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The two-dimensional orthography of phonology and morphology in differentiating Korean and Chinese

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ABSTRACT

The differences of writing systems are reflected in the processing of the languages in question. Word recognition constrained by writing systems has been attended by various theories. By analysing the recognition processes of Korean and Chinese words in this study, two of theories, the orthographic depth hypothesis (ODH) and the two-dimensional orthography of phonology and morphology (OPM) were compared. The ODH predicted that word recognition in the case of transparent orthography between sound and spelling is processed by grapheme-phoneme decoding to show the phonological effect in a lexical task. Since the OPM posits two independent dimensions of phonology and morphology, it can explain the morphological effect which is independent of the phonological effect and which is disregarded by the ODH. Testing morphological intrusion in a pronunciation-matching task, this study confirmed that the larger effect on Chinese in Experiment 2 compared with Korean in Experiment 1 supported the OPM. However, further discussion suggests that the ODH is not rejected, but regarded to be subordinate to the OPM. The former was posited only on one dimension of phonological orthography, and the latter both on phonology and on morphology.

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Introduction

What a writing system serves is to differentiate the processing of the given language relevant. It is proposed that the perception of sound is constrained by the writing system which the perceiver uses (Lee & Blare, unpublished). It has been predicted by various theories that the word recognition would be differentiated by its writing system. One of them, the orthographic depth hypothesis (abbreviated as ODH after Frost, Katz, & Bentin, 1987) was tested by the recognition of words differentiated by one's orthographic depth, which is defined as the transparency between sound and spelling (Katz & Frost, 1992). As predicted by ODH, orthographic transparent words would have more advantages in processes through the congruency of grapheme-phoneme conversion compared with orthographic opaque ones. The advantages in the process were shown through the positive phonological effect in pronunciation tasks (i.e. naming) and phonological intrusions in meaning tasks (i.e. lexical decision) for orthographic transparent words. In contrast, orthographic opaque words showed the frequency effect construed as lexical variables (see Forster & Davis, 1984, for review) in pronunciation tasks. Orthographic depth was compared in various

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languages, among which Serbo-Croatian and Spanish were assigned to the transparent, but Hebrew and English to the opaque (Katz & Frost, 1992). In general, the ODH has recently been applied to languages worldwide. This hypothesis was also tested with dialects in India (Rimzhim, Katz, & Fowler, 2013). The phonological effect regarded by the ODH is also concerned with other theories such as the phonological precedence theory (Lukatela, Eaton, Sabadini, & Turvey, 2004) in English, and the general phonological principle (Perfetti, Zhang, & Berent, 1992) in Chinese. The effect of a phonological rule, consonant assimilation of Korean, was also tested (Lee, Moreno, Park, Carello, & Turvey, 2006).

The test of the ODH contributed to the differentiation of word recognition varied by the writing systems. However, the theory stressed the difference on the phonological aspect, which is only one side of orthography, disregarding the other side as morphological orthography (Lee, 1995). Writing systems are distributed on two dimensions of phonology and morphology (see DeFrancis, 1989 for review in linguistics). Thus, Lee and Carello (2016) verified these two orthographic dimensions in word recognition of Korean, proposing a hypothesis of two-dimensional orthography as phonological and morphological (abbreviated as OPM from now). They found phonological intrusion on a meaning-matching task, which was construed as the effect of phonological orthography, and also the morphological intrusion on a pronunciation-matching task, which was exemplified as the effect of morphological orthography. The intrusion effect was defined in the reciprocal task; the morphological intrusion on a pronunciation-matching, and the phonological intrusion on a meaning-matching task.

In the comparison of Korean and Chinese writing systems, there are many contrasts as well as similarities. Being many variances in Korean and Chinese, there are also common features. Korean utilises an alphabetic system (Gelb, 1963) where each letter has one sound (phoneme) with minor exceptions (so-called, the phonological rules such as consonant assimilation) (see Lee, Moreno, Carello, & Turvey, 2013 for experimental test). In contrast, Chinese has no alphabetic system but the clustered units of syllables in writing and pronunciation, where most of them except simple units are composed of two radicals; one plays a meaning cue for the word in question and the other gives a pronunciation hint (see Lee & Lee, 2009 for experimental test). The aspect of clustered units called Character is conspicuous in both Chinese and Korean. However, the Characters of Korean and Chinese are different from each other in the quality of phonology and morphology. Phonologically, Korean Characters have a composite sound, mostly (with some exceptions) to reserve each phoneme of letters in a cluster so that it is rule-governed. In contrast, Chinese characters are directly or indirectly related to its radical in pronunciation which is not analysed into phonemes, but mapped to a syllable so that it is arbitrarily associated. According to Perfetti, Liu, and Tan (2005), which regarded the correspondences of Chinese Character's pronunciation to its radical, many variations from its radical's phonology were observed. However, the radical contribution is thought to be conspicuous in processing the radical attached Character. Even for variations, their pronunciation is indirectly cued by radicals in regard to phonological development. For example, although 植 [zhí] and 稙 [zhī] have the same radical of 直 [zhí], they are not exactly same in sound, but affiliated to derivations of the phonological radical to facilitate activation of association, which was concerned by this study.

In the aspect of morphology, a meaning radical of Chinese has reserved meaning across Characters. Most Chinese characters (approximately 80%) are composited of two radicals (Li & Kang, 1993). However, some parts of compound characters share only the same rimes and differ in onsets and tones (He, Wang, & Anderson, 2005) since the radicals have been developed and changed from their initial forms. The radicals have been originally modelled from natural pictures, but gradually evolved to cue meaning and pronunciation. That is the feature of logographic (see DeFrancis, 1989; Gelb, 1963, for more discussion). In contrast, Korean Characters are not analysed into pronunciation radicals associated with pictures, but into letters which work as phonemes.

Comparing properties between Korean and Chinese, they are different in terms of the orthographic depth; Korean is transparent between sound and spelling while Chinese is opaque. As

proposed and tested by Lee and Carello (2016), Korean and Chinese are also differentiated in the two-dimensional orthography of phonology and morphology. While the two dimensions are apparent both in Korean and Chinese, Korean is more transparent than Chinese in the phonological dimension, and Chinese is more consistent in the morphological dimension than Korean.

Whether or not lexical access is induced, depends on the requirement of morphological consistence. Lexical access for Chinese word can be achieved by its meaning radical, which is visually recognised. However, Korean can be decoded by letter-phoneme rules prior to lexical access, called as pre-lexical processes. Thus, in comparison of Korean and Chinese, the question is whether or not it is processed lexically or pre-lexically. The two processes rely on the phonological transparence between sound and spelling according to the ODH, which predicts that Korean in terms of transparent orthography is processed pre-lexically, but Chinese in terms of opaque orthography is done lexically. However, the OPM reasons that the lexical process conspicuous in Chinese is caused by the consistence of morphological dimension, endorsed in the meaning radical of Chinese Character. For the ODH, it is premised that orthography is varied from Korean as transparent to Chinese as opaque only in phonological dimension. However, the OPM posits that orthographies are distributed on two dimensions of phonology and morphology; Korean is more transparent than Chinese, if measured on the phonology, but Chinese is more consistent than Korean, if measured on morphology. However, the two dimensions leave a margin that Chinese inherent in morphology has features of phonology cued by the pronunciation radical, and that Korean born in phonology reserves morphological roots.

In Korean morphology, there are two types of word origins, one of which is associated to Chinese words, and the other of which so-called pure Korean word does not have Chinese traces. The former, exemplified as 주방 (associated with 廚房; kitchen) is consistent in the morphology of a Chinese word, but the latter as 부엌 (kitchen) is morphologically inconsistent. In this theoretical framework, some lexical processes attested to the frequency effect (a kind of lexical effects) in some Korean words, could be explained in Lee et al. (2006). The rivalry of OPM and ODH can be tested on whether or not the differentiation in analysis of a lexical effect is caused by morphological consistence or phonological opaqueness. In order to break the limitations of Lee and Carello (2016), which tested only Korean-Chinese words, the design should not be limited to only Korean people, but open to Chinese people as well to test each native language for the validity of OPM.

The purposes of this study

This study attempted to compare the ODH and OPM with the stimuli of Korean and Chinese words where participants speak their mother tongues. It is the between-subject manipulation that this study is different from Lee and Carello (2016). The morphological intrusion on a pronunciation-matching task is construed as the morphological effect, which attests to the morphological dimension of orthography. The OPM predicts a larger morphological intrusion on a pronunciation-matching task of a Chinese word compared to a Korean since Chinese is composed of radicals more stubborn to morphemes than Korean is. However, the ODH does not have a clear prediction on morphological intrusion since it disregards the morphological aspect, and only relies on its phonological one. What was remarked just above is noticeable. When orthography is depicted by one-dimensional phonology where morphological levels are dependent, as transparent phonology is right to the inconsistent morphology, and vice-versa, the ODH does not work for predicting the morphological effect which is independent of the phonological effect. However, in cases that morphology and phonology are independent as OPM premises, both the phonological and morphological effect could be explained.

In the first experiment, Korean words (used presently in Korea, called as 한글/Hangul/) were presented to Korean subjects. A sample of pure Korean words was stimuli of target. If grapheme-phoneme decoding is efficient in Hangul, the evidence of a faster processing time

should be observed. The second experiment exposed Chinese words (used presently in China, called as 简化字/jienhuàzì/) to Chinese subjects. The decision about the word's pronunciation required lexical access since decoding is not possible in Jienhuàzì. Thus, the decision latency should result in a longer time compared with that of Hangul.

Both experiments were interested in word recognition either to show morphological intrusion or not. In a pronunciation-matching task for the pairs of prime and target there were three conditions on deciding if they were 'Similar' or 'Different'. For the first condition (coded as P≠M≠), the prime and target differed in both pronunciation and meaning, thus requiring a response of 'Different'. For the second condition (P=M=), the two stimuli had a similar pronunciation and similar meaning, thus requiring a response of 'Similar'. And for the third condition (P=M≠), the prime and target had different meaning, but a similar pronunciation, thus requiring 'Similar' response. In the third condition, the different meaning should act as a spoiler to interfere with a positive decision (see Holender, 1992, for a general discussion). Therefore, P≠M≠ requiring negative response in pronunciation is a control condition of response bias for comparing positive ones between P=M= and P=M≠, some significances of which index a meaning interference on pronunciation.

Rationalising the above manipulation, if decoding of Hangul precedes lexical access, the difference in meanings between the prime and target of the lexical information should be irrelevant. Therefore, the meaning discordance will not affect the decision time in the pronunciation-matching tasks in that the faster responses should be emitted. In contrast, if the pronunciation of Jienhuàzì is determined only lexically, there should be a mutual distraction between processing phonemes and morpheme, resulting in a delayed response as a morphological intrusion into the judgment of pronunciation. Thus, it is expected that the morphological intrusion effect coincides with delayed judgment of pronunciation in the processing of Jienhuàzì in Experiment 2, compared with Hangul one in Experiment 1.

Experiment 1

Experiment 1 attempted to analyse the response latency on a pronunciation-matching task between two sequential words, both of which were printed in Hangul. The OPM by which Hangul is regarded as having transparent phonology and inconsistent morphology, predicts that the pronunciation-matching of two Hangul words is faster, showing little morphological intrusion.

Method

Participants: Nineteen students sampled from Gyeongsang National University participated in Experiment 1 as part of their course requirements. They were born with the mother language in Hangul. All participants were covered by the University Review Board for Human Subject Protection.

Stimuli: Two sequential words were presented to the participants at every trial. The first word as prime and the second as target were printed in Hangul. The targets belonged to pure Korean words. All of the words consisted of two syllables. The participants had to decide whether or not the first Character of target had a similar pronunciation to the first Character of prime, while ignoring the meanings of both words (hence call, a pronunciation-matching task). Since most monosyllabic words of Korean have multi-meanings, the second Character of target and prime worked as a context to fix the meaning of words.

The stimuli were designed in a Within-Subject with three prime-target conditions, P≠M≠, P=M=, and P=M≠, shown in Table 1. The rivalled condition of the third represents the intrusion of meaning on the judgment of pronunciation if the irrelevant dimension intrudes into the

Table 1. Stimulus example for each condition in Experiment 1 for Hangul.

Prime	Target	Relation morphology-phonology
수식/su-sig/ (numberform)	물통/mul-tong/ (water-basket)	P≠M≠
물논/mul-non/ (water-pod)	물통/mul-tong/ (water-basket)	P=M=
문란/mul-lan/ (disorder-confusion)	물통/mul-tong/ (water-basket)	P=M≠

decision process of phonology. The targets for a subject across the three conditions were not repeated.

The participants tried 80 randomly ordered pairs of prime and target. They were asked to respond either with 'Similar' or 'Different' by pressing one of two keys designated. To control the response bias, 40 trials (50% of all 80 trials) were allocated for a negative response on the P≠M≠ condition, 20 trials (25%) for a positive response on the P=M= condition, and 20 trials (25%) for a positive response on the P=M≠ condition.

All target stimuli were controlled in familiarity, which is considered a general variable, compounded by such things as dictionary frequency and neighbourhood to affect lexical processes as discussed and used for sampling Korean and Chinese words in Lee et al. (2006, 2013; Lee & Carello, 2016; Lee & Lee, 2009). The familiarity measure is good for compatibility with other languages (Chinese in Experiment 2). For familiarity rating, 30 subjects were sampled from a population similar to the subjects of this experiment. They did not participate in this experiment. On the Likert scale (scored from 1 to 7), each stimulus was rated of its familiarity. The *Mean* (and *SD*) was analysed for each condition; 3.95 (0.93) for (P≠M≠), 3.96 (1.20) for (P=M=), and 3.96 (0.89) for (P=M≠). In analysis of variance, non-significance was found.

Procedure: The presentation and responding done by a PC were programmed with ePrime. At each trial, a focus (three asterisks as '***') appeared in the centre of the screen for 300 msec, followed by a blank screen for 500 msec. A prime was presented for 300 msec, followed by a 500 msec blank, and then a target was presented for 300 msec. At last, subjects responded with one of two keys assigned to 'Similar' or 'Different'. The next trial began after a 2 sec pause following the subject's response. The participants were positioned at a distance approximately 40 cm from the screen. Stimuli were subtended approximately 2 degrees of the arc. The task began with a practice block of 20 trials, during which any questions could be answered. Then, when the subjects signalled that they were ready to enter, the main block of 80 trials began.

Results and discussions

The statistical analysis has regard to the reaction time (RT) in 'msec' between the target presentation and the response start of matching in pronunciation, and to the accuracy in percentage for the exact responses of all trials. RTs below 250 msec and above 1.5 sec were not included in analysis. They amounted to 0.35% of all the RT data. RT and Accuracy data were processed by analysis of variance which had two types; subject-analyses (*F1*) and stimulus-analyses (*F2*). *Mean* and *SD* of RT and Accuracy are shown in Table 2.

Concerning the experimental question on whether or not the meaning intrudes on pronunciation, RT data is further regarded in the discussion. As expected for Accuracy, Condition was non-

Table 2. Results for each condition in Experiment 1 for Hangul.

		Accuracy		RT	
Prime-target condition	Correct response	*Mean*	*SD*	*Mean*	*SD*
P≠M≠	Different	97.11	5.00	454.63	20.26
P=M=	Similar	97.11	3.63	417.54	18.31
P=M≠	Similar	96.47	4.68	408.39	15,18

Note: Accuracy is percentage of correct response. RT is measured in msec.

significant in both *F1* and *F2*. It was confirmed that RT and Accuracy were not traded off, since the lower accuracy was not correlated with the faster latency as inspected in the following analysis of RT.

For RT, Condition (P≠M≠, P=M=, and P=M≠) was significant in both *F1* and *F2*: $F1\ (2, 36) = 27.550$, $MSe = 415.230$, $p < .001$; $F2\ (2, 77) = 51.167$, $MSe = 347.515$, $p < .001$. The significance could be attributable to the difference between the positive and negative responses. Thus, in order to find morphological intrusion, P=M= and P=M≠ were compared. The analysis of variance showed non-significance in both *F1* and *F2*. Therefore, morphological intrusion was not observed in Experiment 1. Elaborating furthermore, it was not found that the different meanings of P=M≠, an irrelevant variable could intrude into the matching in pronunciation.

However, in this Experiment 1, some morphological effects except the observed phonological one were expected since Hangul is positioned at phonological transparence and morphological consistence in two-dimensional orthography as proposed by Lee and Carello (2016). However, there was a difference in the property of the Korean words between Experiment 1 which sampled pure Korean words and Lee and Carello (2016) of Korean-Chinese ones. The former is regarded as having phonological transparence and morphological inconsistence and the latter as holding phonological transparence and morphological consistence. Thus, it explains that no morphological influence in Experiment 1 was observed.

Would morphological intrusion appear when the word to be pronounced is printed in Jienhuàzì? The pronunciation of Jienhuàzì which is accomplished through the lexical access would be slower than Hangul. These are the issues examined in Experiment 2.

Experiment 2

In Experiment 2, both prime and target were written in Jienhuàzì. As logography, Jienhuàzì embeds the morphology in parts of its Character, called radical. It is reasonable that the working of the radical is construed as morphological influence at a delayed lexical process. Thus, the manipulation of the radicals in Experiment 2 attempted to find more morphological intrusions on the matching of pronunciation and slower RT compared with Hangul of Experiment 1.

Method

Participants: Sixteen students sampled from Gyeongsang National University participated in Experiment 2 as part of their course requirements. They are international students who all speak Chinese as their mother language. All of them were covered by the University Review Board for Human Subject Protection.

Stimuli and Procedure: The general design was similar to that of Experiment 1 except that Experiment 2 stimulated Jienhuàzì words instead of Hangul words of Experiment 1. Since Chinese words in monosyllables are not ambiguous in meaning, both the prime and target are monosyllabic compound of pronunciation and meaning radicals as shown in Table 3.

All target stimuli were controlled in familiarity like the way which Experiment 1 handled. *Mean* (and *SD*) was analysed for each condition; 4.76 (0.23) for (P≠M≠), 4.76 (0.22) for (P=M=), and 4.73 (0.26) for (P=M≠). In analysis of variance, the condition was non-significant.

Table 3. Stimulus example for each condition in Experiment 2 for Hanja.

Prime	Target	Relation morphology-phonology
别/bié/ (different)	说/shuō/ (theory)	P≠M≠
晴/qíng/ (fine)	情/qíng/ (feeling)	P=M=
湿/shī/ (damp)	诗/shīī/ (poem)	P=M≠

Results and discussions

The statistical analysis was processed in a similar fashion as Experiment 1. *Mean* and *SD* of RT and Accuracy are shown in Table 4. RTs below 250 msec and above 1.5 sec were not included in analysis. They amounted to 0.25% of all RT data.

For Accuracy analysis, Condition was non-significant in both *F1* and *F2*. It was confirmed that RT and Accuracy were not traded off since the lower accuracy was not correlated with the faster latency as inspected with the following RT analysis.

For RT, Condition (P≠M≠, P=M=, P=M≠) was significant for both *F1* and *F2*: *F1* (2, 30) = 941.668, *MSe* = 740.225, $p < .001$; *F2* (2, 77) = 299.370, *MSe* = 4008.083, $p < .001$. The significance could be attributable to the difference between the positive and negative responses. Thus, in order to find morphological intrusion, P=M= and P=M≠ were compared. The pair comparison was significant in both *F1* and *F2*: *F1* (1, 15) = 658.694, *MSe* = 547.137, $p < .001$; *F2* (1, 38) = 210.475, *MSe* = 2095.740, $p < .001$. Table 4 shows that the P=M= was faster than the P=M≠.

This is consistent with what should appear if meanings intrude in pronunciation. Also, this experimental result would be expected if pronunciation is retrieved in the lexical stage, which is associated with semantic processes.

General discussions

This study attempted to test the ODH and OPM, observing response latency and morphological intrusion in pronunciation-matching task between prime and target with Hangul words in Experiment 1 and Jienhuàzì words in Experiment 2. It is proclaimed that the writing systems are distributed on the two dimensions of phonology and morphology. Comparing Hangul and Jienhuàzì words, the former is positioned at a higher level of phonology than the latter, and at a lower level of morphology than the latter. This taxonomy anticipates that pronunciation is faster if Hangul is processed in grapheme-sound decoding by a letter unit without waiting for morphological intrusion which is outcome at a later time where Jienhuàzì is processed.

In regards to the results of pronunciation matching, the processing of Hangul words showed faster RT and less meaning intrusion compared to that of Jienhuàzì words. Generally, this result implies that the quality of word recognition is constrained by its writing system (Lee & Blair, unpublished). Specifically, the OPM is supported by morphological intrusion since the theory posits both the phonological and morphological dimensions. The reciprocal theory, ODH is biased only in regard to the phonological influence, because it presupposes that the morphological aspect is dependent on the phonology which is mainly concerned; correlated with a lower morphological level and a higher phonological level, or vise versa. Thus, it presupposes no clear prediction of morphological influence which should be independent from the phonological one.

Even though the ODH has the limitation of no morphological dimension, it can manage to partially deal with the results of this study by the following. None of morphological influence observed with Hangul would be explained, even according to the ODH which champions only phonological dimension, and would claim that Hangul is so transparent to be processed pre-lexically for phonological assembling. Therefore, it is modestly commented that the ODH concerned only with phonology should be subordinated to the OPM, which proposes independence between

Table 4. Results for each condition in Experiment 2 for Hanja.

		Accuracy		RT	
Prime-target condition	Correct response	*Mean*	*SD*	*Mean*	*SD*
P≠M≠	Different	95.94	6.25	1023.67	76.62
P=M=	Similar	99.06	3.06	605.71	52.74
P=M≠	Similar	95.0	5.94	815.73	37.55

Note: Accuracy is percentage of correct response. RT is measured in msec.

phonology and morphology. To test this more definitely, a design is required to manipulate both the phonology and morphology, and measure both effects.

Further refinement of phonological and morphological differentiation is addressed in a theory that the grain size of word process, characterised as the orthographic unit at which phonology or morphology is analysed from print (Ziegler & Goswami, 2005). For phonology, Korean has a small grain size of letters while the grain size of Chinese characters is larger. For example, a Korean Character, '간' has a syllabic sound composed of letters such as 'ㄱ'/g/, 'ㅏ'/a/, and 'ㄴ'/n/. In contrast, a Chinese Character, '植'/zhí/ has a syllabic sound regarding the radical '直'/zhí/, but not the radical '木'/mù/. For its morphology, Chinese has a consistent cue for the meaning, thus having a small grain size. For example, '植' (planting) is derived from '木' (plant). In contrast, Korean needs more neighbour Characters to fix a meaning, thus leading to a large grain size. For example, a Korean word, '간' (salt or time) varies in meaning by its neighbour; '간' of '순간' matches for 'time', and '간' of '간수' for 'salt'. However, Chinese character itself is sufficient, such as a differentiation of '澗' (salt) or '間' (time). Thus, the grain size processed in word recognition is questionable when comparing Korean and Chinese. Thus, it is remarked that the results of this study are explained in terms of grain size. In the naming task with Hangul, the latency which is faster than with Jienhuàzì, attests to the smaller grain size of Hangul phonological process than Jienhuàzì. In contrast, for morphological processes, the smaller grain size of Jienhuàzì than that of Hangul results in morphological intrusion in the Jienhuàzì naming task. The difference between Korean and Chinese processing was also reflected in a study on reading tasks (Wang, Koda, & Perfetti, 2003), where Korean and Chinese people were compared in reading units of English; the former in smaller grain size of alphabetic-phoneme, and the latter in larger grain size of orthographic-radical.

In a relational aspect in this study, the processing difference between the writing systems of Hangul and Jienhuàzì was concluded in the negative correlation of two aspects; faster processing time and less morphological intrusion as shown in joint of Experiment 1 and Experiment 2. Referring to other research, Frost's (1998) reviews that the reading processes of phonologically transparent orthographies make more use of decoding than that of opaque orthographies are in alignment with this discussion. For Serbian, as it is one of phonologically transparent orthography, phonological processing takes precedence over morphological processing (Lukatela & Turvey, 1994). For Hangul, another of phonologically transparent orthography, there is an evidence that phonological rule as a consonant assimilation influences the reading (Lee et al., 2013). In summary, Korean and Chinese words are different phonologically and morphologically on the prescription of two-dimensional orthography. It is supported by two experiments in this study which shows phonological processes for Korean with faster latency, and less morphological intrusion than that for Chinese, since the former is more transparent in the phonology dimension and less consistent in the morphological one than the latter is.

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