Native Language Suffixation Patterns and Perception of Sequences: A Case of Cantonese Speakers

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Abstract

In the languages of the world, it is more common to form complex words by adding suffixes to the end, rather than prefixes at the beginning. It has been argued that this pattern may reflect the salience of word beginnings (Hawkins and Cutler 1988, Hupp et al. 2009). For example, Hupp et al. (2009) find that English speakers rate sequences of syllables that differ at the end as more similar than those that differ at the beginning. However, subsequent research has shown that people's perceptions of sequence similarity are affected by the word-formation patterns in their native language. While the beginnings of sequences are perceived as more salient by speakers of suffixing languages (e.g., English), the ends are more salient to speakers of prefixing languages (e.g., Kîîtharaka, Martin and Culbertson 2020). Thus, it remains unclear whether *universal* perceptual preferences are linked to the predominance of suffixing in the world's languages. We address this question by investigating perceptual-similarity judgments in speakers of Cantonese – a language with little affixation. We find that, like English speakers, Cantonese speakers perceive the beginnings as more salient, in sequences of shapes and syllables. This finding revives the possibility of a universal perceptual bias, albeit one that can be strengthened or attenuated with language experience.

Keywords: language, suffixing, prefixing, word recognition, psycholinguistics, perception

Introduction

In many languages, complex words can be formed by adding affixes. For instance, the word "happy" can be nominalized by adding the suffix "-ness" and can convey the reverse meaning by adding the prefix "un-". Across languages, in addition suffixes at word ends, and prefixes at word beginnings, infixes can also be added in the middle a word stem. However, a bias towards suffixing has been observed in the world's languages (Dryer, 2013; Greenberg, 1957; Hawkins and Cutler, 1988). In the World Atlas of Language Structures, for example, Dryer (2013) classifies 406 languages as strongly suffixing, 123 as weakly suffixing, 58 as strongly prefixing and 94 as weakly prefixing; infixation is the rarest pattern.

A prominent explanation for this so-called suffixing preference is that word formation processes can be shaped by speech perception. For example, word beginnings have been argued to be more important than the endings for lexical access (Hawkins and Cutler 1988). Along similar lines, it has been proposed that domain-general sequential processing mechanisms may lead people to perceive beginnings as more salient than endings (Hupp, Sloutsky, and Culicover, 2009). For example, Hupp et al. (2009) found that native English speakers perceived a base pair of syllables (e.g., ***ta-te***), music notes and shapes as more similar to a triplet when a new element was appended to the end of the base (e.g., ***ta-te***-*bo*), rather than to the beginning (e.g., *bo*-***ta-te***). They argue that this reflects a universal processing preference which may have driven languages to preferentially use suffixes in word-formation. However, this hypothesis has been challenged by a recent study comparing participants with different language backgrounds. Martin and Culbertson (2020) replicated Hupp et al.'s (2009) study with both English speakers and speakers of Kîîtharaka, a strongly prefixing Bantu language. The two groups of participants made opposite judgments: while English speakers judged sequences differing at the end to be more similar, Kîîtharaka speakers judged sequences that differed at the beginning to be more similar. This suggests that experience with different types of affixations patterns in a person's native language can shape the salience of specific sequence positions.[1] Importantly, as Martin and Culbertson (2020) note, these results call into question whether the suffixing preference in languages is really driven by a universal perceptual preference. Instead, it could be the result of diachronic processes (e.g., as argued by Bybee, Pagliuca & Perkins, 1990; Enrique-Arias, 2002; Himmelmann 2019, and others),

Here, we use the paradigm described above to investigate similarity judgments made by speakers of Cantonese – a language classified as having little affixation (Dryer, 2013). In fact, for Cantonese (as for Mandarin) it is debated whether there is any affixation at all. Analyses which argue for limited affixation patterns have proposed a total of 29 affixes (8 prefixes, 19 suffixes and 2 infixes; Matthews and Yip, 1994). Thus, Cantonese speakers have substantially less experience with affixations patterns (e.g., compared to English, where there is broad agreement that affixation exists, an estimate of

[1] See also Polyanskaya et al. 2024 for potentially related evidence using a different kind of experimental paradigm to investigate speakers of German and Slovak (both suffixing languages).

In D. Barner, N.R. Bramley, A. Ruggeri and C.M. Walker (Eds.), *Proceedings of the 47th Annual Conference of the Cognitive Science Society*

between 82 and 143 distinct affixes; Bauer, L., 1983; Marchand, H., 1960; Minkova, D., and Stockwell, R., 2009). This population therefore allows us to test whether word endings or beginnings are more salient to speakers in the absence of robust experience. If perceptual strategies are purely dependent on this kind of experience, then neither the beginnings nor the ends of sequences should be more salient to Cantonese speakers. If, on the other hand, there is a universal perceptual preference favouring word beginnings, then Cantonese speakers should exhibit similarity judgments similar to English speakers.

Experiment

Here, we replicate the Martin and Culbertson (2020) study, following Hupp et al. (2009), who used sequences of non-words and shapes to probe perceptual similarity judgments. As mentioned above, we focus on Cantonese, a language with approximately 73,800,000 speakers spread around the south of China, including Macau, Hong Kong, most of Guangdong and Hainan province, and the east of Guangxi Zhuang Autonomous Region (Eberhard, Simons and Fennig, 2024). Our participants were recruited from mainland China, specifically, from Dongguan, a prefecture-level industrial city in the central of Guangdong Province, bordering Guangzhou to the north and Shenzhen to the South. We recruited participants aged 50 to 70, who are less likely to have high levels of education or exposure to English compared to younger generations.[2] It is also worth noting that in mainland China, a left-to-right writing system has been mandatory in all publications since January 1st 1956 (Zheng, 2014). Thus, the orthographic order of these participants is the same as for the English and Kîîtharaka speakers tested in previous studies.

Method

Participants 110 Cantonese speakers (aged between 50 and 70) were recruited through local contact. Eighty-four of them reported being native speakers of Cantonese, the remainder were native speakers of other dialects with similar affixation patterns (e.g., Hsiang, Hakka, and Teochew dialect) who acquired Cantonese later in their life. Most of them had some knowledge of English from school, however, only a limited number (n=11) had been exposed to it in other contexts (i.e., work). None of them reported any foreign language experience other than in English. Participants were randomly assigned to the syllables (n=54) or shapes condition (n=56), described below. They were paid 20 RMB for their participation in the syllables condition and 10 RMB for the shapes condition (which took less time to complete).

Materials In both conditions, there were forty trials in total: 25 critical trials (testing our hypothesis) and 15 catch trials (checking whether participants were paying attention and understood the task). Each trial comprised a target stimulus and two test stimuli. Target stimuli consisted of sequences of two nonidentical elements, chosen randomly from the set of syllable stimuli (e.g., ***ta-te***) or shape stimuli (e.g., **circle-square**), depending on the participants' condition. The full stimulus sets are shown in Figure 1. Each target sequence could only appear once within an experimental session. Test stimuli differed depending on the trial type. In critical trials, the test stimuli always involved adding an element to the target sequence either at the start (pre-changed, e.g., *bo*-***ta-te***) or at the end (post-changed, e.g., ***ta-te***-*bo*). In addition to these critical trials, there were five types of catch trials. For three trial types, one of the test sequences was identical to the target and the other 1) differed in all elements from the target, 2) had a new element added to the beginning of the target (pre-changed), or 3) had a new element added to the end of the target (post-changed). For the remaining two types, a sequence that was completely different from the target was paired with either a pre-changed or a post-changed sequence. See Appendix I for all trial types (with syllable stimuli).

Figure 1: Syllable (A) and shape (B) stimuli used in the experiment. Adapted from "Revisiting the Suffixing Preference: Native-Language Affixation Patterns Influence Perception of Sequences" by A. Martin and J. Culbertson, 2020, *Psychological Science*, 31(9), p1109

The syllable and shape stimuli were adapted from Martin and Culbertson (2020). Thirty-seven of the possible syllable sequences were excluded from the stimulus pool due to their

[2] Foreign language education in China was disrupted and severely undermined during the Cultural Revolution (1966-1976) and only started to resurface as an important topic in the development of education system in The National Symposium on Foreign Language Education in 1978 (Wang & Zeng, 2019). Since 1983, foreign languages (such as English, Russian, Japanese, French, German and Spanish) have become a mandatory subject in the University Entrance Examination and thus providing opportunities for the public to encounter a foreign language (General Office of the State Council of the People's Republic of China, 1983).

phonetic similarity to meaningful words in Chinese (considering both Mandarin and Cantonese). See Appendix II for the excluded syllable sequences.

Procedure Participants were informed that they would be asked to judge the similarity of sounds or pictures. After consenting to their participation, two audio check trials were presented to participants regardless of condition. They were asked to listen to audio recordings (i.e., "apple" and "seahorse" in Cantonese) and choose which of two pictures corresponded to the recordings. Instructions for the judgment task were then delivered via Cantonese video clips recorded by the experimenter. Participants were first instructed to perform the task in a quiet environment with a stable network connection. In the syllables condition, further instruction proceeded as follows: "You will hear an audio recording whilst a picture of a grey loudspeaker appears on the screen. This will be our target audio. After that, two grey loudspeakers will appear on screen. These are the options you need to choose from. The first option will be played when one loudspeaker turns green, and the second one will be played when the other loudspeaker turns blue. Choose the option that sounds more similar to the target audio and click on the corresponding loudspeaker. Repeat the steps above until you are directed to the survey." In the shapes condition, the subsequent instructions were: "You will see a sequence of shapes in the middle of the screen. These are the target shapes. You will then see two new sequences of shapes. Choose the one you think is more similar to the target sequence from those two. Repeat the steps above until you are directed to the survey." Two practice trials (randomly chosen from the five types of catch trials) were presented before the experimental trials to ensure participants' understanding of the task.

In the syllables condition, a grey loudspeaker (with the label "target audio" below it) appeared in the middle of the screen and the target syllables were played. After that, two greyed-out loudspeakers appeared on each side of the screen for 1000ms. The left-hand loudspeaker then turned green and the first test sequence was played. After that, the loudspeaker greyed out again for 1000ms, and the loudspeaker on the right turned blue and the second test sequence was played. Both loudspeakers were displayed in colour afterwards, and the participants were instructed to click on the loudspeaker corresponding to the sequence they found more similar to the target ("Please choose the audio that is more similar to the target"). Each trial was concluded by a 500ms interval. The loudspeaker which corresponded to the correct sequence was assigned randomly per trial.

In the shapes condition, a fixation cross was first displayed in the middle of the screen for 500ms, then both elements of the target sequence (with "target shapes" written below) was simultaneously presented (2000ms). After a 250-ms blank, the two test sequences were displayed next to each other horizontally. Participants were instructed to choose the sequence that was more similar to the target ("Please choose the shapes that are more similar to the target"). The position of the correct sequence was assigned randomly per trial.

After the judgment task, participants were asked to fill in a survey which included questions about their age, education level, and language background (their native languages and experience with second languages). They were also asked to report any strategies they used during the experiment and what they thought the purpose of the study was.

Results

Strategies and Purposes Most participants reported no specific strategies used during the experiment (e.g., "Choose the one that is similar", "focus more"). Ten participants from the syllables condition reported their preference towards choosing sequences that shared the same beginning as the target (e.g., "listen to the beginning", "pick the one that is similar at the beginning", "Based on the target, choose the one that has the target sound at the beginning"). These

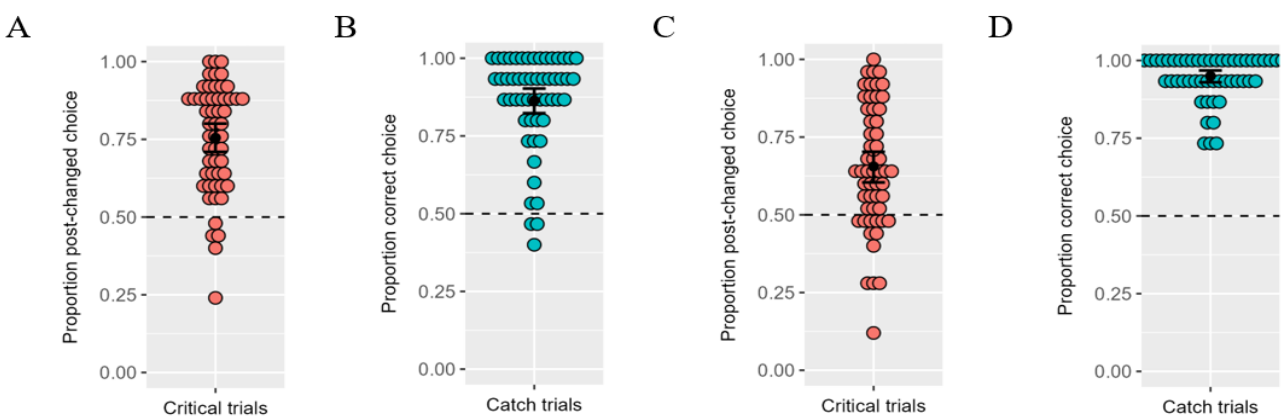

Figure 2: Results of the similarity judgment task from Cantonese speakers in syllables conditions on critical trials (A) and catch trials (B) and in shapes conditions on critical trials (C) and catch trials (D). (A) and (C) shows the proportion of post-changed items chosen on critical trials ("suffixation"), whilst (B) and (D) shows the proportion of correct responses on catch trials. Coloured dots show the means of individual participants. Black dots show by-participant group means. Error bars show the standard error of the group means. The dashed lines represent chance level.

strategy reports help us rule out the influence of unintended alternative strategies. None of the participants was able to discern the purpose of the study (e.g., "testing the ability to distinguish between different sounds", "memory test and judgment test").

Catch Trials Participants' performance on catch and critical trials is summarized in Figure 2. All data reported here were analysed with mixed-effects logistic regression models run in R (Version 4.2.2; R Core Team, 2024) using the lme4 package (Bates, 2010). To investigate whether performance on catch trials was similar and above chance in both conditions, we ran two logistic mixed-effects models: one with an intercept term only, the other included a fixed effect of condition (treatment coded, with the syllables condition as the reference level). Both models included by-participant and by-item random intercepts. Model comparison using likelihood ratio tests (alpha-level set to .05) indicated that including condition improved model fit (χ^2 (1) = 15.002, p < .001). There was a significant positive intercept, indicating that participants' accuracy on catch trials was above chance in the syllables condition (M = 86.4%, SD = 15.5%, β = 2.2683, SE = 0.2759, z = 8.222, p < .001). Additionally, being in the shapes condition (M = 95%, SD = 7.3%) resulted in a 1.1831 increase in the log-odds of the participants choosing the correct answer (SE = 0.3084, z = 3.837, p < .001). In summary, participants in both conditions successfully performed the task, though participants found the shapes condition easier.

Critical Trials To analyse whether participants showed a preference towards choosing pre- or post-changed test items in the critical trials, we ran two logistic mixed-effects models including only a by-participant random intercept (including by-item intercepts led to convergence issues). The first model included only the intercept, the second model included a fixed effect of condition (treatment coded, with the shapes condition as the reference level). Model comparison indicated that condition improved model fit (χ^2 (1) = 7.2663, p < .05). In the shapes condition, participants chose the post-changed items at a rate that was significantly above chance (M = 65.6%, SD = 20.1%, β = 0.7695, SE = 0.1399, z = 5.500, p < .001). Additionally, being in the syllables condition (M = 75.7%, SD = 17.4%) was associated with a 0.5531 increase in the log-odds of the participants choosing the post-changed choice compared to the shapes condition (SE = 0.2017, z = 2.742, p < .05).

As noted above, our participants differed in their educational backgrounds, and in their knowledge of English. In principle, either of these could have affected their behaviour in the task. Most obviously, exposure to or use of English, even as an L2, could have increase their familiarity with suffixes, and therefore altered their similarity judgments in favour of post-changed items. Educational background may correlate with this, but could also independently influence behaviour, for example through an increase in phonological awareness, or by experience with orthography (an issue which we will return to in the discussion). To test whether participants' preference for choosing post-changed items was driven by these factors, we specified another model including fixed effects of condition, participants' education level (five levels: "primary school", "secondary school", "high school", "undergrad", "postgrad"; treatment coded with the "primary school" as the reference level) and their self-rated proficiency of their English skills (a continuous variable scored from 1 to 10). The initial model also included all two-way and three-way interactions between these fixed effects, as well as random by-participant intercepts. This full model did not converge, therefore we simplified it by removing higher order terms: starting with three-way interactions and proceeding with removing two-way interactions. Once the model converged, we used backward selection to remove predictors that were not significant from the model and stopped the removing process once a significant loss of fit was perceived after removing a predictor. All interactions were removed due to convergence issues. Neither the main effect of education level nor the proficiency of English contributed to fit. Therefore, the retaining model included only the intercept term, the fixed effect of condition and the by-participant random intercept. See Appendix III for details of the maximal model that converged. This suggests that neither increased English proficiency nor education level led to an increase in preference for post-changed test items.

Comparison with prior experiments To investigate whether similarity judgments made by Cantonese speakers (who had little affixation) were significantly different from those made by people either from a strongly suffixing (English) or strongly prefixing (Kîîtharaka) language background, we compared our results with the data from English and Kîîtharaka speakers in Martin and Culbertson (2020). Participants' performance on critical trials from the three experiments is summarized in Figure 3. Two mixed-effect logistic regression models on the combined data set were run. The first model contained the intercept only, and the second one contained a fixed effect of language (treatment coded, with Cantonese set as the reference level). Both models included only the by-participant random intercepts, as including the by-item intercepts led to convergence issues. As mentioned above, there was a significant difference between participants' preferences in the syllables and shapes conditions for Cantonese participants. Therefore, we ran the models separately for data from each condition across the three populations.

In both conditions, adding language as a fixed effect improved model fit significantly (syllables: χ^2 (2) = 53.215, p < .001; shapes: χ^2 (2) = 42.385, p < .001). Kîîtharaka speakers chose the post-changed items at a significantly lower rate compared to Cantonese speakers in both the syllables (M: 37.3%, SD: 17.8%, β = -2.0238, SE = 0.2762, z = -7.328, p < .001) and the shapes conditions (M: 37.2%, SD: 25.3%, β = -1.5732, SE = 0.3090, z = -5.091, p < .001). However, English speakers chose the post-changed items in a significantly larger proportion of trials than Cantonese speakers in the shapes condition (M: 76.3%, SD: 28.7%, β = 0.9147, SE: 0.3509, z = 2.607, p < .01) but not in the syllables condition (M: 77.5%, SD: 28.6%, β = 0.3469, SE = 0.3351, z = 1.035, p = 0.301). Analysis scripts for the experiments are available via OSF at https://osf.io/cgh24/.

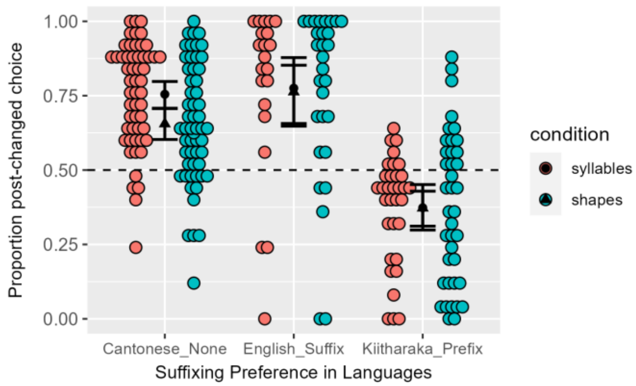

Figure 3: Proportions of post-changed items chosen by Cantonese, English, and Kîîtharaka speakers on critical trials in the syllables and the shapes conditions. The dashed horizontal line indicates chance level. Red dots show individual participant means in the syllables condition and green dots show individual participant means in the shapes condition. Black dots indicate the by-participant group means in the syllables condition, and black triangles indicate the by-participant group means in the shapes condition. Error bars show the standard error of the group means.

Discussion

Following Martin and Culbertson (2020), we conducted a similarity judgment experiment with Cantonese speakers to investigate whether biases in sequence processing are found in participants who have minimal experience with affixation. Results show that Cantonese speakers, like English speakers, judged sequences that differed at their ends to be more similar than sequences that differed at their beginnings in both the syllables and shapes conditions. This points to the possibility that a perceptual bias could underlie the cross-linguistic preference for suffixal affixation. In other words, this opens up the possibility that a default preference for suffixation exists in sequence processing. This preference can be altered by experience with a prefixing language, such as Kîîtharaka, or remain unchanged for speakers of languages with minimal affixation (or with equal prefixing and suffixing).

First, it is worth revisiting whether this effect could be explained by the fact that, although Cantonese has very few affixes, it still exhibits a numerical preference for suffixation. Dryer (2013) analysed the use of ten categories of inflectional affixes across languages and assigned each language an affix index score based on the number of inflectional affix types it employed, with one point awarded per category used, except for three categories which were considered sufficiently important and awarded two points per category (case affixes on nouns, pronominal subject affixes on verbs, and tense-aspect affixes on verbs). Languages with less than 2 points were categorized as having little affixation. Cantonese employs only one type of inflectional affix analysed—tense-aspect affixes on verbs—with suffix being the predominant form (Map 69A in WALS). Additionally, Matthews and Yip, (1994) argue that Cantonese has 19 suffixes, but only 9 prefixes; i.e., twice as many suffixes than prefixes. This might constitute sufficient evidence that related words are grouped based on similarities at the start, or that starts are generally more important or salient. Given that we don't have an independent measure of sensitivity to affixation type, it is difficult to know what to make of this possibility. Future research with other populations, e.g., speakers of languages with even less affixation, or infants with little knowledge of the morphological structure or word formation patterns of their language, would help determine which explanation is more likely.

Understanding exactly how experience with word formation patterns changes perceptual preferences would also benefit from a study more directly aimed at gathering evidence from Cantonese speakers whose experience with English differs. Among our participants, there is a subset who reported being monolingual (n = 37), and an additional subset whose self-rated English proficiency ranged from 1 to 10. We did not find any clear effects of these differences on participants' behaviour. Compared to monolingual participants (the reference group in the GLMM with monolingual status as a fixed effect and by-participant random intercept), non-monolingual participants did not show a significant difference in task performance in either the shapes condition (monolingual: M = 66.2%, SD = 19.1%; non-monolingual: M = 65.4%, SD = 20.6%, β = -0.05206, SE = 0.33319, z = -0.156, p = 0.88) or the syllables condition (monolingual: M = 72%, SD = 19.1%; non-monolingual: M = 78.3%, SD = 15.7%, β = 0.3508, SE = 0.2846, z = 1.233, p = 0.218). However, this may be because of insufficient data across the range.

Our study also found a difference not apparent from previous studies: the salience of beginnings was significantly more pronounced in the syllables condition than the shapes condition for Cantonese speakers. This contrasts with previous studies which found no difference across stimulus types (Hupp et al., 2009; Martin and Culbertson, 2020; cf. Polyanskaya et al. 2024 who found some differences based on stimulus type in a study with a different design). In some respects, a difference between auditory and shape stimuli is perhaps not surprising; if the perceptual preference in shape sequences is the result of transfer from language (e.g., as suggested by Martin and Culbertson), then it would make sense for the latter to be weaker. Moreover, humans are used to perceiving sequential auditory stimuli, which they readily chunk into units. By contrast, there is evidence that shape stimuli are not processed sequentially in the same way (Conway and Christiansen, 2005; Emberson et al, 2011).

However, another possible contributing factor is the unique writing system of Chinese. Most characters in Chinese script are comprised of multiple subcomponents, such as semantic radicals and phonetic radicals, which can be combined either in a left-right (e.g., "任" "仆") or a top-down orientation (e.g., "想" "念"). Radicals have been found to influence the processing of characters on an orthographic level. For instance, meanings of semantic radicals are activated during word processing, even when they do not correspond to the meanings of the whole characters (Wang et al., 2022). Chinese radicals have been divided into 201 forms (Institute of language, Chinese Academy of Social Sciences, 2016). We counted the number of radicals in terms of the position they could be in a character (see Table 1). Note that the functions (semantic or phonetic) or the frequency of the radicals is not taken into consideration here. The flexibility in arrangements of radicals indicated in Table 1 might foster distinct strategies for processing spatial characteristics of visual components (Pae, 2020), potentially differing from those employed by speakers of other languages. This in turn could lead to pre-changed sequences being perceived as more similar in the visual domain for Cantonese speakers than for other participants.

Table 1: Counts of Radicals in Terms of Their Positions.

Positions of Radicals	Number
Can only be around other radicals	18
Can only be inside other radicals	2
Can only be left to other radicals	21
Can only be right to other radicals	9
Can only be on top of other radicals	18
Can only be below other radicals	5
Can be in two different positions	68
Can be in three or more different positions	60
Total	201

Conclusion

To summarise, a perceptual preference towards the beginning of sequences was found among Cantonese speakers, pointing to the possibility of a universal perceptual bias either augmented or diminished by language experience. An alternative explanation to this preference lies on the numerical advantage of suffixes existed in Cantonese. This prompts future research on populations with even less exposure to affixation. Additionally, preference for the beginning was stronger in syllables than in shapes sequences. The potential influence of language experience on strategies for processing different sequences warrants further investigation.

Appendix I

Examples of Each Trial Types in the Experiment

Target	Test Item 1	Test Item 2	Trial Type
bote	mobote	botemo	Critical (pre- vs. postchanged)
bote	bote	jinake	Catch (identical vs. different)
bote	bote	botemo	Catch (identical vs. postchanged)
bote	bote	mobote	Catch (identical vs. prechanged)
bote	botemo	jinake	Catch (postchanged vs. different)
bote	mobote	jinake	Catch (prechanged vs. different)

Appendix II

Deleted Syllable Sequences

bujuyi	butako	butani	janibu	janime
janiya	janiyo	jayu	jejoni	joyiwe
junija	keniya	koji	kojuyo	kotaya
kotayo	mejiju	meyo	meyoni	meyona
meyoya	nabuko	nabume	najobu	najoni
nayiye	nejayo	neweya	nibuko	nijayo
nijuna	nimeyo	tomeya	tomeyo	wetaya
yaju	yemeyo			

Appendix III

Maximal Converging Model for Responses on Critical Trials in both the syllables and the shapes conditions

Predictor	Estimate	SE	Z
Intercept	1.34474	0.79945	1.682
Condition: syllables	0.56243	0.20981	2.681
Education level: secondary	-0.54511	0.82392	-0.662
Education level: high	-0.67189	0.80665	-0.833
Education level: undergrad	-0.47319	0.80175	-0.590
Education level: postgrad	-0.12623	0.93382	-0.135
English proficiency	-0.03857	0.05523	-0.698
Random Effect		**Variance estimate**	
Subjects: Intercept		0.8461	

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