range: 8-96 months, SD: 25.08). All participants were sufficiently familiar with Greeklish - 18 out of the 22 participants used Greeklish in reading and writing on a daily basis, and the remaining four used Greeklish either every other day or 2-3 times per week.

3.2 Procedure

To measure the participants' transliteration preferences, and to ascertain the relationship between word-recognition and written production, participants provided a sample of e-mails they had written in Greeklish. To measure their word-recognition in Greek and Greeklish, subjects participated in an on-line lexical decision task in Greek and in Greeklish. The participants sat in front of a CRT screen connected to a laptop and a button box with one green and one red button. Participants saw one word at a time at the centre of the screen and had to press one of the two buttons as fast and as accurately as possible – the green button for real words and the red button for not real words. The elapsed time between the presentation of the word and the button press, the reaction time (RT), was recorded on the laptop. The presentation of the stimuli and the recording of RTs were controlled by the software E-Prime (Psychology Software Tools Inc.).

Instructions were given both orally and on the computer screen. A training block of 12 words (6 real words, 6 non-words) was employed at the beginning of each session to ensure that the participants were accustomed to the equipment and the procedure. If participants did not feel confident enough after the first training block, they did a second 12 items training block. The main experiment was divided into two separate blocks (15-20 minutes each). In the first block, the subjects saw words written in Greeklish and in the second block they saw the same words written in Greek. The order of the two blocks was the same for all subjects in order to avoid priming effects from Greek to Greeklish. Both blocks were run in the same session with a five-minute break in between.

3.3 Materials

This study focused on one character of the Greek alphabet, the letter 'ω' (omega) that can be transliterated in Greeklish as 'o' (phonological transliteration) or as 'w' (visual/orthographic transliteration). We used 60 real Greek words and 60 non-words that were created from real words by changing one or two characters.

To investigate the impact of inflectional morphology and frequency effects, the character omega was in one of the three following positions: (1) in the stem ‘*νιώσατε*’ (felt.$_{2P}$), (2) in the penultima of ‘-***ω***νω’ verbs ‘*σκότ**ω**σα*’ (killed.$_{1S}$), and (3) in the suffix ‘*διστάζ**ω***’ (hesitate.$_{1S}$). In the first two positions, omega is in the stem, whereas in the third one, it is in the suffix encoding syntactic information – 1st person singular. Differences between 1, 2 *vs* 3 can reveal an effect of stem *vs* suffix. Omega in the suffix of verbs is very frequent. In addition, Greek has about 1,000 ‘-ωνω’ verbs (Μπαμπινιώτης 1998), all of which have the letter omega in the penultima, i.e. the letter omega is very frequent in this position. Thus, differences between 1 *vs* 2, 3 can reveal a frequency effect.

To avoid word-class effects, all words were verbs and to minimise practice effects, the verbs varied as to person and tense marking. All target words were controlled for length – number of syllables (3-to-4 syllables long) and number of characters (6-to-8 characters long). In addition, all words were controlled for surface frequency based on the Hellenic National Corpus (34,307,276 words, 3/2/2004). Wilcoxon non-parametric tests showed no significant differences between the frequency of the verbs in the three conditions (stem *vs* ‘-ono’: z = -.044, n = 20, ns; stem *vs* suffix: z = -.505, n = 20, ns; ‘-ono ’ *vs* suffix: z = -.887, n = 20, ns). Finally, none of the target words included any other characters that could be transliterated in more than one ways. This was done to ensure that any effects shown on the reaction times were due to the transliteration of the tested variable, i.e., omega and not due to other factors.

3.4 Design

For the block with Greek characters, there was one within subjects factor, i.e. the position of the character omega (stem, penultima of ‘-ono’ verbs, suffix). This yielded a 1 x 3 design with three conditions, as shown in Table 1 below.

Table 1. Conditions for the block with Greek characters

Condition	*Position*	*Example*	*Gloss - syntactic inform.*
Condition 1	Stem	*νι**ώ**σατε*	felt.$_{2P}$
Condition 2	Penultima ‘–ono’ verbs	*σκότ**ω**σα*	killed.$_{1S}$
Condition 3	Suffix	*διστάζ**ω***	hesitate.$_{1S}$

For the block with Greeklish, there were two within subjects factors: 1) the transliteration type (orthographic = ‘w’, phonological = ‘o’), and 2) the position of the target character (stem, penultima of ‘-ono’ verbs, suffix). This resulted in a 2 x 3 design with six conditions, as shown in Table 2 below.

Table 2. Conditions for the block with Greeklish

Condition	*Position – Transliteration*	*Example*	*Gloss - syntactic inform.*
Condition 1	Stem: orthographic	*ni**w**sate*	felt.$_{2P}$
Condition 2	Stem: phonological	*ni**o**sate*	felt.$_{2P}$
Condition 3	Penultima ‘-ono’:orthographic	*skot**w**sa*	killed.$_{1S}$
Condition 4	Penultima ‘-ono’:phonological	*skot**o**sa*	killed.$_{1S}$
Condition 5	Suffix: orthographic	*distaz**w***	hesitate.$_{1S}$
Condition 6	Suffix: phonological	*distaz**o***	hesitate.$_{1S}$

3.5 Formulation of hypotheses

In this study, we tested four hypotheses. The first one concerned the relationship between Greek and Greeklish. Given that native speakers of Greek are more familiar with (and have acquired first) Greek spelled with Greek characters, which is their native alphabet, than with Greeklish, we predicted that the block with the Greek characters will show faster RTs than the block with Greeklish.

The second hypothesis is based on the ODH. Since Greek is a language with shallow orthography, phonological properties should be more involved in word recognition than orthographic properties. Therefore, RTs to phonological transliterations are predicted to be faster than to visual/orthographic ones.

The third hypothesis relates to the influence of inflectional morphology in word-recognition. Visual similarity of the transliterated character with the letter omega could access the syntactic information encoded in the inflectional suffix of the verb, and could facilitate word-recognition. If this is true, RTs of visual/orthographic transliterations on the suffix of verbs should be shorter than those of phonological transliterations.

The last hypothesis relates to frequency effects. The letter omega is very frequent in the suffix of verbs and in the penultima of '-ono' verbs. This could facilitate word-recognition when the transliterated character is visually similar to the character omega, and would predict that RTs of visual/orthographic transliterations in the suffix and in the penultima of '-ono' verbs will be shorter than RTs of phonological transliterations.

These four predictions are summarised in Table 3 below.

Table 3. Predictions for RTs

Predictions	*Examples*
1. Greek *vs* Greeklish	*νιώσατε < niwsate/niosate, σκότωσα < skotwsa/skotosa, διστάζω < distazw / distazo*
2. ODH	*niosate < niwsate, skotosa < skotwsa, distazo < distazw*
3. inflectional morphology	distazo > distazw
4. frequency	distazo > distazw, *skotosa > skotwsa*

4. Results

4.1 Written production

Two participants did not provide samples of their written production. To investigate whether the remaining 20 participants had a preference towards one of the two transliteration patterns, we first examined the subjects' e-mails focusing on the character omega in verbs. Table 4 shows the percentage of verbs written with 'w' and 'o' in the three positions we used in our on-line task.

Table 4. E-mail analysis – frequency of verbs per pattern

	w	*o*
stem	46.2%	53.8%
verbs in '-ono'	41.2%	58.8%
suffix	52.1%	47.9%

Wilcoxon non-parametric tests showed no significant differences between the two transliteration patterns in all three positions (stem: z = -.265, ns; penultima: z = -.557, ns; suffix: z = -.131, ns). Furthermore, participants were consistent with their transliteration choice, i.e. 10 participants used the visual/orthographic transliteration and 10 participants used the phonological pattern in more than 90% of the cases. Thus, based on the analysis of e-mails, the subjects can be divided into two groups, those who preferred the visual/orthographic pattern, and those who preferred the phonological pattern.

4.2 Lexical-decision task

The participants' performance was examined on the basis of their accuracy and RTs, and statistical analyses were carried out separately for the two blocks, Greek and Greeklish.

4.2.1 Off-line accuracy data

The mean accuracy rate for the block with Greek characters was 96.03% (SD = 11.84) and for the block with Greeklish 95.58% (SD = 8.99). One subject showed an accuracy rate of 47.5% in the block with Greek and 36.67% in the block with Greeklish, which were more than 2 SD below the group mean. This subject's RTs were, thus, excluded from further analyses. The accuracy data from the remaining 21 subjects are shown in Table 5 below.

Table 5. Accuracy rate in percentage

	Greek	*Greeklish*
Real Words	99.13%	97.77%
Non-Words	97.60%	96.43 %

A Chi-square test showed no significant differences between the scores above. Further analyses were conducted to identify significant differences between the experimental conditions. For the block with Greek characters, a repeated measures ANOVA with the factor Position (stem, penultima of '-ono' verbs, suffix) revealed a significant difference between the three positions ($F (2, 19) = 3.606, p < .05$). Post-hoc Bonferroni-corrected t-tests revealed that this was attributed to the larger number of inaccurate responses in words with omega in the penultima from '-ono' verbs (8 errors) as opposed to the stem (1 error) ($p < .05$). For the block of Greeklish, a repeated measures ANOVA with the factors Transliteration Type (w, o) and Position (stem, penultima of '-ono' verbs, suffix) showed only a marginal main effect of Transliteration Type ($F (1, 20) = 3.257, p = .086$). This was followed up by Bonferroni-corrected t-tests that showed a marginally significant difference between the phonetic and orthographic transliteration ($p = .086$) (9 errors in words with visual/orthographic *vs* 19 in words with phonological transliteration). Inaccurate responses were excluded from further analyses.

4.2.2 RT data

RT data were first screened for outliers – RTs above and below 2 SDs were calculated by subject and item for each condition. For the block with Greek characters, this affected 8.64% (108 out of 1249 data points) and for the block with Greeklish 8.1% of the data set (100 out of 1232 data points).

Greek vs Greeklish block: The mean RTs for the block with Greek characters was 657.28 ms (SD = 133.04) and for the block with Greeklish was 886.44 ms (SD = 268.2). A Wilcoxon non-parametric test showed that the difference was highly significant (z = -4.911, $p < .001$). RTs in the Greek block were significantly shorter than in the Greeklish block.

Greek block. The mean RTs for each condition in the Greek block are shown in Table 6 below.

Table 6. Mean RTs Greek block

	Mean	*SD*
stem	680.26	79.22
penultima '-ono' verbs	672.83	72.94
suffix	619.54	68.21

A repeated measures ANOVA with the factor Position (stem, penultima '-ono' verbs, suffix) revealed a significant main effect of Position (F (2, 19) = 29.506, $p < .001$). Bonferroni-corrected t-tests showed that this was due to a significant difference in RTs between stem and suffix and penultima of '-ono' verbs and suffix (both $p < .001$), but there was no significant difference between stem *vs* penultima of '-ono' verbs ($p > .1$).

Greeklish block. The mean RTs for the block with Greeklish are shown in Figure 1 below.

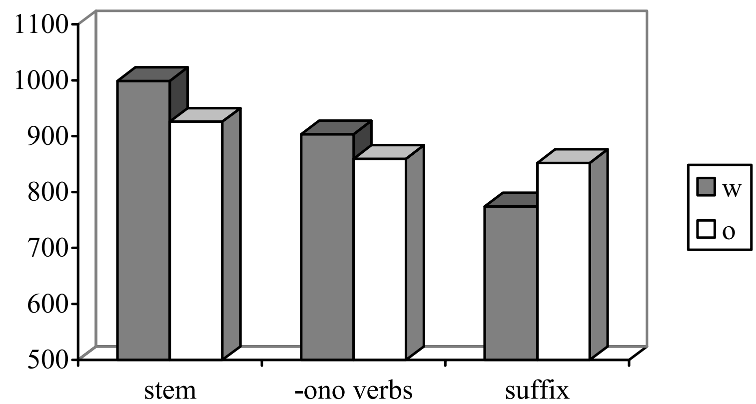

Figure 1. Mean RTs Greeklish block

A repeated measures ANOVA with the factors Transliteration Type (w, o) x Position (stem, penultima of '-ono' verbs, suffix) revealed a significant main effect of Position (F (2, 19) = 31.393, $p < .001$) and a significant interaction between Transliteration Type x Position (F (2, 19) = 13.074, $p < .001$). To further investigate this interaction, t-tests were conducted per subjects (t1) and items (t2). In the case of the stem, the difference was approaching significance in the subjects analysis (t1 (20) = 2.021, p = .057), and it was significant in the items analysis (t2 (19) = 2.433, $p < .05$). In the case of the penultima of '-ono' verbs, the difference was significant in the subjects analysis (t1 (20) = 2.196, $p < .05$), and marginally significant in the items analysis (t2 (19) = 1.869, p =

.077). Finally, at the suffix, the difference was significant in both the subjects and items analyses (t1 (20) = 4.895, p < 0.001; t2 (19) = -2.674, p = .015).

Further t-tests were conducted to investigate the two transliteration types separately. For the phonological transliteration, there was a significant difference between the stem and the penultima of '-ono' verbs in the subjects analysis (t1 (20) = 3.244, p < .01; t2 (19) = 1.369, ns), and between the stem and the suffix in the subject analysis (t1 (20) = -2.788, p < .05; t2 (19) = 1.526, ns). For the visual/orthographic transliteration, all differences were significant (stem *vs* penultima of '-ono' verbs: t1 (20) = 3.548, p < .01; t2 (19) = 2.692, p < .05; stem *vs* suffix: t1 (20) = 8.964, p < .001; t2 (19) = 5.622, p < .001; penultima of '-ono' verbs *vs* suffix: t1 (20) = 9.152, p < .001; t2 (19)= 3.569, p < .01).

Word recognition vs written production: To investigate the relation between the subjects' word-recognition and written production, we divided the participants in two groups based on the results from their written production: those who preferred the orthographic and those who preferred the visual/phonological transliteration (there were 9 participants with preference for phonological and 10 for visual/orthographic transliteration). The phonological group's RTs are displayed in Figure 2, and the RTs of the visual/orthographic group are shown in Figure 3 below.

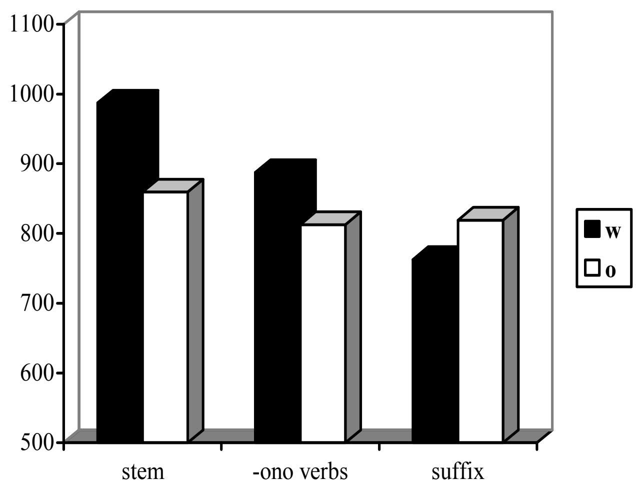

Figure 2. Mean RTs of the phonological group

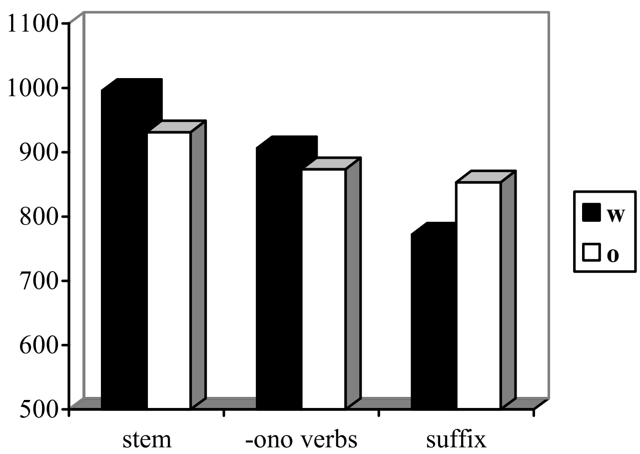

Figure 3. Mean RTs orthographic group

A repeated measures ANOVA with the between factor Group (phonological, orthographic) and within factors Transliteration Type (w, o) and Position (stem, penultima of '-ono' verbs, suffix) showed a main effect of Position ($F(2, 16) = 23.425$, $p < .001$) and an interaction between Transliteration Type x Position ($F(2, 16) = 12.884$, $p < .001$). There was no significant effect of Group ($p > .1$) and no significant interactions between Transliteration Type x Group ($p > .1$) and Position x Group ($p > .1$). Thus, although the two groups showed a clear preference for one of the two transliteration patterns in their written production, they did not show any differences in word-recognition.

5. Discussion

This study looked at word-recognition of verbs involving the letter omega in Greek and Greeklish, and tested four hypotheses based on the ODH and previous research in word-recognition. In addition, a sample of the subjects' written production in Greeklish was analysed to examine the relationship between word-recognition and written production.

First, we found that Greek is processed faster than Greeklish independent of the transliteration pattern and the position of omega within the words. Similar to Tseliga's (2004) study, successful processing and recognition of Greeklish overall seems to require more time than when the words are written with Greek characters. Furthermore, the Greeklish block elicited more errors than the block with Greek characters, reflecting that Greeklish is harder to recognise/read than Greek. This shows an overall prevalence of the first-learned alphabet (Greek) over the use of a non-native alphabet (Latin).

Second, although Greek has a shallow orthography, it seems that both the phonological and the visual/orthographic route are involved in word-recognition of Greeklish. This is consistent with previous findings by Chitiri & Willows (1994, 1997) and Tseliga (2004), and suggests a weak version of the ODH. When the target character was in the stem of the verb, RTs were faster for the phonological transliteration, whereas the opposite pattern was attested when the target character was in the suffix. This shows that phonological properties are more salient when omega is in the stem, whereas visual/orthographic ones are more salient when it is in the suffix of verbs.

Inflectional morphology seems to impact on word-recognition of Greek and Greeklish. In the Greek block, words were recognised faster when the target character was in the suffix as opposed to the stem. This complies with Chitiri & Willows' (1994, 1997) results. Moreover, in the Greeklish block, RTs to the visual/orthographic transliteration were shorter than to phonological transliteration when omega was on the suffix. This effect was also evident in the accuracy data, as the number of errors was higher for the phonological transliteration than for the visual/orthographic transliteration. Thus, it seems that the syntactic features encoded in the letter omega in the suffix of verbs (Person and Number) facilitate word-recognition. An alternative interpretation could be that the effect attested in the verb suffix is due to the high frequency of the letter omega at the end of Greek verbs. However, if this effect was attributed only to frequency, we would expect to find a similar effect at the penultima of '-ono' verbs, as omega is also very frequent in this position. This hypothesis was not confirmed by the data. In this position, similar to words with omega in the stem, RTs were shorter for the phonological transliterated words than for the visual/orthographic ones. This suggests that inflectional morphology has a greater impact on the word-recognition of Greeklish than frequency.

Finally, it seems that the participants' preferences for one of the two transliteration patterns, as evidenced in their written production, do not affect the way they process Greeklish on-line, as both groups followed the same pattern in word-recognition.

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