

# A Phonetically Natural vs. Native Language Pattern: An Experimental Study of Velar Palatalization in Serbian\*

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*Abstract:* Two experiments test the naturalness hypothesis of velar palatalization. This hypothesis, based on surveys of various languages with velar palatalization, states that if a language has palatalization before [e], then it will have palatalization before [i], but not necessarily vice versa. Serbian is a *prima facie* counterexample to this generalization in certain morphosyntactic contexts, including the present-tense paradigm examined in this paper. In this context, Serbian palatalizes a velar stop [k] to a palatoalveolar affricate [tʃ] before [e] but not before [i]. Two experiments are conducted to test whether Serbian-speaking children and adults generalize from the existing pattern of palatalization before [e] to the natural pattern of palatalization before both mid and high vowels. The results from the first experiment show that children conform to the phonetically natural pattern but adults do not. These results suggest that speakers must be exposed to the pattern that “violates” the phonetically natural one for a substantial period of time before overwriting the phonetically natural pattern. The results from the second experiment, artificial pattern learning, show that the type of task *and* the type of palatalization (before [i] or [e]) play a crucial role, while age does not. These findings strengthen the hypothesis that subjects are more likely to choose a phonetically natural form presented to them than to volunteer it.

## 1. Introduction

This paper reports on experiments designed to test the naturalness of velar palatalization in different contexts. Typological surveys of various languages with velar palatalization (Bhat 1978, Guion 1994, 1998, Bateman 2011) reveal the same pattern: if a language has pala-

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talization before [e], then it has palatalization before [i], but not necessarily vice versa. Although Serbian generally adheres to this principle, which I call (following Wilson 2006) the *naturalness hypothesis*, it does however present a counterexample to this typological generalization in certain morphosyntactic contexts: the present-tense verbal paradigm in particular. Serbian has what will be referred to as a native language pattern of velar palatalization in present tense: a velar stop [k] palatalizes to a palatoalveolar affricate [tʃ] before the mid-front vowel [e] but not before the high-front vowel [i].<sup>1</sup> Because this paper focuses on speakers of a language that violates the generalization that the palatalization of velars before mid vowels implies palatalization before high vowels only in a specific morphosyntactic context, my results cannot be taken to predict the behavior of speakers whose languages violate the naturalness hypothesis across the board (although to my knowledge no such languages are reported). However, the results do raise interesting questions with respect to mental grammars and how they are adjusted after exposure to unnatural patterns. At the same time, the results suggest that the phonetically natural pattern is still present in the grammars of Serbian native speakers who use (and sometimes favor) this pattern if asked to generalize outside their native language data.

The change of velars to palatoalveolars before front vowels and the palatal glide is commonly called the First Slavic Palatalization (Mrazović and Vukadinović 1990, Schenker 1993, Guion 1994). There is, however, another type of velar palatalization: the Second Slavic Palatalization (*ibid.*). This sound change affects velars in that they change to dental affricates before front vowels ([k] becomes [tʃ], for instance). The two Slavic palatalizations are two separate phenomena. They differ not only in the outcomes of the change that the velars undergo ([tʃ] vs. [tʂ]) but also in the front vowels that trigger the change. The front vowels involved in the Second Slavic Palatalization but not the First Slavic Palatalization are the result of monophthongization (they came from the Proto-Slavic diphthongs [ai] and [oi]). Also, the two

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<sup>1</sup> Two other velars ([g] and [x]) also undergo palatalization in the same context but they are not discussed in the paper. This was done to avoid additional complexity in the experiments; for instance, the differences in frequency of the verb stems with final [k], [g], or [x] and the number of experimental items, which would triple if the experiments were to include all three velars.

Slavic palatalizations took place at different times.<sup>2</sup> This paper focuses on one instance of the First Slavic Palatalization type: palatalization of the voiceless velar stop [k] to the palatoalveolar affricate [tʃ] before mid- and high-front vowels [e] and [i] in the present-tense verbal paradigm in Serbian.

Two computer-based experiments were conducted to test whether Serbian-speaking children and adults would generalize from the existing native language pattern (palatalization before mid vowels) to the presumed phonetically natural pattern (palatalization before both mid and high vowels). One of the experiments was set in a native-language context and tested whether the native language pattern of palatalization before [e] but not before [i] applies only to existing verbs in Serbian or whether the process is extended to new verbs as well—that is, whether velars in new verbs are palatalized before high-front vowels, in addition to mid-front vowels. Thus, this experiment was designed to determine if the native language pattern is a productive pattern, and if it is, whether it is “stronger” than the phonetically natural one. The second experiment was an artificial pattern learning experiment in which participants first learned a new pattern of velar palatalization and then were asked to generalize from the impoverished input to new contexts. This experiment tested whether Serbian speakers, who have what seems to be the marked pattern in a specific morphosyntactic context in their native language, favor the phonetically natural pattern when asked to generalize from a newly learned pattern to new contexts.

The results from the first experiment show that children largely conform to the phonetically natural pattern, while adults do not. The results from the second experiment show that the type of task together with the type of palatalization (before [i] or [e]) plays a crucial role, while age does not.

The naturalness hypothesis is questioned from two points of view: how *universal* the hypothesis is, given that it does not hold true in Serbian present-tense verbal paradigms; and which pattern emerges in new contexts, the native language pattern or the cross-linguistically natural pattern.

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<sup>2</sup> For a detailed description of the two palatalizations, see Schenker 1993 and Guion 1994, and references therein.

## 2. Background on Velar Palatalization

Palatalization is a very common synchronic alternation across languages. This paper focuses on the palatalization of the voiceless velar stop [k] to the palatoalveolar affricate [tʃ] when it precedes the mid- and high-front vowels [e] and [i]. Voiceless velar palatalization before front vowels is considered to be the most common type of palatalization (Bloomfield 1933: 378, Chen 1973, Bhat 1978, Hock 1991, Guion 1998) and it is widely found, e.g., throughout the Slavic languages (Comrie and Corbett 2003), in some dialects of Italian (Calabrese 1993), in Kinyarwanda (Ladefoged and Maddieson 1996), and in French (Buckley 2003). This common pattern of palatalization before front vowels appears to be phonetically motivated. Velars followed by front vowels have articulatory, acoustic, and perceptual similarities with palatoalveolar affricates. An X-ray study by Keating and Lahiri (1993) showed that velar stops in Czech, Hungarian, English, and Russian are articulated further front on the palate when followed by front vowels than when followed by back vowels and this fronting effect makes the articulation of velar stops and palatoalveolar affricates somewhat similar. The acoustic similarity of fronted velars and palatoalveolar affricates is observed in the peak spectral frequency (Guion 1998).

Typological studies of various languages with velar palatalization have shown that if a language has palatalization before the mid-front vowel [e], it is expected also to have palatalization before the high-front vowel [i], but not necessarily vice versa (originally observed by Ohala 1992). This observation led to postulation of the naturalness hypothesis (Wilson 2006: 950) in (1):

- (1) a. (/ke/ > /tʃe/) ⇒ (/ki/ > /tʃi/)  
 b. (/ki/ > /tʃi/) ⇏ (/ke/ > /tʃe/)

To test the hypothesis that mid-front vowel [e] palatalization is most likely to generalize to high-front vowel [i] palatalization, Wilson (2006) designed an artificial pattern learning experiment involving two groups of participants, all native speakers of American English. One group was exposed exclusively to a pattern of velar palatalization before the high-front vowel [i] and the other group to the pattern of palatalization before the mid-front vowel [e]. After the exposure phase, the participants were tested to determine whether they would

generalize the palatalization to other vowel contexts, the front vowel that they were not exposed to and the back vowel [a]. The results show that the participants generalized palatalization from the mid-front vowel to the high-front vowel much more often than they generalized palatalization before the high-front vowel to the mid-front vowel. The results of Wilson's experiment supported the naturalness hypothesis not only for speakers who have productive velar palatalization in their phonological systems but also for those who do not. The acoustic, articulatory, and perceptual similarities between velars followed by front vowels and palatoalveolar affricates are shown to be phonetically natural.

The question that this paper addresses is: Will Serbian speakers show evidence of knowledge of the phonetically natural pattern when lexical information does not bias them towards the native language pattern? This will be tested under two conditions: (i) new verbs in their native language and (ii) new forms in an artificially learned pattern. Before we turn to the experiments, let us first take a closer look at the existing pattern of velar palatalization in Serbian.

### 3. Velar Palatalization in Serbian

Velar palatalization is a productive morphophonemic alternation in Serbian. It appears in different morphological contexts and its triggering elements vary. In the present-tense verbal paradigm, there is palatalization before [e] but not before [i]. Since palatalization before [i] does not appear in this paradigm, although the naturalness hypothesis would seem to predict it should, the paradigm presents an interesting place to test the hypothesis. However, before we take a closer look at the present-tense verbal paradigm, let us look at velar palatalization before [e] and [i] in Serbian in general.

Voiceless velar palatalization appears before the high-front vowel [i] only in derivational morphology. The following are derivational processes of this kind:

- (2) Voiceless velar palatalization before [i]
- a. derivation of a noun from an adjective (by suffix /-ina/):
 

/jak/	+	/-ina/	→	/jaʃina/
strong <sub>ADJ</sub>		SUFFIX		strength <sub>N</sub>
  - b. derivation of a verb from a noun (by suffix /-iti/):
 

/lek/	+	/-iti/	→	/leʃiti/
drug <sub>N</sub>		SUFFIX		cure <sub>V</sub>
  - c. derivation of a perfective from an imperfective verb:
 

/skakati/	→	/skotʃiti/
jump <sub>V-IMP</sub>		jump <sub>V-PF</sub>
  - d. augmentatives (by suffix /-ina/):
 

/ʃovek/	+	/-ina/	→	/ʃoveʃina/
man		SUFFIX		man <sub>AUG</sub>
  - e. diminutives (by suffixes /-itʃ/ and /-itsa/):
 

/deʃak/	+	/-itʃ/	→	/deʃaʃitʃ/
boy		SUFFIX		boy <sub>DIM</sub>
/slika/	+	/-itsa/	→	/sliʃitsa/
picture		SUFFIX		picture <sub>DIM</sub>
  - f. imperatives:
 

/vik-/	+	/-i/	→	/viʃi/
yell <sub>INF</sub>		SUFFIX		yell <sub>IMP</sub>

Voiceless velar palatalization before the mid-front vowel [e] can be found in both inflectional and derivational morphology:

- (3) Voiceless velar palatalization before [e]
- a. masculine singular vocative inflection (by suffix /-e/):
 

/vojnɨk/	+	/-e/	→	/vojnɨʃe/
soldier <sub>N</sub>		SUFFIX		soldier <sub>VOC</sub>
  - b. derivation of passive participle (by suffix /-en/):
 

/pek-/	+	/-en/	→	/peʃen/
bake <sub>STEM</sub>		SUFFIX		baked

(3) c. derivation of adverbial comparatives (by suffix /-e/):<sup>3</sup>

/jako/	+	/-e/	→	/jaʃe/
strong <sub>POSITIVE</sub>		SUFFIX		strong <sub>COMPARATIVE</sub>

## d. diminutives (by suffix /-e/):

/jastuk/	+	/-e/	→	/jastuʃe/
pillow		SUFFIX		pillow <sub>DIM</sub>

Let us now look at cases when palatalization does not take place in the same phonological environment. Palatalization before the high-front vowel [i] does not appear in the following instances of derivational morphology:

## (4) Failure of voiceless velar palatalization before [i]

## a. derivation of possessives (by suffix /-ina/):

/baka/	+	/-ina/	→	/bakina/
grandma		SUFFIX		grandma <sub>POSS</sub>

## b. derived iteratives:

/vikati/	→	/povikivati/
shout <sub>V-IMP</sub>		shout <sub>V-ITERATIVE</sub>

## c. female nationality (by suffix /-ijna/):

/grk/	+	/-ijna/	→	/grkijna/
Greek <sub>N,M</sub>		SUFFIX		Greek <sub>N,F</sub>

## d. diminutives (by suffixes /-itɕ/ and /-itsa/):

/sok/	+	/-itɕ/	→	/sokitɕ/
juice		SUFFIX		juice <sub>DIM</sub>
/deka/	+	/-itsa/	→	/dekitsa/
grandpa		SUFFIX		grandpa <sub>DIM</sub>

What immediately stands out from these data is that palatalization does not take place consistently before diminutive suffixes beginning in a high-front vowel. The same suffixes in the same phonological

<sup>3</sup> Historically in the derivation of comparatives, palatalization occurred as a result of the coalescence of the velar and the morpheme-initial glide [j]. Synchronically, palatalization looks like it occurs before vowels, e.g., /jak-/ 'strong' → /jaʃ-a/ 'stronger<sub>F.SG</sub>', /jaʃ-i/ 'stronger<sub>M.SG</sub>', /jaʃ-e/ 'stronger<sub>F.PL</sub>'.

environment yield different outcomes, palatalized and non-palatalized. It is also not uncommon to encounter co-existent palatalized and non-palatalized diminutive forms of the same word:

$$\begin{array}{rclcl}
 (5) & /ruka/ & + & /-itsa/ & \rightarrow & /rukitsa/ \\
 & \text{arm} & & \text{SUFFIX} & & /rufitsa/ \\
 & & & & & \text{arm}_{DIM}
 \end{array}$$

Therefore, it could be concluded from the data above that [i] palatalization in Serbian almost exclusively appears in derivational morphology, and is sometimes even optional (diminutives). Interestingly, borrowed words do not undergo palatalization in the context just described:

$$\begin{array}{rclcl}
 (6) & /disk/ & + & /-itʃ/ & \rightarrow & /diskitʃ/ \\
 & \text{disk} & & \text{SUFFIX} & & \text{disk}_{DIM}
 \end{array}$$

Voiceless velar palatalization before the mid-front vowel [e] does not appear in some instances of inflectional morphology:

(7) Failure of voiceless velar palatalization before [e]

a. masculine plural accusative (by suffix /-e/):

$$\begin{array}{rclcl}
 /uʃʎenik/ & + & /-e/ & \rightarrow & /uʃʎenike/ \\
 \text{pupil}_{NOM.SG} & & \text{SUFFIX} & & \text{pupil}_{ACC.PL}
 \end{array}$$

b. feminine plural nominative/accusative (by suffix /-e/):

$$\begin{array}{rclcl}
 /devojka/ & + & /-e/ & \rightarrow & /devojke/ \\
 \text{girl}_{NOM.SG} & & \text{SUFFIX} & & \text{girl}_{NOM/ACC.PL}
 \end{array}$$

c. feminine singular genitive (by suffix /-e/):

$$\begin{array}{rclcl}
 /devojka/ & + & /-e/ & \rightarrow & /devojke/ \\
 \text{girl}_{NOM.SG} & & \text{SUFFIX} & & \text{girl}_{GEN.SG}
 \end{array}$$

Palatalization before the mid-front vowel [e], when compared to palatalization before [i], is more widespread in the sense that it appears in both derivational and inflectional morphology. Furthermore, palatalization of [k] before [e] invariably occurs in derivational morphology. There are no instances of non-palatalized forms. But the differences between the palatalization before [e] and before [i] are par-



ticularly notable in the present-tense verbal paradigm. There are three conjugation classes, indicated by present-tense theme vowels [i], [e], or [a] followed by person and number suffixes:

- (8) a. /tʃek-/ + /-am/ → /tʃekam/  
       wait<sub>V-STEM</sub> SUFFIX<sub>PRES.1SG</sub> 'I wait'
- b. /plak-/ + /-em/ → /plakʃem/  
       cry<sub>V-STEM</sub> SUFFIX<sub>PRES.1SG</sub> 'I cry'
- c. /zrik-/ + /-im/ → /zrikim/  
       squint<sub>V-STEM</sub> SUFFIX<sub>PRES.1SG</sub> 'I squint'

As (8b) illustrates, it is only stem-final velar [k] verbs with the initial mid-front vowel [e] theme vowel that palatalization targets. Historically, in this class of verbs palatalization occurred as a result of coalescence of the velar and the inflectional morpheme-initial glide [j], but synchronically, palatalization appears to occur before the vowel [e]. Native speakers of course do not have historical knowledge but rather rely on the pattern that they see in the language at present, i.e., palatalization takes place before [e] in (8b) but not [i] in (8c).

Verbs taking the present-tense theme vowel [a] are the greatest in number. Verbs taking [e] constitute a smaller set and the ones taking [i] even smaller. In fact, the latter are restricted to “baby-talk” verbs (Comrie and Corbett 2003). Put differently, there is a frequency difference among the verb classes that are to be tested in the study.

The theme vowels [i], [e], and [a] are the initial vowels of inflectional suffixes. There are also derivational suffixes with initial [i] and [e] which could trigger velar palatalization (as in (2b), for instance). In these cases the root of the verb already contains a palatoalveolar affricate as a result of palatalization triggered by the vowel-initial derivational suffix. As such, these verbs do not present candidates to test the triggers of palatalization with inflectional suffixes and are not further discussed. The focus of the study is on verbs with stem final voiceless velar [k] and the interaction (palatalization or not) between the velar and the theme vowel of the inflectional suffix.

The table below shows the conjugation of two verbs taking the [e]-initial suffix and one verb taking the [i]-initial suffix. The two verbs taking the [e] initial suffix have a different infinitive form. In both the voiceless velar [k] undergoes palatalization. The important difference

between the two for the purposes of this study is that the verb with the /-tʃi/ infinitive suffix does not have the voiceless velar in its infinitive form, e.g., /petʃi/, whereas the /-ti/ infinitive verb does, e.g., /skakati/. It is assumed that Serbian speakers have to know the stem form of the /-tʃi/ verbs where the voiceless velar surfaces, e.g., /pek-/, in order to be able to use the verb in the present tense.<sup>4</sup> This is important for the design of the first experiment because the verbs are introduced in their infinitive form and then used in the present tense. In order for participants to know that there is a voiceless velar, the /-ti/ infinitive verbs are used.

		[k] + [e] → [tʃe]		[k] + [i] → [ki]
		/petʃi/ 'to bake'	/skakati/ 'to jump'	/sikiti/ 'to suckle'
SG	1st	petʃem	skatʃem	sikim
	2nd	petʃeʃ	skatʃeʃ	sikiʃ
	3rd	petʃe	skatʃe	siki
PL	1st	petʃemo	skatʃemo	sikimo
	2nd	petʃete	skatʃete	sikite
	3rd	peku	skatʃu <sup>5</sup>	sike <sup>6</sup>

#### 4. Experiment 1: Testing the Native Language Pattern in New Words

This experiment tested whether Serbian native-speaker children and adults would generalize from the existing pattern of palatalization before mid-front vowels to the natural pattern of palatalization before

<sup>4</sup> I am adopting the Jakobsonian one-stem system, according to which every verb has a full stem, which is taken to be an “alternant which appears in a position where the other alternant too would be admissible” (Jakobson 1971: 120). In our case, the basic alternant for the verb with an infinitive form /petʃi/ is /pek-/.

<sup>5</sup> The third person plural may be regarded as a case of paradigm leveling. It was therefore not tested in this study, but presents a candidate for a future study. It would be interesting to see whether [ku]–[ʃu] alternation extends to new verbs in Serbian since the alternation is highly morphologized and not phonetically driven.

<sup>6</sup> There is no palatalization before the third plural suffix [e]. This is an example of paradigm leveling.

both mid- and high-front vowels when learning new words. Because the native language pattern is so common in the present-tense verbal paradigm of many verbs, this paradigm was used in the experiment. As already mentioned, there are three conjugation classes, indicated by present-tense theme vowels [i], [e], or [a] followed by person and number suffixes. The suffixes provide a full set of potentially palatalization-triggering elements, which include both front vowel as well as back vowel environments. Further, and more important for the purposes of this study, palatalization appears before [e] but not before [i], contrary to the predictions of the naturalness hypothesis. This distribution of palatalization raises important questions: (i) Is the native language pattern a learned pattern that overwrites the phonetically natural one? (ii) Is it a productive pattern, i.e., does its application extend to new verbs. These questions are addressed in the first experiment.

The verbs were introduced in the infinitive form and participants were asked to choose from three possible present-tense forms of the verb the “correct” one. At the beginning of the experiment, the participants were explicitly told that they would learn new verbs in Serbian, to make sure that the participants knew the experiment was about their native language. I tested which phonological patterns would apply to new words: the pattern present in their native language or the phonetically natural pattern, which learners should be predisposed to (Wilson 2006).

#### 4.1. Stimuli

The stimuli were possible but nonexistent verbs of the form  $C_1VC_2$  followed by the Serbian infinitive suffix [ati], as in [hakati]. The first consonant ( $C_1$ ) came from the set of Serbian consonants [ b v g d ~~ʒ~~ z j k l  $\lambda$  m n  $\eta$  p r s t ~~ʦ~~ f x ~~ʦ~~ ~~ʃ~~ ~~ʒ~~ ~~ʃ~~ ]. The vowel (V) was drawn from the set of Serbian vowels [ a e i o u ]. The second consonant ( $C_2$ ) came from the set [ b d k l m  $\eta$  p f ].<sup>7</sup> This set of consonants was used because the consonants in the set, except [k], rarely undergo any sound change in

<sup>7</sup> As pointed out by an anonymous reviewer, this set could have contained the [d] voiceless counterpart, i.e., [t]. The same reviewer also wondered why nasal [n] was not included in this set. It was not included to avoid additional morphological complexity due to the numerous verbs that take the verbal suffix *-nu-*, as in *brinuti* ‘to worry’.

the present-tense verbal paradigm in Serbian. In fact, some of these consonants do undergo sound changes when followed by an [e]-initial suffix, but they do not if the suffix begins with [a] or [i]. Only three of the consonants from the set above, namely [ b m ɲ ], appeared with the [e]-initial suffix. The labials [b m] have two possible outcomes: (i) no change, as in /grebati/ 'to scratch' → /grebe/ 'scratch<sub>3SG</sub>' and /razumeti/ 'to understand' → /razume/ 'understand<sub>3SG</sub>', and (ii) change, as in /zobati/ 'to peck' → /zobǎe/ 'peck<sub>3SG</sub>' and /xramati/ 'to limp' → /xramǎe/ 'limp<sub>3SG</sub>'. The experiment was set up in such a way that the participants were forced to choose one of the provided forms which did not contain tokens that underwent [b] → [bǎ] or [m] → [mǎ]. This was done in order to avoid the introduction of additional sound changes and to focus on testing only velar palatalization. The nasal palatal [ɲ] does not undergo any change. The critical items were the ones where C<sub>2</sub> was [k], such as [sukati]. The items where C<sub>2</sub> was drawn from the rest of the set, that is [ b d l m ɲ p f ], were fillers, as in [dipati].

Nonexistent verbs were introduced in the infinitive form. The participants were presented with pictures of boys or girls performing an action.<sup>8</sup> Each of the pictures introduced a new verb. Once presented with a new verb, the participants were asked to choose one of three provided present-tense forms by giving a verbal response to the experimenter. The choice for the critical items always included: (i) a palatalized form, where the velar [k] followed by the mid- or high-front vowel was palatalized, e.g., [xatʃe] for the infinitive [xakati]; (ii) a non-palatalized form, where the velar [k] followed by the mid- or high-front vowel was not changed, e.g., [xake]; and (iii) a control case, where the velar [k] underwent an unattested change, e.g., [xaǎe].<sup>9, 10</sup>

<sup>8</sup> The pictures were taken from the website [www.clipart.com](http://www.clipart.com).

<sup>9</sup> An anonymous reviewer pointed out that giving only three possible answers might skew the results. The choice of three possible answers was motivated by my wanting to test if palatalization would take place, hence a palatalized and a non-palatalized form. The third answer was introduced to control for random choice, signaling that the participant was not following any phonological pattern. If instances of other sound changes were given as possible answers, like the Second Slavic Palatalization (as suggested by the reviewer), I would be testing a pattern that does not exist in the language, since the Second Slavic Palatalization does not take place in the present-tense verbal paradigm. It is true that the participants might have been making com-

The first two forms—palatalized and non-palatalized—were critical for the experiment. The third one—the random consonant change—was used to test the possibility that the participants simply wanted to choose a form that is randomly different from the given one.

The fillers, such as [dipati], always included three forms: (i) no change, as in [dipe]; (ii) C<sub>2</sub> undergoing a possible sound change<sup>11</sup> but not one specifically found in this environment in Serbian (such as voicing, as in [dibe]); and (iii) C<sub>2</sub> undergoing an unattested random change, as in [dixe]. The fillers controlled for random phonological changes and a systematic application of velar palatalization only. In other words, they were indicators of whether (i) the participants simply wanted to choose a different form from the initial one, following no phonological rule (a random phonological change); (ii) they applied some phonological change (velar palatalization or any other occurring phonological change); or (iii) they systematically applied the phonological pattern of velar palatalization and thus did not change the fillers since they were not subject to velar palatalization.

The experiment consisted of 40 nonce verbs, all of which were introduced in the infinitive and tested in the third person singular. There were 30 verbs in which C<sub>2</sub> was [k] and 10 in which C<sub>2</sub> was taken from the filler set [ b d l m n p f ]. Of the 30 verbs, 10 had the [a]-initial suffix, another 10 the [e]-initial suffix and, another 10 the [i]-initial suffix. Of the 10 fillers, three had the [a]-initial suffix, four the [e]-initial suffix, and three the [i]-initial suffix. The critical items and fillers were randomized, and the three types of choices appeared in random order.

The suffix environments [i] and [e] were critical, since Serbian does not palatalize before the [i]-initial present-tense inflectional suffix, whereas we find palatalized alternations before the [e]-initial present-tense suffix. Such a pattern contradicts the naturalness hypothesis. The back vowel [a] was included in the experiment as a control case, since this vowel does not trigger velar palatalization.

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pletely different generalizations if given attested alternations in the wrong environment. These cases are candidates for a follow-up study.

<sup>10</sup> In [xakati] the use of [e] in the suffix was forced. The three suffix initial vowels—[i], [e], and [a]—were evenly distributed among the stimuli.

<sup>11</sup> Possible sound changes are ones that exist in the phonological system of some languages. Unattested sound changes are changes that are not attested in any language.

The alphabet used in the experiment was Serbian Cyrillic, which is phonetic. This was done because the experiment involved reading the stimuli and it included children between seven and nine years of age. At this age, the children learn their first alphabet, Cyrillic, at school. This was done to avoid potential mistakes in presenting the stimuli, especially among children, since they were reading the stimuli themselves.

#### **4.2. Participants**

Fifteen children and fifteen adult L1 speakers of Serbian participated in the experiment. There were eight female and seven male children and eleven female and four male adults. All of the participants were residents of Novi Sad. The age of the children ranged from seven to nine and the adults from 25 to 69. The participants were not paid. The experiment was anonymous; the only personal information obtained was the participants' gender and date of birth.

#### **4.3. Procedure**

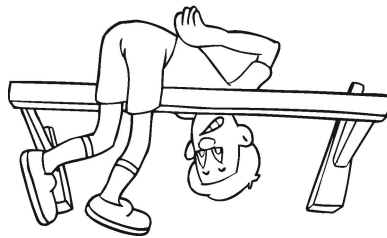
During the experiment participants were seated in front of a laptop computer and stimuli were presented to them on the computer screen using Microsoft PowerPoint. There was no time limit for the experiment; the participants moved to the next slide whenever they felt ready to do so. At the beginning of the experiment, they were given instructions. The first few slides of the presentation stated that they were about to learn some new verbs in their native language. In order to make sure that the participants fully understood the task, they were given an example in the instruction section in which an existing Serbian verb, which does not undergo velar palatalization, was used.<sup>12</sup> This way the participants were not biased to use velar palatalization. The participants were further told that the new verbs were going to be presented to them in the following way: first, a picture of a boy or a girl performing an action would be presented. Beneath the picture, a new verb would be written in capital letters. The verb was used in a

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<sup>12</sup>The participants were given only one example of the existing verb in Serbian. The example illustrated that the verb given in the infinitive form needs to be put in the present-tense form. It was assumed that no further practice items were needed.

simple sentence describing what the boy or the girl would be doing the next day. For instance, see example (9) below. The future tense was used because it involves the infinitive. The same form of a sentence was used for all the stimuli. As mentioned earlier, after the participants were introduced to a new verb, they were asked to choose among three possible present-tense forms. In the instruction section, it was explicitly said that only one verb form could be chosen.

(9)



Дечак ће сутра ХАКАТИ.  
 [detʃak tɕe sutra xakati]  
 boy AUX tomorrow ХАКАТИ

‘The boy will ХАКАТИ tomorrow.’

The present-tense form was forced by a *when* clause, as in (10). The sentence used in all of the stimuli states that a girl or a boy is happy when she or he performs an action described by the newly introduced verb.

(10) Дечак је срећан кад  
 [detʃak je sretɕan kad]  
 boy AUX happy when  
 a. ХАКЕ                      б. ХАЧЕ                      в. ХАЉЕ<sup>13</sup>  
    [xake]                      [xatɕe]                      [xalje]

‘The boy is happy when he...’

When the participants decided which form they found “correct,” they spoke the chosen form to the experimenter, who wrote down their choice. This was done in order to facilitate automatic responses for

<sup>13</sup> An example including the [i]-initial suffix would be: [nokati] → [noki], [nofi], [nobi].

both age groups (children and adults). After the participants uttered the chosen verb form, they clicked on the space button on the laptop and moved to the next slide, which presented them with a new verb.

#### 4.4. Results

The results reveal differences between the two age groups. The adults unanimously chose forms with palatalization before the mid vowel (100%) but much less frequently before the high vowel (22%).<sup>14</sup> There was only one instance of palatalization before the back vowel (0.7%). The fillers were rarely changed, only 3.4%. The table below summarizes these results.

**Table 1.** Experiment 1: Results for Adults

	[ki] (10) <sup>15</sup>	[ke] (10)	[ka] (10)	filler (10)
palatalized <sup>16</sup>	22%	100%	0.7%	0%
non-palatalized	78%	0%	99.3%	96.6%
other	0%	0%	0%	3.4%

The adults never applied a random sound change to the velar [k]. Although the fillers were generally not changed, the change in fillers was more likely to appear before the mid-front vowel (4 out of 5 items) than the low back vowel (1 out of 5 items).

The children, on the other hand, largely chose forms with palatalization before both mid (98%) and high-front vowels (90%). The results are summarized in Table 2 below.

<sup>14</sup> The percentage refers to the total number of response tokens in the group.

<sup>15</sup> The number in the brackets is the number of items.

<sup>16</sup> I use the terms “palatalized” and “non-palatalized” for both critical items and fillers in order to be consistent. However, the terms do not mean the same thing. Since fillers did not contain [k], they were not able to undergo palatalization at all. Thus, “palatalized” for fillers means “changed” and “non-palatalized” means “not changed.” For instance, a filler [kipati] had three possible outcomes: (i) changed [kiba] (possible sound change—voicing), (ii) not-changed [kipa], and (iii) other [kiṭsa] (impossible sound change).



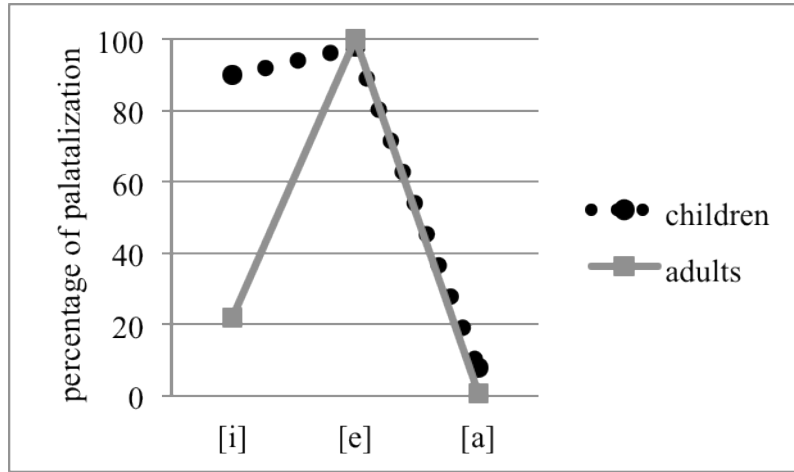
**Table 2.** Experiment 1: Results for Children

	[ki] (10)	[ke] (10)	[ka] (10)	filler (10)
palatalized	90%	98%	8%	0%
non-palatalized	9.3%	0%	82.7%	46.6%
other	0.7%	2%	9.3%	53.4%

As opposed to the adults, the children did apply a random sound change to both critical items and fillers. The critical items underwent these changes infrequently: for the high-front vowel following the velar [k] there were only 0.7% such responses, 2% for the mid-front vowel, and 9.3% for the back vowel. These percentages are small and as such do not affect the overall tendency observed. The children failed to palatalize the velar before the high-front vowel [i] only 9.3% of the time. Furthermore, they infrequently palatalized before the back vowel [a], 8% of the time. Such results show that velar palatalization was systematically applied and there was a strong tendency towards the phonetically natural pattern.

As for the fillers, a random sound change did occur in the majority of responses, 53.4%, whereas no change occurred 46.6% of the time. The forms that were changed occurred 46.25% of the time before [e], 28.75% before [i], and 25% before [a]. This result was not predicted, but it is relevant to observe that even a random sound change largely occurred before [e].

For the cases where participants from both age groups palatalized the velar stop [k], I conducted a by-subject ANOVA with the vowel ([i], [e], [a]) as a within-subject factor and with age (adults vs. children) as a between-subject factor. I found two significant effects, an age effect ( $F(1,29)=70.349$ ,  $p<.0001$ ), which suggests that the children and the adults differ in their responses. The interaction among the vowels also shows a significant effect ( $F(2,28)=521.316$ ,  $p<.0001$ ). The high-front vowel [i] responses differ from both mid-front [e] and back vowel [a]; the mid-front [e] responses differ from both high-front and back; and the back vowel [a] responses differ from the high and mid-front vowel responses. The differences are found in both age groups. These facts are summarized in Figure 1 below.



**Figure 1.** Comparison of Responses Obtained from Adults and Children in Experiment 1 for Critical Items

Figure 1 shows the interaction of age and vowel contexts. The gray solid line represents responses of the adult group and the black dotted line represents responses of the children to the critical items. The x-axis shows three different vowel contexts ([i], [e], and [a]) and the y-axis presents percentages of palatalized responses (1–100%). We can see that the two age groups do not differ in the mid-front vowel context [e], both groups palatalizing. Similarly, the groups do not differ in the back vowel context [a], neither group palatalizing. The crucial difference is shown in the high-front vowel context [i], where the children largely palatalized the velar (above 80%) and the adults did not (around 20%).

For the cases where participants from both age groups chose a non-existent (random) consonant change for the critical items, I conducted a by-subject ANOVA with the vowel ([i], [e], [a]) as a within-subject factor and with age (adults vs. children) as a between-subject factor. No significant effect was found, which suggests that the children and the adults show no significant difference in choosing the non-existent consonant change form. The age ( $F(1,29)=2.554$ ,  $p=.121$ ) and vowel ( $F(2,28)=1.581$ ,  $p=.224$ ) effects for both age groups found to be insignificant.

The results from this experiment clearly show that there is a difference between the two age groups,<sup>17</sup> i.e., age plays a crucial role in applying the native language pattern in the present-tense verbal paradigm in Serbian. The adults favor the native language pattern (invariant palatalization before [e] and infrequent before [i]) while the children favor the phonetically natural pattern (palatalization largely applied before both [e] and [i]). This finding is not surprising given the difference in the amount of exposure to the native language pattern between the two age groups. Interestingly, neither children nor adults chose the non-palatalized form of the velar before the mid-front vowel, [ke]. This finding suggests that palatalization before the mid-front vowel is strong in their native language and never fails to apply to new words.

To sum up, the experiment showed that the adults failed to generalize the phonetically natural pattern, whereas the children did generalize it, despite their native language pattern.

### **5. Experiment 2: Testing the Native Language Pattern in a Language Game**

The second experiment was an artificial pattern learning experiment. It was designed to test whether the naturalness hypothesis holds for L1 Serbian-speaking children and adults in a newly learned pattern, i.e., whether the speakers would generalize to other vowel contexts from an impoverished input. The question was would they generalize from the existing native language pattern of palatalization before mid-front vowels to the phonetically natural pattern of palatalization before both mid and high-front vowels, or would they conform to the native pattern of palatalization only before mid-front vowels.

The second experiment consisted of three parts: exposure, break, and a test phase. In the exposure phase the participants were presented with written pairs of nonce verbs introduced by pictures of boys and girls (either one or three) performing various actions. The verb in the first picture indicated an action performed by only one actor (singular) and the verb in the second picture indicated the same

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<sup>17</sup> The experiment reports on two different age groups (children and adults), and this represents, as one reviewer points out, differences in length of exposure to native patterns of palatalization.

action performed by three actors (plural). The plural was formed by adding one of the nonce suffixes, [ita], [eta], or [ata]. This morphological rule of adding these nonce plural suffixes was not revealed to the participants. Further, the suffix-initial vowel [i], [e], or [a] mapped to the gender of the people performing an action. The high-front vowel [i] was used for female, the mid-front [e] for male, and the back [a] for a mix of both male and female. Again, the participants were not told about the mapping of the suffix-initial vowel to the gender of the actors. The morphological process of suffixation triggering palatalization was chosen in order to resemble the existing process in Serbian of palatalization before the present-tense suffix [e]. However, in this experiment, the suffix did not denote tense, but number and gender agreement. A morphological process of this particular kind does not exist in Serbian. It is for this reason that it was chosen for the experiment; i.e., there should not be any interference with existing morphological processes. At the same time, the native language morphological process and the made-up one both involve verbal inflection.

The new words described actions and as such could easily be understood as verbs. The purpose of this was to make participants operate on the same morphological level. In other words, the native language pattern appears among verbs in Serbian, so the idea was that the participants might rely on that pattern if they were asked to deal with the same lexical category.

There were two condition groups in the exposure phase of the second experiment: high-front [i] and mid-front [e]. The participants in the high-front condition group were presented with examples such as [jukita] ... [juʃita] and the participants in the mid-front condition group were presented with examples such as [loketa] ... [loʃeta]. Importantly, the participants in the high-front condition group were not presented with examples in which the velar [k] appeared before the mid-front [e]. Similarly, the participants in the mid-front condition group were not presented with any examples in which the velar [k] appeared before the high-front [i]. All of the examples presented to each of the two condition groups, which contained the stem-final velar [k], also contained the palatalized alternate.

In the test phase of the experiment, both condition groups were presented with examples in which the velar [k] appeared in all three vowel contexts. Therefore, in the second part of the experiment, the participants were presented with the vowel context that conditioned

palatalization in the first part of the experiment ([e] for the mid-front and [i] for the high-front condition groups) and also with the vowel contexts that did not appear in the first part of the experiment ([i, a] for the mid-front and [e, a] for the high-front condition groups). The vowel context that the groups were exposed to in the first part of the experiment will be referred to as the “exposure” context, and the new vowel contexts that appear in the second part of the experiment will be referred to as the “novel” context. The participants were deliberately not informed whether velar palatalization should apply in the novel contexts, forcing them to form their own generalizations.

### 5.1. Stimuli

The stimuli were pairs of nonce words, where the first word was of the form  $C_1VC_2$ , and the second one was of the same form followed by one of the three nonce suffixes: [ita], [eta], or [ata]. Both forms of the nonce words ( $C_1VC_2$  and  $C_1VC_2$  followed by one of the suffixes) are possible consonant-vowel combinations in Serbian; thus, they are possible real word candidates.

The first consonant ( $C_1$ ) came from the set of Serbian consonants [ b v g d ʤ z j k l λ m n ɲ p r s t ʦ f x ʦ ʃ ʧ ʃ ]. The vowel (V) was drawn from the existing set of Serbian vowels [ a e i o u ]. The second consonant ( $C_2$ ) came from the set [ b v ʤ z j k l λ m n p r t ʦ f ʧ ʃ ]. This set was randomly chosen from the existing set of Serbian consonants, excluding all the velars but [k]. The items where  $C_2$  was [k], such as [nuk], were the critical ones. The items where  $C_2$  was drawn from the rest of the set, e.g., [sadʤ], were fillers.

There were two types of tasks in this experiment: gap and choice. In the gap task, the participants were asked to fill in the gap with whatever they thought was the correct response, i.e., their responses were not restricted to a set of provided answers. In the choice task, they were given three forms and were directed to choose the one they considered to be correct. The choice for the critical items always included: (i) a palatalized form, where the velar [k] followed by the mid or high-front vowel was palatalized, as in [noʃeta]; (ii) a non-palatalized form, where the velar [k] followed by the mid or high-front vowel was not changed, as in [noketa]; and (iii) a control case, where the velar [k] underwent an unattested change, as in [nofeta]. The first two forms—palatalized and non-palatalized—were critical for the experi-

ment, while the third one—the random consonant change—was a control. The former served to test whether the participants would apply palatalization to the velar [k] followed by different vowels in the case of suffixation or not. The latter was used to signal that the participants were not applying an attested phonological change but rather choosing a random form.

The choice for the fillers (for instance [veleta]) always included three forms: (i) a form with no change, such as [veleta]; (ii) a changed form, where C<sub>2</sub> underwent a possible phonological change which does not occur in Serbian (for instance, the change of [l] into [r]), as in [vereta]; and (iii) a randomly changed form, where C<sub>2</sub> underwent an unattested consonant change, as in [veđeta]. The fillers controlled for random sound changes and for phonological changes that the participants were not exposed to in the first part of the experiment. They tested whether the participants just wanted to choose a form that was different from the given or a different form following some particular sound change rule (velar palatalization or any other phonological change) or they systematically applied only the phonological pattern of velar palatalization and did not change the fillers (since they were not subject to velar palatalization).

The exposure phase consisted of 40 nonce words. There were 20 words in which C<sub>2</sub> was [k] and 20 in which C<sub>2</sub> was taken from the filler set [ b v đ ž ʒ j l λ m ŋ p r t ʈ ʂ f ɟ ʃ ]. The group that was exposed to the high-front vowel [i] palatalization encountered 20 words with [k] followed by the [i]-initial suffix and 20 fillers followed by the [i]-initial suffix. The mid-front vowel [e] palatalization group was exposed to 20 words where [k] was followed by the [e]-initial suffix and 20 words where fillers were followed by the [e]-initial suffix. In the exposure phase both groups were presented with just one vowel context, either [i] or [e].

The test phase included 40 nonce words as well. There were 30 words with the velar [k] as C<sub>2</sub> and 10 fillers. Out of 30 words with the velar [k] as C<sub>2</sub>, 10 had a suffix [ita], 10 [eta], and 10 [ata]. The fillers all had the same suffix that they appeared with in the exposure phase. Thus, for the [i] condition group, in the test phase, all of the fillers had the suffix [ita], and for the [e] condition group, all of the fillers had the suffix [eta]. In both exposure and test phases, the critical items and fillers were randomized. The same was done with the three choices in the choice task.

The two vowel contexts [i] and [e] were the critical factors, while the back vowel [a] was included in the experiment as a control. The naturalness hypothesis states that if there is palatalization before [e] then palatalization before [i] is asymmetrically implied. However, there should be no generalization to palatalization before the back vowel [a] from the front vowel contexts.

## 5.2. Participants

Fifteen children and fifteen adult L1 speakers of Serbian participated in the high-front vowel condition group. There were six female and nine male children and thirteen female and two male adults. The age of the children ranged from seven to nine and of the adults from 21 to 64. In the mid-front vowel condition group, there were 15 children and 15 adult L1 speakers of Serbian: seven female and eight male children and twelve female and three male adults. The age of the children ranged from seven to nine and of the adults from 21 to 63. All participants were residents Novi Sad and none were paid. The experiment was anonymous; the only personal information obtained was the participants' gender and the date of birth. Participants in experiment 2 were different from the participants in experiment 1.

## 5.3. Procedure

The first part of the experiment was an exposure phase. In this phase the participants were seated in front of a laptop computer and stimuli were presented to them using Microsoft PowerPoint. At the very beginning of the exposure phase, the participants were given instructions. It was explained that they were about to learn a new language game. They were told that in order to play the game they first needed to learn the rules. Once they had seen the rules (the exposure phase), they moved on to the actual game (the test phase).

Learning the rules of the game actually meant exposing the participants to a velar palatalization pattern triggered by suffixation marking gender and number agreement. The participants were first shown a picture of a boy or a girl performing an action. Underneath the picture a nonce word was written in capital letters. For instance:

(11)



ЖОК  
[ʒok]

The next slide presented three boys or girls performing the exact same action. Underneath that picture, the following sentences were written: “I say X” ... “You say X” (where X stands for a nonce word). The participants were asked to repeat out loud the second nonce word, i.e., the one that appeared after “You say”.<sup>18</sup> The idea behind this was to expose the participants to suffixation marking gender and number agreement, which triggers palatalization of the voiceless velar [k]. This was the rule of the language game that the participants were supposed to observe and then apply by analogy in the test phase. All of the picture pairs involved first a picture of a single actor performing an action (singular) and then a picture of three actors performing the exact same action (plural). The suffix appeared on the verb in the plural instances only. All of the pictures in the [e] condition group were pictures of boys ([eta] mapped to male gender), whereas all of the pictures in the [i] condition group were pictures of girls ([ita] mapped to female gender).

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<sup>18</sup> The method used in the experiment is a replication of the Wilson study. The pairs “I say...” – “You say...” are used to indicate the experimenter (I) and a participant (You). The experiment is set up in such a way that an experimenter first pronounces a new word (“I say...”) and the participant is asked (“You say...”) to give a spoken response (change the stem of the word or not).



(12)



Ja kažem ŽOKETA.	Ти кажеш ŽOČETA. <sup>19</sup>
[ja kaʒem zoketa]	[ti kaʒeʃ zoʧeta]
I say	you say

After the exposure phase (consisting of 40 nonce verbs), the participants were given a short break. During the break, they were asked to answer 10 questions that were considered relatively easy relative to the participants' age. The questions were typed on a piece of paper and the participants wrote down their answers. The questions for children were taken from the children's magazine *Malac Radoznanac* designed for children seven to nine years of age. The questions for adults were taken from the quiz *Ko želi da postane milioner* 'Who wants to become a millionaire'. There were two types of tasks in the break phase, which mapped to the type of the task in the test phase. When the participants were about to do a gap task in the test phase, they were given a gap task in the break phase as well; likewise, when they were about to do a choice task in the test phase, a choice task was given to them in the break phase. In order to be consistent with the test phase, the participants were given a choice of three possible answers in the break phase as well. The break-phase questions in the two types of tasks were different. The purpose of the break phase was to keep the participants mentally occupied so that they did not dwell on the data provided in the exposure phase. Once the participants finished answering the questions, they turned in their answers to the experimenter.

The break phase was followed by a test phase. The same participants did both types of tasks with the same stimuli in both exposure and test phase on two different occasions. The gap task was performed

<sup>19</sup> An example for the [i] condition group would be [ja kaʒem zokita] ~ [ti kaʒeʃ zoʧita].

first. It was followed by a choice task a few days later. The order in which the two types of tasks were performed was such so that the potential bias from the choice task (which included given answers) would be avoided. The same stimuli were used in both types of tasks in order for the results to reflect the influence of the tasks only and not the stimuli. There was a break for a few days between the two types of tasks and this was done so that the participants would forget the stimuli to which they had been exposed.

In the gap task, the participants were asked to fill in the gap in “You say X” with whatever they felt to be correct. For instance:

- (13) Ja кажем ЖОКЕТА.      Ти кажеш ...  
       [ja kazem zoketa]      [ti kazeʃ]  
       I say                      you say

They were asked to say their responses out loud and the experimenter wrote down the responses. As in the first experiment, this was done to facilitate automatic responses.

In the choice task, the participants were given three forms out of which they were supposed to pick out only one they considered correct:

- (14) Ja кажем ЖОКЕТА.      Ти кажеш  
       [ja kazem zoketa]      [ti kazeʃ]  
       I say                      you say  
       a. ЖОКЕТА      б. ЖОЧЕТА      в. ЖОТЕТА  
       [zoketa]      [zotʃeta]      [zoteta]

When the participants decided which form they found correct, they told their choice to the experimenter, who wrote it down. After the participants uttered the chosen form, they clicked on the space button on the laptop to move to the next slide.

#### 5.4. Results

There were slight differences in the results obtained from the two age groups, but overall children and adults behaved very similarly. The results reveal differences in behavior between the two condition groups in that the groups exposed to [i] palatalization very infre-

quently generalized palatalization to the mid-front vowel [e] in both types of tasks (which confirms the naturalness hypothesis). However, the groups exposed to [e] palatalization behaved differently depending on the type of the task. The participants did not generalize palatalization to the high-front vowel [i] in the gap task (contradicting the naturalness hypothesis), whereas they did in the choice task (confirming the naturalness hypothesis).

#### 5.4.1. Gap Task: Adults and Children

The adults' responses from both condition groups in the gap task are summarized in Table 3 below. The vowel contexts are labeled as [ki], [ke], and [ka] and the group exposed to the high-front vowel is labeled [i]-group and the one exposed to the mid-front vowel is labeled [e]-group. The children generally exhibited the same behavior as the adults. Their responses are summarized in Table 4.

**Table 3.** Experiment 2: Responses of Adults in Gap Task

	[ki] (10)		[ke] (10)		[ka] (10)		filler (10)	
	[i]-group	[e]-group	[i]-group	[e]-group	[i]-group	[e]-group	[i]-group	[e]-group
palatalized	98.6%	4.7%	5.3%	97.3%	3.3%	0.7%	0%	0%
non-palatalized	1.4%	95.3%	89.4%	2%	92%	98%	100%	99.3%
other	0%	0%	5.3%	0.7%	4.7%	1.3%	0%	0.7%

**Table 4.** Experiment 2: Responses of Children in Gap Task

	[ki] (10)		[ke] (10)		[ka] (10)		filler (10)	
	[i]-group	[e]-group	[i]-group	[e]-group	[i]-group	[e]-group	[i]-group	[e]-group
palatalized	98%	2.7%	8%	72%	2.8%	1.4%	0%	0%
non-palatalized	2%	81.3%	86.6%	19.3%	88.6%	77.3%	90%	85.3%
other	0%	16%	5.4%	8.7%	8.6%	21.3%	10%	14.7%

Overall, the results of the [i]-condition groups confirm the naturalness hypothesis; i.e., the participants palatalized before [i] but did not

generalize palatalization to the [e] context. However, the results obtained from the [e]-condition groups do not support the naturalness hypothesis. The participants applied palatalization before [e] but failed to generalize palatalization to the [i] context. The results of each of the condition groups are discussed in detail below.

#### 5.4.1.1. Adults and Children Exposed to [i]

The adults and children in the high-front exposure condition applied palatalization to the voiceless velar stop before [i] consistently in the gap task: 98.6% and 98% of the time, respectively. No other sound change except velar palatalization occurred as a response.

In the novel context, before the mid-front vowel [e], a significant number of responses included the non-palatalized form: 89.4% for adults and 86.6% for children. The palatalized responses occurred rarely: 5.3% of the time for adults and 8% for children. The small number of such responses does not interfere with the overall implications of the results. A large percentage of non-palatalized responses clearly indicates that [i] palatalization was not generalized to [e]. The small percentage of palatalized and random sound change responses (5.3% for adults and 5.4% for children) is considered noise.

Palatalization was also not generalized to the back vowel [a]. Palatalized responses occurred 3.3% of the time for adults and 2.8% of the time for children, while the random sound change occurred 4.7% of the time and 8.6% of the time, respectively.

As for the fillers, they were never changed for adults, whereas children applied random sound change 10% of the time. Again, the great majority of responses that were not changed tell us that both age groups (adults and children) systematically followed the phonological process of velar palatalization as the only sound change.

#### 5.4.1.2. Adults and Children Exposed to [e]

For the adults exposed to the [e] palatalization condition, the great majority of responses before the mid-front vowel [e] were palatalized (97.3%), a very small number were not palatalized (2%), and one instance exhibited a random sound change.

The children exposed to [e] palatalization largely chose the palatalized form in the mid vowel context (72%). The non-palatalized re-

sponse appeared 19.3% of the time, and a random sound change 8.7%. It can be concluded then that both adults and children followed the palatalization pattern well and applied it accordingly in the test phase.

The results obtained in the high-front vowel context are extremely interesting. The adults failed to generalize palatalization from the mid to the high-front vowel context to a large extent. Only 4.7% of the responses were palatalized. Children behaved very similarly and palatalized only 2.7% of the time. They did, however, apply a random sound change 16% of the time. Even though there is some noise among these results, they suggest that the children failed to generalize palatalization to the high-front vowel in the gap task.

Furthermore, palatalization was not generalized to the back vowel [a], where it applied only 0.7% of the time for adults and 1.4% of the time for children. Random sound change responses rarely occurred (1.3%) for adults. However, it is worth noting here that 21.3% of the time (marked as "random" in Table 4), the children did not use the suffix presented to them, for instance [ati], but rather used the suffix that they learned in the exposure phase, for instance [eti]. All taken into consideration, both adults and children did not generalize palatalization to the back vowel [a].

The fillers were not changed for adults (99.3%). The children tended not to change them as well (85.3%). Random sound change appeared once for adults and 14.7% of the time for children. The children's responses present some noise, but overall the results obtained from both age groups indicate that the participants systematically applied only one phonological change, velar palatalization, and therefore they generally did not change the fillers.

To sum up, the two condition groups (both children and adults) in the gap task differ in their responses for the mid and high-front vowel contexts. The [i] group did not generalize palatalization to the mid-front vowel [e] and the [e] group did not generalize to the high-front vowel [i]. In other words, both of the condition groups applied the pattern that they were exposed to but failed to generalize the pattern to the novel vowel contexts. The high-front [i] exposure group conformed to the naturalness hypothesis and did not generalize to the mid vowel [e]. However, the mid-front [e] exposure group conformed to the native language pattern and did not generalize palatalization from the mid to the high-front vowel, contrary to the naturalness hypothesis.

As mentioned earlier, the results from the choice task differ in that overall they support the naturalness hypothesis; i.e., both condition groups (high and mid-front vowel) behaved in accordance with the predictions of the naturalness hypothesis: the groups exposed to [i] palatalization generally did not extend the pattern to [e], whereas the groups exposed to [e] generalized palatalization to [i]. These results are presented in the following section.

#### 5.4.2. Choice Task: Adults and Children

The choice task involved the exact same stimuli as the gap task. The difference between the two types of tasks is the following: the participants were given three possible answers in the choice task but no choices were provided in the gap task. Hence, the choice task biased the participants and restricted their responses. For this reason, the choice task was carried out a few days after the gap task with the exact same participants. The results obtained from both condition groups in the choice task support the naturalness hypothesis: the participants generalized from the mid to the high-front vowel context and they did not do so from the high to the mid-front vowel context.

Let us now look at the results obtained from both age groups (adults and children) in both conditions (mid and high-front) in the choice task. Table 5 below summarizes results obtained from adults and Table 6 from children.

**Table 5.** Experiment 2: Responses of Adults in Choice Task

	[ki] (10)		[ke] (10)		[ka] (10)		filler (10)	
	[i]-group	[e]-group	[i]-group	[e]-group	[i]-group	[e]-group	[i]-group	[e]-group
palatalized	100%	96%	11.3%	100%	2.8%	8%	0%	0%
non-palatalized	0%	4%	88%	0%	96.6%	92%	96%	96.6%
other	0%	0%	0.7%	0%	0.6%	0%	4%	3.4%

**Table 6.** Experiment 2: Responses of Children in Choice Task

	[ki] (10)		[ke] (10)		[ka] (10)		filler (10)	
	[i]-group	[e]-group	[i]-group	[e]-group	[i]-group	[e]-group	[i]-group	[e]-group
palatalized	98%	80%	17.3%	100%	4.7%	4.7%	0%	0%
non-palatalized	0.6%	20%	80%	0%	87.3%	94%	84.6%	84%
other	1.4%	0%	2.7%	0%	8%	1.3%	15.4%	16%

The results of each of the condition groups are discussed below.

#### 5.4.2.1. Adults and Children Exposed to [i]

The adults exposed to [i] palatalization invariantly applied palatalization in the high-front vowel context in the choice task (100%). The children showed very similar behavior: they palatalized in the high-front vowel context 98% of the time. This strongly suggests that the pattern to which the participants were exposed was mastered and applied (almost) perfectly.

The mid-front vowel context yielded mostly non-palatalized responses (88% for adults and 80% for children). Palatalized responses occurred 11.3% of the time for adults and 17.3% of the time for children. These responses will be considered noise since statistical analysis (presented below) shows that there is no significant effect. The overall generalization is that the participants did not generalize palatalization from the high to the mid-front vowel.

Also, palatalization was not generalized to the back vowel [a]. Non-palatalized responses occurred 96.6% of the time for adults and 87.3% of the time for children. Palatalized responses were rare (2.8% for adults and 4.7% for children). Random sound change responses were also infrequent (0.6% and 8% of the time for adults and children, respectively). Thus, it could be concluded that the participants did not generalize palatalization from the high-front vowel to the low back vowel.

The adults rarely changed the fillers, only 4% of the time, whereas children changed them 15.4% of the time. The much greater majority of non-changed responses tells us that both adults and children gener-

ally did not apply random sound changes to the fillers and were systematically applying only velar palatalization.

#### 5.4.2.2. Adults and Children Exposed to [e]

Both adults and children exposed to [e] palatalization invariably applied palatalization in the mid-front vowel context (100%). Interestingly, both age groups largely generalized palatalization to the high-front vowel (96% for adults and 80% for children). The non-palatalized form was chosen only 4% of the time among adults and 20% of the time among children. A random sound change was never a response in either age group.

Palatalization was not generalized to the back vowel [a]; palatalization applied only 4.7% of the time for adults and 8% of the time for children. The adults chose a random sound change 1.3% of the time, whereas there were no random sound change responses among children.

The fillers were mostly not changed among adults (96.6%). The children had a tendency not to change the fillers (84%) but there was some noise (16%).

To sum up, in the choice task both the children and the adults exposed to [i] failed to generalize to the mid-front vowel, and both age groups exposed to [e] palatalization generalized the pattern to the high-front vowel [i], conforming to the phonetically natural pattern. Therefore, both condition groups in the choice task behaved as the naturalness hypothesis predicts: the high-front condition group did not generalize to the mid-front vowel context and the mid-front condition group did generalize to the high-front vowel context.

For the cases where the participants palatalized [k], I conducted a by-subject ANOVA with the vowel ([i], [e], [a]) and task (gap, choice) as within-subject factors, and with age (children vs. adults) and exposure ([i] vs. [e]) as between-subject factors. There was no significant difference between the groups as far as age is concerned ( $F(1, 59) = 0.937, p = .337$ ). This shows that both age groups exhibited more or less the same behavior and age did not play any crucial role in this experiment. I found a significant interaction of vowel and exposure effect ( $F(2, 58) = 803.234, p < .0001$ ). The data suggest that when the participants were exposed to [e], they palatalized before [i] or [e] but not be-



fore [a], whereas when the participants were exposed to [i], they palatalized only before [i].

For the cases where the participants chose a random sound change, I conducted a by-subject ANOVA with the vowel ([i], [e], [a]) and task (gap, choice) as within-subject factors, and with age (children vs. adults) and exposure ([i] vs. [e]) as between-subject factors. I found a significant age effect ( $F(1, 59) = 7.335, p = .009$ ). This suggests that the two age groups exhibited different behavior, the children choosing random sound change responses more than the adults. I also found a significant vowel effect ( $F(1, 59) = 11.618, p < .001$ ), which means that different vowels triggered different responses. No significant exposure effect was found ( $F(1, 59) = .293, p = .590$ ). This suggests that both exposure groups behaved more or less the same.

As the results above show, there are no big differences in the critical item responses obtained from the two different age groups. However, there is a huge discrepancy in generalizing the palatalization from the mid to the high-front vowel depending on the type of task. Such a discrepancy is not encountered in generalizing the palatalization from the high to the mid-front vowel. The next subsection compares the results obtained from the gap and choice tasks.

#### 5.4.3. Comparison of Results: Gap and Choice

Tables 7 and 8 below summarize the responses from the mid-front condition groups and the two tasks:

**Table 7.** Experiment 2: Adults Exposed to [e]: Gap and Choice

	[ki] (10)		[ke] (10)		[ka] (10)		filler (10)	
	gap	choice	gap	choice	gap	choice	gap	choice
palatalized	4.7%	96%	97.3%	100%	0.7%	8%	0%	0%
non-palatalized	95.3%	4%	2%	0%	98%	92%	99.3%	96.6%
other	0%	0%	0.7%	0%	1.3%	0%	0.7%	3.4%

**Table 8.** Experiment 2: Children exposed to [e]: Gap and Choice

	[ki] (10)		[ke] (10)		[ka] (10)		filler (10)	
	gap	choice	gap	choice	gap	choice	gap	choice
palatalized	2.7%	80%	72%	100%	1.4%	4.7%	0%	0%
non-palatalized	81.3%	20%	19.3%	0%	77.3%	94%	85.3%	84%
other	16%	0%	8.7%	0%	21.3%	1.3%	14.7%	16%

Both age groups failed to generalize from the mid to the high-front vowel in the gap task, while they did generalize in the choice task. These responses are shown in the first two columns of the Tables 7 and 8. The [i] environment is the most intriguing one, since the responses of the age groups drastically differ in the two tasks. In the gap task, where the participants were asked to produce a form that they thought was a correct one, they did not palatalize before [i]. On the other hand, when the participants were asked to choose one of the provided forms, they chose the ones in which [k] underwent palatalization before [i]. These results raise some interesting questions about the naturalness hypothesis, since it holds in one type of task (choice) and not in the other (gap).

In contrast, both age groups exposed to [i] palatalization in the exposure phase very infrequently generalized palatalization to the mid-front vowel [e] in both types of tasks. This is in accordance with the naturalness hypothesis. The responses of both age groups exposed to [i] palatalization are summarized in Tables 9 and 10 below:

**Table 9.** Experiment 2: Adults Exposed to [i]: Gap and Choice

	[ki] (10)		[ke] (10)		[ka] (10)		filler (10)	
	gap	choice	gap	choice	gap	choice	gap	choice
palatalized	98.6%	100%	5.3%	11.3%	3.3%	2.8%	0%	0%
non-palatalized	1.4%	0%	89.4%	88%	92%	96.6%	100%	96%
other	0%	0%	5.3%	0.7%	4.7%	0.6%	0%	4%

**Table 10.** Experiment 2: Children Exposed to [i]: Gap and Choice

	[ki] (10)		[ke] (10)		[ka] (10)		filler (10)	
	gap	choice	gap	choice	gap	choice	gap	choice
palatalized	98%	98%	8%	17.3%	2.8%	4.7%	0%	0%
non-palatalized	2%	0.6%	86.6%	80%	88.6%	87.3%	90%	84.6%
other	0%	1.4%	5.4%	2.7%	8.6%	8%	10%	15.4%

Contrary to the [e]-exposure groups, the [i]-exposure groups behaved almost identically in both types of tasks (the second two columns of Tables 9 and 10); i.e., the responses to the mid-front vowel environment obtained from the [i] groups in both the gap and choice tasks are both largely non-palatalized.

For the cases where the participants palatalized the velar [k], I conducted a by-subject ANOVA with the vowel ([i], [e], [a]) and task (gap, choice) as within-subject factors, and with age (children vs. adults) and exposure ([i] vs. [e]) as between-subject factors. The interaction of vowel, exposure, and task was significant ( $F(2, 58) = 207.332$ ,  $p < .0001$ ), which means that when the participants were exposed to [e], they palatalized before [i] only in a choice task while they did not in a gap task.

For the cases where the participants chose a random sound change, I conducted a by-subject ANOVA with the vowel ([i], [e], [a]) and task (gap, choice) as within-subject factors, and with age (children vs. adults) and exposure ([i] vs. [e]) as between-subject factors. There was a significant task effect ( $F(1, 59) = 7.373$ ,  $p = .009$ ), which shows that the type of task yielded different responses.

These results suggest that in an artificially learned pattern context, age does not play an important role. Both adults and children exhibited more or less the same behavior. What matters is the vowel that appears in the exposure phase ([i] or [e]) and the type of task (gap or choice) in generalizing the pattern to novel vowel contexts. In the high-front exposure group the type of task did not play a crucial role. The results are in accordance with the naturalness hypothesis: palatalization failed to generalize from the high-front vowel [i] to the mid-front vowel [e]. However, in the mid-front exposure group, the type of task played a crucial role. The gap task yielded responses showing that the native language pattern is favored over the phonetically natural

one (palatalization before [e] fails to generalize to [i]). The choice task, on the other hand, showed that the phonetically natural pattern is favored over the native language one (palatalization before [e] generalizes to [i]).

## 6. Summary and Conclusion

The questions that led to the experiments were the following: (i) Is the native language pattern a learned pattern that overwrites the phonetically natural one? (ii) Is it a productive pattern, i.e., does it apply only to existing verbs in Serbian or does it extend to new verbs as well? and (iii) Does the pattern apply only in a native language context or in artificially learned patterns as well?

The hypothesis in the first experiment was that the children would follow the phonetically natural pattern while the adults would not. The reasoning behind this hypothesis lies in the difference in exposure to the native language pattern. The adults were expected to be biased towards the native language pattern given that they had sufficient exposure to master the grammar of the language, whereas the children were expected to follow the phonetically natural pattern at least to some extent since they had less exposure. The results confirmed the expectations: in general, the children favored the phonetically natural pattern, the adults the native language one. The children, while still in the process of acquiring the native language pattern, do what seems to be most natural to them. Also, the experiment showed that for the adults the native language pattern of palatalization is productive, since it applies to new verbs.

Furthermore, the first experiment highlighted some issues that need further investigation. One of them concerns age and its importance in the acquisition of the native language pattern. The children that participated in this experiment were from seven to nine years of age, which would make them competent speakers of the language, and yet they exhibited a behavior pattern different from the one that exists in the language. One wonders at what critical age or amount of exposure a child acquires the native pattern in favor of the phonetically natural one. Additionally, some responses among adults included the palatalized form before the high-front vowel [i], although they were not numerous (22%). This raises the question of whether adults have a

phonetically natural pattern, albeit not as strong as the native language pattern.

The second experiment tested how biased Serbian-speaking children and adults were towards the native language pattern even after having been taught a new palatalization pattern. Here, in contrast to the first experiment, results did not differ according to age of participants. The relevant factors were the vowels that the participants were exposed to ([i] or [e]) and the two types of task, gap and choice. These factors and their interaction yielded some striking differences in the responses.

The responses obtained from the high-front condition group are exactly what the naturalness hypothesis predicts. Generalization to the mid-front vowel rarely occurred in either age group regardless of the type of task. It is worth noting, though, that once participants were given a choice, more palatalized responses appeared. Such a finding might be explained by assuming that when palatalized forms are presented as an option, they activate similar palatalized forms found in the participants' native language, and therefore are more likely to be chosen. Overall, the [i]-condition group confirmed the naturalness hypothesis and showed that the native language pattern did not interfere with the newly learned pattern.

The mid-front condition group behaved as predicted by the naturalness hypothesis in the choice task but completely unexpectedly in the gap task. The participants generalized palatalization to [i] when they were presented with choices but failed to do so when they were asked to produce the new form. It is important to highlight here that the pattern the participants were taught is one they already have in their language (palatalization before [e] in verbal inflectional morphology). Even though this is a particular morphosyntactic context, it seems to be strong when the same lexical category (verb) and the same type of morphology (inflectional) are at play. This native language pattern "overwrote" the phonetically natural one only in the gap task in the mid-front condition group.

These results are the opposite of what was obtained from the same mid-front condition group in the choice task. Both children and adults favored the phonetically natural pattern when given a choice. These results shed some light on the results of the first experiment. When the adults did the same type of task (choice) in the first experiment, which involved their native language, they favored the native language pat-

tern (no palatalization before [i]). The children, on the other hand, behaved the same in both experiments (palatalization before [i]). It could be the case that the children who participated in the first experiment had not yet acquired the native language pattern and therefore relied on the phonetically natural one. The children from the second experiment did the same. Strikingly, though, when the children were given a gap (no choices provided), they followed the rules of their language specific to verbs and inflectional morphology. Since the first experiment did not include the gap task, it is hard to say whether the children would conform to the native language pattern but it is still possible to hypothesize that they would have based on the results from the second experiment.

On the other hand, the adults seem to have been aware of the language they were operating in. In the first experiment, they largely chose the native language pattern of palatalization (palatalization before [e] and not before [i]). In the second experiment, in the gap task, the adults from the mid condition group followed the native language pattern as well. However, in the choice task, they favored the phonetically natural option (palatalization before both [e] and [i]). While the same explanation as for the children could account for the gap-task results, the choice-task results remain unexplained. Interestingly, though, these results strengthen the assumption (Wilson 2006, Moreton 2008, Hayes, Zuraw, Siptár, and Londe 2009) that subjects are more likely to choose a phonetically natural form presented to them than to volunteer it. That is, once subjects are presented with a choice, the phonetically natural bias wins over the native language one. However, the findings from this experiment call for further research on palatalization and the factors that shape different responses (vowels in the exposure phase, type of task) before a full explanation can be provided.

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