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Does Korean Grapho-Phonemic Systematicity Enhance Spontaneous Learning?

Hana Jee, Monica Tamariz & Richard Schillcock

Abstract. I investigate whether such a systematicity is spontaneously intuited and whether it then enhances learning. During the experiment, the participants had to learn Korean letters by themselves without any instruction. All participants had the opportunity to learn the correct phoneme-grapheme associations and randomly paired, fake phoneme-grapheme associations. It was hypothesised that participants would learn better and faster when the association was the veridical one. However, the performance was not significantly different between the two conditions. The participants repeated less in learning consonants than vowels. Nasals were the easiest consonants to learn. The participants had difficulties in learning vowels when jaw movements were not involved. Those whose first language was Chinese showed comparatively poorer performance in general.

1. Background

Hangeul, the orthography of the Korean language is renowned for the availability of knowledge surrounding its origins. It is also the only orthography that a king himself designed for the illiterate among his people. The 28 letters were completed in 1444, promulgated in 1446 and named *Hunmin Jeongeum*, the Standard Sounds for the Instruction of the People. Until recently, it was believed that King Sejong the Great (reigned 1418–1450) ordered a group of scholars from the Jiphyeonjeon ('Hall of Worthies') to create hangeul, but more and more evidence indicates that it was Sejong who studied the phonology, linguistics, oral

Hana Jee 0000-0001-6248-9786. School of Education, Language and Psychology, York St John University, Lord Mayor's Walk, York YO31 7EX, United Kingdom.
E-mail: h.jee@yorksj.ac.uk
Monica Tamariz 0000-0003-4688-1774. School of Social Sciences, Heriot Watt University, Edinburgh EH14 4AS, United Kingdom.
E-mail: m.tamariz@hw.ac.uk
Richard Shillcock 0000-0002-0616-3703. Informatics Forum, 10 Crichton Street, The University of Edinburgh, Edinburgh EH8 9AB, United Kingdom.
E-mail: r.shillcock@ed.ac.uk

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anatomy, and foreign writing systems to design the letters. The creation of hangeul was an important paradigm shift from logograph to phonograph and from knowledge as privilege to knowledge for equality.

Korean phonemic system is basically alphabetic like English, in which a letter is linked to a phoneme (either consonant or vowel) but specifies phonological features (Sampson, 1985). For example, tensed phonemes are distinguished from tenseless phonemes: /p/ - / p͈ /; /t/ - / t͈ /; and /k/ - / k͈/. Along with the tensed phonemes, Korean consonantal sounds consist of sets of three: lenis, aspirated and tensed. In hangeul, these phoneme sets are visually consistent letters. In general, adding a stroke makes the lenis aspirated (e.g., ㄱ /g/ - ㅋ /k/) and duplicating the letter makes it tensed (e.g., ㄱ /g/ -ㄲ /k͈/). Overall, a set of the phonemes that share an articulation point have visually similar letter-shapes (e.g., ㄱ /g/ - ㅋ /k/ - ㄲ /k͈/).

Meanwhile, the vowels of hangeul reflect the prevalent philosophy of the times. The basic three vowel ㅡ, ㅣ, and ㆍ respectively symbolizes the earth, a person and the heaven. The combination of these three components means the harmony between human beings and the nature. For example, ㅗ /o/ combines ㅡ and ㆍ on the top, and ㅏ /a/ combines ㅣ and ㆍ on its right. Despite its philosophical background, diphthongs are systematically distinguished from monophthongs by an additional stroke (e.g., ㅏ/a/ - ㅑ /ja/).

The systematic relation between hangeul letters and their sounds was recently quantified and defined as 'grapho-phonemic systematicity' (Jee, Tamariz, and Shillcock, 2021; 2022; 2023). The pairwise distances between letters and their corresponding pairwise distances between phonemes were measured by a few computational techniques. As expected, hangeul returned the highest grapho-phonemic systematicity amongst other phonographs such as Arabic, Cyrillic, Greek, English and Hebrew.

The systematic letter-sound relation of hangeul is expected to lead to efficient learning. Inji Jeong (1397–1478), one of the scholars who got involved in the hangeul creation project even mentioned that the clever would learn it in a day and even fools, in ten days (Preface of Hunmin Jeongeum, 1446). The current paper investigates if the systematic letter-sound relation like hanguel is picked up and exploited by new learners and if it indeed leads to faster and easier learning compared to non-systematic letter-sound relations.

We let the participants spontaneously learn the consonants and vowels of hangeul in the two settings: real letter-sound association and fake letter-sound association, and measured their learning processes and reaction times.

2. Experiment

2.1. Participants

11 male and 50 female participants were recruited from the University of Edinburgh. 42 were postgraduates and the rest were undergraduates. Their ages ranged from 18 to 34. All of them were at least bilingual. They were told that they would learn Korean consonants and vowels. After a 40-minute experiment, they were paid £8 each.

2.2. Stimulus

19 Korean consonants and 18 out of 20 vowels were used for the experiment (Table 1). The vowel ㅔ /e/ and ㅖ /je/ were excluded due to the high confusability of the sound with ㅐ /ae/ and ㅒ /jae/, respectively. I included diphthongs to maximise the systematic visual relation among the vowels.

The visual stimuli were designed on PsychoPy (Ver. 3.2.4). Each letter in white sans-serif font (맑은고딕) was displayed on a black background for 6 seconds in random order. At the same time, the corresponding phoneme was also played over headphones. For the consonants, the phoneme was heard in C-C-CV form (e.g., /g-g-ga/) and for the vowels, V-V form (e.g., /ah-ah/)

TABLE 1. The 19 consonants and 18 vowels used for the experiment

Consonants				Vowels			
ㄱ	/g/	ㅊ	/tɕʰ/	ㅏ	/a/	ㅑ	/ia/
ㄴ	/n/	ㅋ	/k/	ㅐ	/ɛ/	ㅒ	/iɛ/
ㄷ	/d/	ㅌ	/t/	ㅓ	/ʌ/	ㅕ	/iʌ/
ㄹ	/l/	ㅍ	/p/	ㅗ	/o/	ㅛ	/io/
ㅁ	/m/	ㅎ	/h/	ㅜ	/u/	ㅠ	/iu/
ㅂ	/b/	ㄲ	/k*/	ㅚ	/ø/	ㅘ	/oa/
ㅅ	/s/	ㄸ	/t*/	ㅟ	/y/	ㅝ	/wʌ/
ㅇ	/ŋ/	ㅃ	/p*/	ㅡ	/ɯ/	ㅢ	/ɯi/
ㅈ	/tɕ/	ㅆ	/s*/	ㅣ	/i/	ㅙ	/oɛ/
		ㅉ	/tɕ*/				

2.3. Experiment Design

A mixed design was employed. Because the consonant-vowel distinction in Korean orthography is widely recognized as a clear source of systematicity, I focused on the potential effects of orthographic systematicity within the consonants and within the vowels. Half participants learned correct consonants and fake vowels, the other half learned fake consonants and correct vowels. The correct set of letters was always presented first. There was a 3 to 5-minute break between the two sessions. 29 participants learned correct consonants and the randomly associated vowels and 32 learned the correct vowels and the randomly associated consonants.

For the fake condition, the letter stimuli were displayed with the wrong sounds. The participants did not know that they were learning the wrong association at that moment. They had a short lesson to debrief them after the experiment. A 5-minute post-experimental interview was also conducted to investigate the learning strategies they used.

2.4. Procedure

The experiment consisted of a few training phases followed by the test phase. During the training, each letter-sound pair was exposed twice in random order. After the training, the participants took the test with 9 letters only. The letters were displayed altogether, and the participants were required to click the appropriate letter according to the sound played. Letters could be chosen multiple times.

If they failed to score 70%, they had to go back to the training, which repeated a maximum of 4 times. Thus, if a participant failed to pass the test 4 times in a row, the experiment went directly to the final test. During the final test, all the letters (19 consonants or 18 vowels) were displayed altogether, and the participants were required to click the correct letter according to the sound. Letters could be chosen multiple times. In both tests, participants' reaction times as well as answers were recorded.

3. Results

Did the naïve learners learn the Korean alphabet better with the correct letter-sound association? I predicted a difference in performance between the correct association and the random association. However, participants were able to learn letter-sound associations, regardless of condition. The proportion of correct answers and the mean reaction times were not significantly different between the two groups (Fig. 1), confirmed by a Mann-Whitney U test ($U = 356$, $p = .16$ for consonants; $U = 405$, $p = .40$ for vowels). Performance in learning consonants ($M = 61.98$, $SD = 16.20$) was slightly better than vowels ($M = 58.26$, $SD = 12.96$), but the difference was not significant ($U = 402$, $p = .39$).

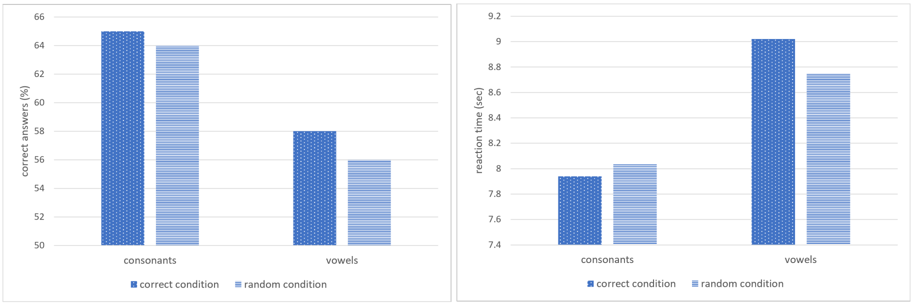

FIGURE 1. The percentage of correct answers (left) and reaction time (right). $SD = 16.20$ (correct consonants); $SD = 16.44$ (random consonants); $SD = 12.96$ (correct vowels); $SD = 17.12$ (random vowels)

Fig. 2 shows the number of tests the participants repeated in each condition. They generally needed more training to learn random letter-sound association, but the difference was not statistically significant ($U = 7$, $p = .44$). Rather, the difference was found between learning consonants and vowels ($U = 2$, $p = .04$). Compared to vowels, the consonants required less training, as shown by the number of tests taken. During the interview, many participants mentioned that the consonants were easier to learn, regardless of the condition.

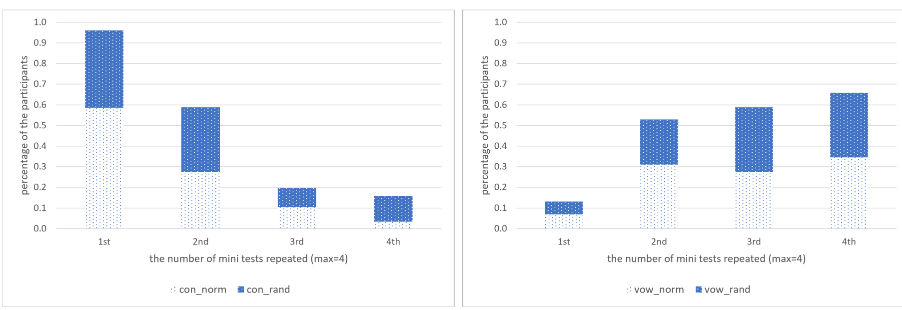

FIGURE 2. The number of the tests the participants repeated for consonants (left) and vowels (right): Many participants passed the first test when learning consonants but had to repeat multiple times for vowels.

The reaction time during the test phase was inversely proportional to the scores (Fig. 3). Taking longer time did not enhance decisions. It rather indicated incomplete learning. This implies that the letter-sound association requires an instant, intuitive judgement rather than thoughtful, comprehensive reasoning skills.

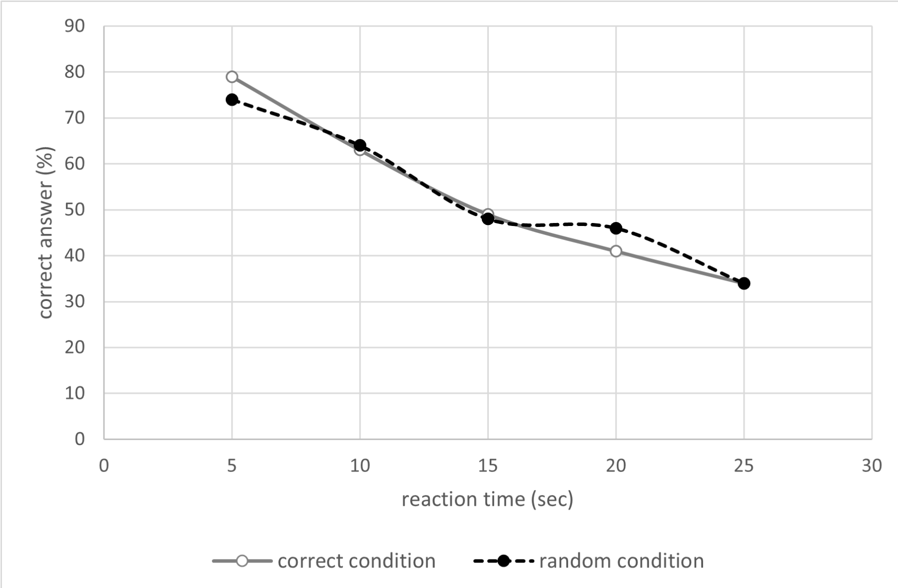

FIGURE 3. Relation between score and reaction time

The easiest consonants to learn were nasals (Fig. 4): they were considered 'special' letters according to the post-interview. When asked about their learning strategies, the participants often answered they began with those nasals and extended from them. In contrast, the most difficult consonants to learn were those for tensed phonemes mainly due to the difficulties in distinguishing sounds. One participant said that she eventually managed to notice the difference between lenis and tensed sounds, but it was too late. This implies that such a fine distinction among Korean phoneme sets requires substantial time to be accustomed to.

Fig. 4 also shows that those vowels accompanied by opening jaw were better learnt than the vowels with closed-jaw. The participants had difficulties in understanding the phonemic boundaries of back vowels (e.g., ㅜ /u/ and ㅡ /ɯ/). Lack of visual information presented such as lip shapes can be a reason for the failure in distinction between ㅗ /o/ and ㅜ /u/. In fact, these vowels were confusable even for a native when heard in the identical setting.

Meanwhile, the participants readily noticed the combination rules for Korean diphthongs. One participant pointed out that ㅚ /ø/ does not sound /oi/ as it is supposed to. According to the general diphthong rule—where basic monophthongs compose diphthongs with their original sounds intact—she was right.

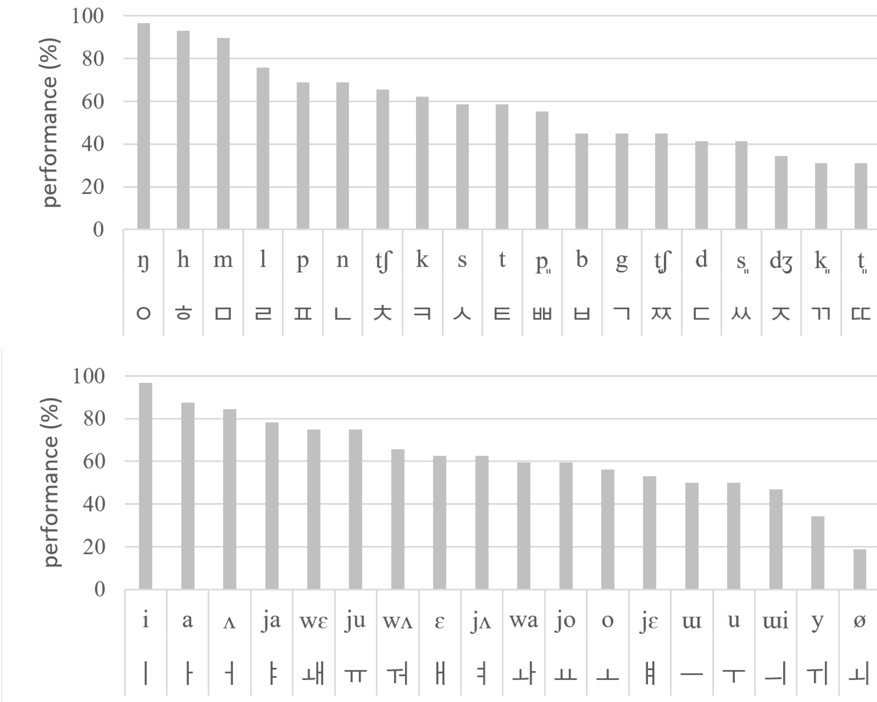

FIGURE 4. The fulfilment of each letter based on the final test

In terms of learning strategies, the participants in general showed very active attitudes. They tended to apply a strategy and if it failed, applied another. Partly due to the experiment design, where they were exposed to the veridical grapheme-phoneme association first, the participants expected and looked for systematicity in the random (fake) condition, too. They explicitly tried to find a pattern, even when there was no pattern to find.

The interview also demonstrated that participants tended to exploit existing knowledge. Most of the participants strategically associated the stimuli with sounds or characters they already knew. For example, they connected Japanese 口 /ku/ with ㅁ /m/, ancient letter H /ae/ with ㅐ, Greek Λ /l/ or Chinese 人 /ren/ with ㅅ, and Cyrillic Г with ㄱ. Sometimes conflicting knowledge helped: Chinese 口 sounded different from Korean ㅁ; Greek Π /p/ sounded the same as ㅈ but looked different (in the random condition); and ㅌ should sound like /e/ as in the participant's name, but sounded different.

Some participants generated particular *meanings*. For example, letter ㅍ /p/ reminded a participant of 'prison' or 'papa who always uses stairs'.

Some others used the vocabulary from their first language to memorize associations. Interestingly, in most cases, this lexical association was related to family: mom, dad, aunt, and even sister-in-law. The vowels were frequently connected to the sound 'yes' in different languages: French /wi/, German /ja/ and Swedish /jʌ/.

Meanwhile, a large proportion of poor performers spoke Chinese as their first language (Fig. 5). Korean consonants rather than vowels seemed more difficult for Chinese participants to learn. Further research is required, however, to investigate whether this was induced by their logographic experience.

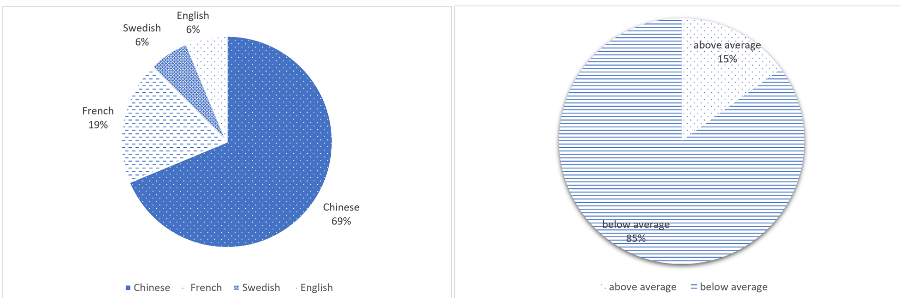

FIGURE 5. The distribution of the first languages of the performers who scored below average (left); and the scores within Chinese participants (right)

4. Discussion

People seem to successfully learn any kind of orthography. It did not matter at all whether it was the real Korean letter-sound association, which maximized audio-visual systematicity, or whether it was randomly paired, fake letter-sound associations. Even learning efficiency, as approximated by the number of repetitions, showed no difference between the two conditions. The results show more differences between learning consonants and vowels. Korean consonants were significantly easier to learn than vowels.

The nasals elicited the best performance, which is attributable to two reasons. First, nasal sounds seem to occupy a special position in human perception. The ratio of obstruents and sonorants is found to be constant across languages (Lindblom and Maddieson, 1988). In addition, nasals, approximants, and laterals are closer to vowels than plosives and fricatives are (Monaghan and Shillcock, 2003; 2008). For example, a trained neural network (Monaghan and Shillcock, 2003) demonstrated that a vowel-layer lesion damaged nasal consonants more than plosives and fricatives (see their Table 2). Therefore, it seems plausible that one of the Korean followed by plosives, aspirated and tensed (Sogang University, 2004). The current data in fact demonstrated the aspirated letters may be easier than plosive letters. Second, the reason for the better performance on nasals may lie in the letter shapes. Due to its special position in the phonemic inventory, nasals may be easily connected to visually canonical figures (e.g., ㅇ, ㅎ, and ㅁ).

Whereas the perception of consonants can be categorical, that of vowels is more continuous. Fry et al. (1962) argued that there is no categorical effect for vowels. In fact, vowels show a much weaker categorical effect (Kronrod et al., 2012) that is more fluid than that of consonants (Toro, et al., 2008): for example, in the latter experiment where the pseudo-word 'cebra' was given, people tended to change vowels (e.g., cobra) rather than consonants (e.g., zebra). This may explain why learning vowels was more challenging than consonants, which can be made more difficult by the similar letter shapes of Korean vowels. For the participants, round back vowels were especially difficult to discriminate. Recorded mouth movements, for instance, are expected to increase the performance.

It is interesting, however, that the participants did not experience any difficulty in learning ㅓ /ʌ/, which hardly exists as an independent phoneme and is usually realized as one of allophones. This can be explained by a 'perceptual magnet effect', where people tend to be sensitive more to non-prototypical vowels than typical ones: the 'poor examplars' are ironically better distinguished than 'good examplars' (Iverson and Kuhl, 2000).

In summary, the current experiment demonstrated that people are very good at learning arbitrary letter-sound association and they do so by exploiting the relations between letters. The merits of hangeul's systematicity is only potentially observed in consonants in connection with learning efficiency. The current findings suggest the inherent difficulties of back phonemes and implies the necessity of additional visual aids in educational settings.

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