Proceedings of 3rd International Conference on Interdisciplinary Humanities and Communication Studies
DOI: 10.54254/2753-7064/2024.20907

Phonetic Approximation in Bilingual Pun and Their Impact on Response Times for Young Chinese-English Bilinguals

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Abstract: This study, integrating psycholinguistic and sociolinguistic perspectives, investigates bilingual puns with phonetic approximations between two languages, Chinese and English, as a medium for humour and identity expression, and how phonetic approximations involving consonantal shifts (e.g., s/sh and f/h), vowel transformations, rhoticity, and additional schwa influence participants' perception of bilingual pun stickers. A quantitative approach was used, involving two experiments: a speech production and perception task, and a response-time experiment. These assessed participants' responses to phonetic approximations in controlled experiments and real-world pun stickers. The results indicate that phonetic similarity, particularly in consonants, leads to faster recognition times, while more pronounced differences, such as between /f/ and /h/, hinder recognition. Vowel roundness, diphthong shifts, and hiatuses were also found to significantly affect pun comprehension, whereas schwa insertion and rhoticity were less influential. The findings highlight the importance of phonetic awareness in bilingual education, with a focus on vowel and consonant accuracy in speech perception and production, and suggest applications of bilingual pun stickers in second language teaching, while acknowledging limitations such as sample size and the absence of multimodal analysis.

Keywords: Phonetic approximation, bilingual puns, bilingual phonetic perception, online stickers

1. Introduction

Punning is a significant form of wordplay in demonstrating language creativity that serves as a device in creating literal humour and rhetorical jokes through the deliberate manifestation of ambiguous characteristics contained in words, morphemes, or syllables [1]. Bilingual punning specifically entails two languages with significant phonetic similarities, particularly in consonants, but across different orthographic systems to convey emotions, most commonly humour. Extant studies on bilingual punning are conducted from the perspectives of both psycholinguistics and sociolinguistics, with the majority falling under psycholinguistics. Research in psycholinguistics has examined bilingual language processing, focussing on the activation of phonological representations across languages, especially about interlingual homophones and homographs. Research indicates that bilingual individuals activate phonological representations from both languages during silent reading tasks,

DOI: 10.54254/2753-7064/2024.20907

even within a single-language context [2-3]. Cross-language activation may result in either facilitation or interference effects in participants' perception of language, but it is influenced by other variables such as language proficiency and task demands [4-5]. Numerous psycholinguistic investigations deliberately create bilingual puns or interlingual homophones to analyse bilingual language processing. In this sense, the deliberately constructed bilingual puns are less representative of those used in real-life social contexts. Sociolinguistic studies, on the contrary, investigate bilingual puns in their authentic social context. In the sociolinguistic study on linguistic landscape, research has examined the use of bilingual puns in public places to elucidate the sociolinguistic dynamics of bilingualism [6].

However, there exists a relatively limited number of studies that investigate bilingual puns from both psycholinguistic and sociolinguistic perspectives. Incorporating psycholinguistic concepts, especially about bilingual perception indicated by the response time, into sociolinguistic research on bilingual punning in social contexts should enhance our comprehension of the creation and utilisation of bilingual puns. Such integration would enhance bilingual expressiveness and promote the spread of humour through linguistic play. To address this gap in research, our study focusses on the use of bilingual punning in online stickers, a ubiquitous form of computer-mediated communication, particularly among young people.

Recent studies on online stickers and analogous pictorial communication underscore their significant importance in digital discourse. In addition to emojis and emoticons, stickers aid in emotional expression, elucidate messages, and elevate mood in digital communications [7-8]. Stickers have different uses in communication, including showing tone and the speaker's intention [9]. They also reflect artistic identity and help connect people in Generation Z [10]. While emojis are the most popular visuals on social media, young people especially like stickers for their humour and customisation options [11]. The ubiquitous use of stickers and their popularity among young people make bilingual puns in stickers a valuable resource for exploring the practical role of bilingual puns in identity expression.

Research on online stickers is less extensive than studies on memes, which mix text and images to show cultural and social realities. Some studies suggest using pretrained models like BERT for text and VGG for images to classify memes by sentiment, humour, and offensiveness [12-13]. Other research has applied theories like socio-semiotic multimodality and visual grammar to analyse the meaning and visuals in memes [14]. These efforts show a growing interest in the multimodal analysis of both memes and stickers, highlighting their importance in today's online communication and social discourse. While multimodal analysis is important for understanding how the interplay between language and imagery influences bilinguals' perception of bilingual puns, our research will focus solely on the textual component of stickers. In this study, stickers are regarded as a mere medium for conveying bilingual puns, which serves as a faithful reflection of the actual use of bilingual puns in online communication.

Research on phonetic approximation in bilingual puns shows complex interactions between phonology and phonetics. In Japanese puns, phonetic similarity is very important, and speakers tend to prefer small, contrasting changes [15-16]. This similarity principle extends to both segmental and subphonemic features [16]. In bilingual word recognition, orthographic and phonological similarities between languages influence processing, with effects varying by language dominance [17]. In our studies, we identified the major sets of phonetic approximations of bilingual puns on the online stickers.

This study primarily aims to perform a psycholinguistic analysis of how different types of phonetic approximations affect how young Chinese bilinguals perceive bilingual puns, especially in the context of online sticker usage. It looks at how these sound approximations influence response times during pun comprehension tasks among Chinese-English bilinguals. The study also explores how these

DOI: 10.54254/2753-7064/2024.20907

approximations show up in phonetic production and perception experiments, focussing on key types of phonetic approximations being studied.

2. Literature Review

2.1. Online Stickers and Bilingual Puns

Online stickers serve multiple communicative functions in communications. They help express emotions, manage relationships, and complement the text messages to increase expressiveness [18]. Users employ stickers strategically for various purposes beyond emotional expression [7]. Different styles and degrees of uniqueness of online stickers influence users' selections of strikers [19]. People can gain entertainment and affection gratifications when using stickers on messaging apps [20]. Stickers effectively express users' messages during chats [21]. Users' preferences for sticker styles may differ based on their personality and social relationships [22]. Overall, stickers add visual elements into conventional text-only online interactions, improving the ways people interact with each other [7].

Online stickers became a ubiquitous form of communication due to their ability to promote the expressiveness of emotions and supplement nonverbal cues [8]. Stickers are also effective in shaping identity and bridging generational gaps. Users are motivated by the need for self-expression and the desire to display their personality through the use of online stickers [19].

Humour is an important emotion that people want to express by using online stickers, particularly in educational and social contexts. In educational settings, humour through memes and stickers can increase students' motivation, engagement, and comprehension of concepts in classes [23-24]. The incorporation of stickers in messaging applications such as WhatsApp and WeChat enhances message delivery by adding humour, thereby improving both efficiency and user engagement [25]. Humour can be created on online stickers through linguistic play, including detournement, irony, and double entendre [26]. In our study, the technique that enhances humour is bilingual puns. Identifying humour in online content, including reviews, can be achieved through machine learning models with high accuracy [27]. Stickers' complexity may lead to misinterpretation due to ambiguous expressions [28].

Young people value the flatness, humour, and freedom of online communication, according to research [29-30]. Through the usage of emojis, stickers, and visual language, social media and messaging applications like WeChat and LINE have evolved into venues for identity creation and self-expression [10, 31].

Puns have various functions in language and literature. They create humour and draw readers' attention. [32]. In advertising, puns have double meanings and humorous effects, allowing audiences to interpret complex messages based on their background knowledge or past experiences [33]. Additionally, puns' humour production and interpretation processes have been analysed through the Relevance Theory [34-35]. Puns can provide humour that is purposeful or inadvertent [24]. Understanding puns necessitates considering social context as a dynamic concept with nuanced interpretations that vary across cultures and societies [35].

Puns are perceived as more humorous in informal settings, especially when they do not interrupt the flow of conversation. Their humour can be explained by elements like ambiguity and distinctiveness. The interpretation of bilingual puns entails intricate cognitive processes across various languages and cultures. Research has examined multiple aspects of this phenomenon, such as bilingual puns in Indonesian truck graffiti [36] and experimental investigations of bilingual puns [37]. The practice of bilingual writing requires intricate perception and decoding processes [38], which is hard for most people. Bilingualism is associated with enhanced creativity and a heightened perception of the world [39]. Research indicates that bilingualism influences semantic ambiguity resolution both within and across languages [40].

DOI: 10.54254/2753-7064/2024.20907

2.2. Bilingual Phonetic Perception and Phonetic Approximation in Puns

From the earliest months of life, bilingual infants demonstrate an ability to discriminate between their two languages. At just 8 months old, Spanish-Catalan bilingual infants can distinguish between these two rhythmically similar languages [41]. This early discrimination ability is crucial, as it allows bilingual infants to begin separating the input from their two languages.

Although infants who are bilinguals demonstrate early proficiency in language discrimination, the process of developing phonetic categories specific to a certain language is more intricate. Studies have shown that young bilinguals acquire their vowel and consonant categories differently [42].

Prior to effectively differentiating sounds in both languages, bilingual newborns may undergo a brief phase of expanding their phonetic categories, according to certain research findings. For instance, while successfully differentiating these sounds at earlier and later ages, Spanish-Catalan bilingual infants had trouble at 8 and 12 months, respectively, with certain Catalan-specific vowel and consonant contrasts [41].

Not all language pairs or phonetic contrasts follow this pattern, though. At 10 to 12 months of age, infants who were bilingual in French and English shown sensitivity to the phonetic limits of both languages by being able to distinguish between the English and French versions of the /b/-/p/ distinction [41]. Mixed findings have been found in the research on bilingual children's phonological awareness. While some studies [43] find no difference or even advantages for monolinguals in certain tasks, others find no difference or even advantages for monolinguals.

Bilingual infants at 14 months old exhibit comparable patterns to monolinguals in word learning tasks when it comes to connecting new words with objects. However, bilinguals seem to lag behind monolinguals when learning minimal pair words (e.g., "bih" vs. "dih"), succeeding at 20 months instead of 17 months [41]. The higher processing needs of running two phonological systems could be the cause of this delay. The study of bilingual phonetic perception reveals the advantages and disadvantages of the growing multilingual mind. Although bilinguals and monolinguals often reach similar developmental milestones, there may be some variations in the phonetic development path.

Puns can use phonetic approximation in ways other than precise sound matching. As an alternative, it frequently entails maximising the similarity between related segments. Similar to phonological processes, this technique aims to maximise input-to-output similarity for speakers. Researchers can learn more about linguistic similarity knowledge by examining puns.

Netizens have produced subversive puns in the Chinese language that play with the peculiarities of Mandarin. These puns show how language is flexible even when wordplay is formulaic [44]. The analysis of these puns has consequences for comprehending word form encoding and lexical access in Mandarin.

There is a long tradition of wordplay utilising phonetic approximation. Syllable onset and fixed rime spelling systems have been used in Chinese language games since the 16th century [44]. These games are available in many different Chinese dialects, such as Cantonese, Hakka, Taiwanese, and the dialect spoken in Shanxi [44].

Pun phonetic approximation seems to share several common characteristics. These include the semantic oppositeness present in incongruity, the phonological techniques employed to modify strings, and the pseudo-logical resolution of this incongruity [45]. There appear to be consistent patterns in the relative distribution of wordplay types that involve ambiguity and alliteration in different forms across languages.

Beyond informal speech and literature, wordplay uses phonetic approximation. In advertising, figures of speech that rely on sound similarities, such as alliteration, assonance, and puns, are extensively utilised in print ad headlines [46]. This frequency indicates that wordplay's use of

DOI: 10.54254/2753-7064/2024.20907

phonetic approximation has been shown to be successful in drawing listeners in and producing memorable sentences.

3. Methodology

To investigate the varying degrees of hindrance of bilingual phonetic approximation on the perception of bilingual puns among young Chinese-English bilinguals, data was collected from 52 participants aged 16 to 21 with two primary experiments: a speech production and perception experiment, and a response-time experiment. The first experiment focusses on participants' production and perception of seven specific bilingual phonetic approximations. The second experiment focusses participants' response time on the eight stickers selected, with each containing one of the seven parameters under investigation.

3.1. Speech Production and Perception Experiment

This experiment comprises six tasks: two speech production tasks and four perception tasks, as depicted in Table 1. Both task sets investigate the production and perception of phonetic contrasts: s/sh, f/h, w/v, rhoticity, and schwa. To reduce the influence of task similarity on reading duration, participants are directed to perform each task in succession without previewing the following tasks. The two production tasks are presented on separate pages in the document, while the perception tasks are consolidated on a single page.

Table 1: Speech production and perception experiment

	Number	Task Name
Production	Section 1	Non-sentences with s/sh and f/h
	Section 2	Optional rhoticity, additional schwa and w-v conversion
Perception	Section 3	Interchangeable s/sh and f/h
	Section 4	Additional schwa
	Section 5	Optional rhoticity
	Section 6	w-v conversion

In Section 1, two sets of non-sentences involving the s/sh and f/h distinctions are designed to record participants' reading times. The sequence of the two sets is randomized. Each set contains an equal number of words, with consistent punctuation placement and quantity. Each set includes two non-sentences with the phonetic variables s/sh and f/h. These non-sentences are adapted tongue twisters lacking semantic meaning to ensure data accuracy, as familiarity with popular tongue twisters or inconsistent semantic meanings could introduce inaccuracies of reading times.

Non-sentence 1 (without the s/sh distinction) and non-sentence 3 (with the s/sh distinction) are used to compare reading duration for sentences with and without the s/sh distinction. Likewise, non-sentence 2 (with the f/h distinction) and non-sentence 4 (without the f/h distinction) are employed to investigate differences in reading times with and without the f/h distinction.

1) 七八八,八八七,七无七八八,八无七八七。
2) 凤红凰,凤粉凰,粉凤花凰红凰凤,凤红粉两凰凰凤。
3) 寺狮狮,狮狮寺,寺无寺狮狮,狮无寺狮寺。
4) 风树吹,雨花落,猫小草丛里躲在,大小枝上飞树鸟。

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In Section 2, participants were instructed to perform literal translations of Chinese sentences or phrases to elicit patterns of rhoticity, assess their mastery of w/v pronunciations, and examine their ability to pronounce word-final consonants. The English words derived from the literal translations were simple, such as car, fourth, floor, and star (rhoticity); we, went, village, and very (w/v); and dog, book, cat, and bag (word-final consonants). These familiar words were selected to minimise pronunciation errors due to participants' limited English vocabulary, maximising the collection of valid data. The use of literal translations promoted more natural speech production and reduced potential bias from visual cues, such as the letter "r," which might trigger consistent rhoticity if participants were explicitly aware of it.

1) 汽车在四楼,黑黑的天空上有一颗星星。
2) 我们昨天拜访一个风非常大的村庄,水非常烫。
3) 小狗,书本,地图,小猫,袋子

Expected Answer:
1) The car is on the fourth floor. There is a star in the dark sky.
2) We went to a very windy village yesterday. The water was very hot.
3) dog, book, map, cat, bag

Section 3 includes eight intentionally mispronounced Chinese words. Participants had to identify the correct words and fill in the blanks while listening to the audio. The mispronunciations involved altering two words each by substituting "s" with "sh," "sh" with "s," "f" with "h," and "h" with "f," while maintaining other linguistic variables such as tone, vowel, and consonant consistency. The interchangeable pattern of phonetic shifts is illustrated in Table 2. This experiment aimed to assess participants' perception of phonetic approximations in the s/sh and f/h distinctions.

Table 2: Examples in the s/sh and f/h perception experiment

Correct Form	Word in Audio	Change
发表(fā biǎo)	哈表(hā biǎo)	f→h
湖南(hú nán)	弗南(fú nán)	h→f
三思(sān sī)	山思(shān sī)	s→sh
树叶(shù yè)	速叶(sù yè)	sh→s

In Section 4, participants listened to an audio recording of the words dog, book, bag, cat, and map, where each word was deliberately pronounced with an additional schwa sound at the end (e.g., /bʊk/ as /bʊkə/, /bæg/ as /bægə/). The goal of this section was to assess whether participants could accurately identify the words despite the added schwa.

In Section 5, participants listened to three sentences: "The car is on the fourth floor," "The door is near the corner," and "There is a star in the dark sky." The sentences were read with varying degrees of rhoticity in the target words. Participants were instructed to transcribe the sentences in the blanks provided based on what they heard. This section tested participants' perception of optional rhoticity.

In Section 6, participants listen to audio with improper pronunciations of two sentences: "We went to a very windy village yesterday" and "The water is very hot," in which the sounds of "w" and "v" are inverted (e.g., we pronounced as ve). This section aims to find out if participants can tell the difference between the w and v sounds and correctly identify the words in the sentence. They are not

DOI: 10.54254/2753-7064/2024.20907

told whether what they hear is grammatically correct, so their answers rely only on what they hear, not on grammar.

3.2. Time Response Experiment

In the time response experiment, we showed nine stickers in a PowerPoint presentation to the participants. The first sticker was used for explanation and priming on the introductory slide, and the remaining eight were part of the formal experiment to measure the response times of participants. Participants joined a recorded Tencent meeting and were asked to identify the eight stickers featuring bilingual puns in a fixed sequence, as outlined in Table 3. Each sticker targeted one specific parameter under investigation.

Reaction times were manually calculated using video editing software by measuring the interval between the appearance of each sticker on the slide and the participant's verbal identification, as indicated by the audio waveform in the software. To ensure data accuracy, four key instructions were given on the introductory slide: (1) Participants should only say the Chinese meaning of the puns after fully understanding them, without saying them aloud while guessing. (2) They must provide the exact wording of the puns, not explanations or interpretations. (3) Participants may skip a pun if they do not understand it. (4) Puns will appear in the centre of each slide.

Table 3: The eight bilingual puns in the time response experiment

Number	Pun	Correct Answer	Parameter
Priming Token	May 你啥事	没你啥事	
1	关你 peace	关你屁事	s/sh
2	心如 dog	心如刀割	schwa
3	无 fuck 说	无话可说	f/h
4	有 bear 来	有备而来	rhoticity
5	Even 不值	一文不值	w/v
6	eason 不吭	一声不吭	s/sh
7	duck 不必	大可不必	schwa
8	star 皆空	四大皆空	rhoticity

3.3. Results

In the non-sentence production experiment involving s/sh and f/h distinctions, as shown in Table 4, the average reading time for non-sentences with the s/sh distinction was 6.71 seconds, which is 1.13 seconds longer than for non-sentences without the distinction. Similarly, the average reading time for non-sentences with the f/h distinction was 10.76 seconds, 2.52 seconds longer than for those without the distinction.

Table 4: Reading time in the non-sentence production experiment

Condition	With s/sh or f/h	Without s/sh or f/h	Difference
Non-sentence (s/sh)	6.71s	5.58s	+1.13s
Non-sentence (f/h)	10.76s	8.24s	+2.52s

In the optional rhoticity, additional schwa, and w/v conversion production experiment, as shown in Table 5, the rhoticity rates for the words "car," "fourth," "floor," "there," "star," and "dark" were 84.31%, 70.59%, 74.51%, 82.61%, 84.00%, and 65.85%, respectively. The overall average rhoticity production rate was 76.98%.

DOI: 10.54254/2753-7064/2024.20907

In the w-v production experiment, the accuracy rates for the words "we," "went," "very," "windy," "village," and "water" were 98.04%, 89.47%, 100%, 78.13%, 97.92%, and 100%, respectively, as seen in Table 6. The accuracy rate for words that begin with "w" or "v" was 94.13%. However, the word "windy" had a lower accuracy rate of 78.13%. In this case, people said "very vindy" instead of "very windy" by mistake six times.

As shown in Table 7, the overall accuracy rate for words ending with consonants was 97.25%, with only 2.75% of the data showing participants automatically adding a schwa sound at the end of the syllable.

Table 5: Rhoticity rates in the interchangeable rhoticity production experiment

	car	fourth	floor	there	star	dark
Valid Tokens	51	51	51	46	50	41
Rhoticity Rate	84.31%	70.59%	74.51%	82.61%	84.00%	65.85%
Average	76.98%					

Table 6: Accuracy rates in the w-v production experiment

	we	went	very	windy	village	water	very
Valid Tokens	51	19	30	32	48	50	43
Accuracy Rate	98.04%	89.47%	100.00%	78.13%	97.92%	100.00%	95.35%
Average	94.13%						

Table 7: Accuracy rates in the additional schwa experiment

	dog	book	bag	cat	map
Valid Tokens	51	51	51	51	51
Accuracy Rate	96.08%	100.00%	100.00%	94.12%	96.08%
Average	97.25%				

As shown in Table 8, in the interchangeable s/sh and f/h perception experiment, the accuracy rate for words converting s to sh was 82.69%, while the accuracy rate for words converting sh to s was 85.58%, resulting in an overall accuracy rate of 84.13% for the s/sh distinction. The overall accuracy of the f/h distinction was 65.87%, of which the accuracy rate was 68.27% for words changing from "f" to "h" and 63.46% for words changing from "h" to "f." The accuracy rate for the f/h distinction was 18.26% lower than the accuracy for the s/sh distinction.

Table 8: Accuracy rates in the s/h and f/h perception experiment

	s→sh	sh→s	f→h	h→f
Accuracy Rate	82.69%	85.58%	68.27%	63.46%
Average	84.13%		65.87%	

In the additional schwa and optional rhoticity perception experiment, the accuracy rates for perceiving English words with an additional schwa sound and interchangeable rhoticity were both 100%, indicating that participants could fully comprehend English words with these subtle variations.

As shown in Table 9, the accuracy rates in the w/v conversion perception experiment for the words “we,” “went,” “very,” “windy,” “village,” “water”, and “very” were 86.54%, 69.23%, 46.15%, 50.00%, 82.69%, 84.62%, and 92.31%, respectively. The average accuracy rate was 73.08%. Notably, the words "went," "very," and "windy" had lower accuracy because mispronunciations sounded like

DOI: 10.54254/2753-7064/2024.20907

other correct English words, such as "vent" and "weary," which caused confusion and reduced accuracy.

Table 9: Accuracy rates in the w-v production experiment

Correct Answer	we	went	very	windy	village	water	very
Word in Audio	ve	vent	wery	vindy	willage	vater	wery
Accuracy	86.54%	69.23%	46.15%	50.00%	82.69%	84.62%	92.31%
Average	73.08%						

The response times and accuracy rates for the eight stickers in the response time experiment are shown in Tables 10 and 11, respectively. The stickers are divided into four categories based on similar response times and accuracy rates.

The first category includes the sticker duck 不必 (大可不必), with the fastest response time of 1.68 seconds and a 100% accuracy rate. The second category consists of stickers Even 不值 (一文不值) and eason 不吭 (一声不吭), with response times between 1.80 and 2.00 seconds and accuracy rates of 95% to 98%. The third category includes stickers star 皆空 (四大皆空), 无 fuck 说 (无话可说), and 关你 peace (关你屁事), with response times from 2.00 to 2.30 seconds and accuracy rates between 85% and 90%. The fourth category comprises 有 bear 来 (有备而来) and 心如 dog (刀割).

Table 10: Response time of the eight bilingual puns

No.	**Bilingual Pun**	**Response Time (S)**
1	大可不必	1.68
2	一声不吭	1.82
3	一文不值	1.98
4	关你屁事	2.08
5	无话可说	2.10
6	四大皆空	2.22
7	有备而来	3.57

Table 11: Accuracy rate of the eight bilingual puns

No.	**Bilingual Pun**	**Accuracy Rate**
1	大可不必	100.00%
2	一声不吭	98.08%
3	一文不值	96.15%
4	关你屁事	88.46%
5	无话可说	86.54%
6	四大皆空	86.54%
7	有备而来	73.08%
8	心如刀割	44.23%

4. Discussion

The non-sentence production experiment concerning s/sh and f/h distinctions reveals participants experience greater difficulty in articulating these phonetic differences when both distinctions

DOI: 10.54254/2753-7064/2024.20907

frequently appear in the sentence. This is substantiated by longer reading times in contrast to sentences without s/sh and f/h distinctions. The optional rhoticity production experiment showed that participants displayed interchangeable patterns in pronouncing rhotic words, though rhoticity remained the dominant pronunciation. Although participants rarely mispronounced words with an additional schwa, all were able to fully understand the mispronounced English words with added schwa and interchangeable rhoticity.

Contrary to the hypothesis that participants would frequently mispronounce words beginning with w or v—given that Chinese lacks the v sound—participants demonstrated a high accuracy rate of 94.13% in articulating sentences with high concentrations of w and v sounds. However, six instances of hypercorrection were observed, where “very windy” was pronounced as “very vindy,” indicating that some Chinese-English bilinguals are still influenced by the phonetic differences between the two languages.

In the experiment examining the interchangeable perception of s/sh and f/h, participants demonstrated a significantly lower accuracy rate in identifying phonetic shifts between f and h compared to those between s and sh. This indicates Chinese-English bilinguals experience more difficulty in differentiating between f and h, reflecting a reduced consonantal similarity in their perception relative to the s/sh distinction.

In the experiment on perceiving additional schwa and optional rhoticity, all participants correctly identified words with extra schwa sounds and interchangeable rhoticity, even though some mispronounced these words in the production tasks. Many participants showed interchangeable rhoticity patterns in their speech. Participants achieved a high accuracy rate of 73.08% in identifying sentences with w to v conversions and vice versa. This performance is deemed strong given the rapid tempo of the audio and the condition that participants listen to it only once.

The response time experiment analyses eight bilingual pun stickers, categorising them into four main groups based on comparable response times and accuracy rates. The specific order of the puns within each category is not highlighted because of the restricted sample size. The analysis identifies factors that facilitated faster recognition and improved accuracy in specific bilingual puns, as well as the impact of phonetic differences between categories on pun recognition. To effectively present these findings, alignments between English and their Chinese equivalents are delineated using the International Phonetic Alphabet (IPA) chart in Table 12.

Table 12: IPA alignments of the eight bilingual puns

Category	Pun	IPA	Chinese Equivalent	IPA
1	duck 不必	/dʌk/	大可不必	/ta4 kʰɤ3/
2	Even 不值	/iːvn/	一文不值	/i1 uən2/
	eason 不吭	/isən/	一声不吭	/i1 ʂɤŋ1/
3	无 fuck 说	/fʌk/	无话可说	/xwa4 kʰɤ3/
	star 皆空	/stɑː(r)/	四大皆空	/sɯ4 ta4/
	关你 peace	/piːs/	关你屁事	/pʰi4 ʂɚ4/
4	有 bear 来	/beə(r)/	有备而来	/peɪ4 aɻ2/
	心如 dog	/dɒg/	心如刀割	/tɑʊ1 kɤ1/

The first category demonstrates the shortest reaction time and the highest accuracy, characterised by similar articulatory features of consonants, such as d and k, in both languages. Previous studies [15] have shown that psychoacoustic similarity plays a crucial role in pun creation: speakers tend to aim for maximum similarity between consonants. The difference in vowel sounds—specifically the unrounded monophthongs /ʌ/ in 'duck' and /a/ in '大可'—does not significantly affect the pun's

DOI: 10.54254/2753-7064/2024.20907

interpretation. Furthermore, the inclusion of the schwa in the pronunciation transition from "duck" to "大可" does not hinder pun comprehension. This is evidenced by the additional schwa experiment, in which participants demonstrated 100% accuracy in recognising words containing the extra schwa.

Bilingual puns in the second category show slightly longer reaction times and lower accuracy compared to those in the first category. This category involves phonetic approximations of s/sh and v/w. In the pun "一文不值," the absence of the /v/ sound in Chinese often leads to its approximation with /w/. This is consistent with results from the production and perception experiments, where some participants hypercorrected by mispronouncing "very windy" as "very vindy." The w/v conversion experiment also supported this, showing a 74% accuracy rate in approximating w from v and vice versa. In "一声不吭," the phonetic approximation occurs between s and sh. As seen in the non-sentence experiment, participants spend an average of 6.71 seconds reading sentences with frequent s and sh sounds—1.13 seconds longer than those without these distinctions.

While the phonetic approximations between v/w and s/sh make the perception of bilingual puns easier, these subtle differences result in longer reaction times and lower accuracy compared to the first category, where the consonants and monophthongs are more similar. Additionally, in Even 不值 (一文不值), the long vowel /iː/ in "even" contrasts with the short vowel /i/ in the Chinese equivalent. In eason 不吭 (一声不吭), all vowels are short /i/. This shows that the change in vowel length does not influence participants' perception of bilingual puns. Additionally, the added schwa does not affect participants' perception of the bilingual puns in this category.

The third category shows reaction times ranging from 2.0 to 2.3 seconds, with accuracy rates between 85% and 90%. Compared to the first category (with nearly identical consonants and vowel pronunciations) and the second category (with phonetic approximations of w/v and s/sh), participants took longer to process the pun 无 fuck 说 (无话可说). This is due to the greater difficulty in distinguishing f and h. In earlier experiments without sentences, participants made more mistakes with f and h than with s and sh. Larger phonetic differences, like f/h, tend to slow down response times, while smaller differences, like s/sh or w/v, cause less delay. Additionally, both fuck and 话可 feature unrounded vowels (/ʌ/ and /a/, respectively). Importantly, we considered the data for the pun 关你 peace (关你屁事) as invalid, since it was the first sticker shown in the experiment. Despite the priming, data from this initial exposure may be unreliable.

The two instances in the fourth category show the longest response times and the lowest accuracy rates compared to the previous categories. In the rhoticity experiment, the average rhoticity rate is 77%, indicating that the response time for 有 bear 来 (有备而来) should be shorter than for 四大皆空, where the 'r' is not pronounced. This suggests that rhoticity is interchangeable for participants, as evidenced by the 100% accuracy rate in the rhoticity experiment. Further analysis of vowel differences reveals that the vowels in 有 bear 来 (/beə(r)/) and 有备而来 (/peɪ/ aɻ/) are all unrounded, with an additional /ɪ/ in the Chinese equivalent of bear. The diphthong /eə/ in bear is split into two monophthongs in the Chinese characters "备" and "而." In the pun 心如 dog (心如刀割), the vowel /ɒ/ in dog is a rounded monophthong, while its Chinese equivalent is the diphthong /ɑʊ/, combining an unrounded /ɑ/ and a rounded /ʊ/. While monophthong differences didn't greatly affect how participants understood puns, the switch from a diphthong to a monophthong, or between two diphthongs, likely caused longer response times. The extra /ɤ/ sound, like a schwa, didn't have much impact on understanding. Some participants also mispronounced "bear" as "beer," switching one diphthong for another, which made it harder for them to get the pun.

Our findings indicate the following (Figure1):

1) Phonetic similarity, especially in consonants, leads to shorter reaction times. The longest response times occur when this similarity is reduced.

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2) Although /ɤ/ and /ə/ are distinct vowels, the addition of either vowel at the end of English syllables tends to occur automatically, even though participants rarely mispronounce words in this manner. The presence of /ɤ/ or /ə/, and the distinction between them, does not impede participants' perception of bilingual puns.
3) Rhoticity does not significantly affect the perception of bilingual puns, even when it is cleverly integrated into puns like "有备而 (bear) 来" and "四大 (star) 皆空."
4) Phonetic approximations such as s/sh, w/v, and f/h result in faster response times, though not as fast as when the consonants are very similar. However, when the differences between sounds are more distinct, like with f and h, response times slow down, even if the sounds can still be approximated.
5) Changes between monophthongs do not affect how bilingual puns are understood, as seen in "大可 (duck) 不必" and similar examples. However, shifts from monophthongs to diphthongs, or from diphthongs to diphthongs, make it much harder for participants to recognize the puns.
6) Bilingual puns are easier to recognise when the vowel roundness stays the same. If an unrounded diphthong is changed to a rounded vowel in the Chinese version, like in "心如刀割," it becomes harder to identify the pun.
7) A hiatus, as in "有备而来," makes it more difficult to recognise the pun.
8) Changes in vowel length, such as switching from short to long vowels in the Chinese equivalent (like in "一声不吭"), do not affect how bilingual puns are understood.

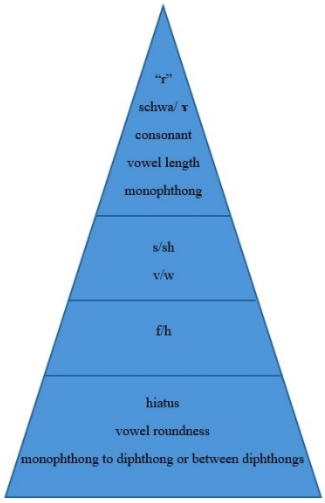

Figure 1: Different levels of hinderance of phonetic approximations in pun perception

5. Conclusion

This research demonstrates how various parameters—such as rhoticity, schwa, vowel length, monophthong, s/sh, v/w, f/h, hiatus, vowel roundness, and shifts from monophthong to diphthong or between diphthongs—affect the perception of bilingual puns among Chinese-English bilinguals. These parameters can either facilitate or hinder comprehension based on their degree of similarity or difference. We also observed that some English words in bilingual puns are capitalised when placed at the beginning of a phrase, following English writing conventions, as seen in Even 不值 and May 你啥. However, this capitalisation pattern is inconsistent.

Key recommendations from this study include:

1) When teaching English to Chinese bilinguals, it is important to emphasise rhoticity, as interchangeable rhoticity patterns were frequently observed in our participants' pronunciation.

DOI: 10.54254/2753-7064/2024.20907

2) Instructors should highlight key differences between Chinese and English pronunciation in pedagogical practices. For instance, since the v sound does not exist in Chinese, students should be made aware of this to avoid hypercorrections like “very vindy.”
3) Our findings suggest that changes between diphthongs significantly hinder perception. It is therefore important to have clear diphthong pronunciation. Proper vowel pronunciation, especially of diphthongs, should be reinforced. Many participants struggled to perceive the pun in “有 bear 而来” due to mispronunciations such as “bear” being pronounced as “beer.”
4) We also recommend incorporating stickers with bilingual puns into pedagogical practices to spark students’ interest in language learning and phonetic differences between English and Chinese.

The main limitations of this research are the small sample size and the lack of automated tools to measure response times accurately. Manually picking time spans from sound waveforms could cause errors. To reduce this problem, we grouped puns by response times and accuracy rates instead of focussing on their exact order. Additionally, although the interplay between text and image may influence participants’ perception of puns, our research does not include multimodal analysis, as the focus is on textual elements where stickers are considered solely as a medium for bilingual puns.

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