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7 One Writing System, Two Dialects: Tonal Information in Bilingual Visual Word Recognition

Abstract

How is the tonal information of written words activated when the reader is a bilingual of two tonal dialects? Standard Chinese (SC) and Jinan Mandarin (JM) are two tonal dialects and share a large number of etymologically related translation equivalents, which are represented by the same Chinese character and usually identical in segments but potentially different in tone. In the present study, we adopted a Stroop paradigm to examine the activation of tonal information in Chinese visual word recognition by tonal bilinguals and tonal monolinguals. Native Beijing SC monolinguals and Jinan JM-SC bilinguals named the ink color of Chinese characters in SC and the bilinguals also performed the color-naming in JM. The Chinese characters were either (1) color characters (e.g. 红, hong2, 'red'), (2) within-dialect homophones of the color characters (S+T+; e.g. 洪, hong2, 'flood'), (3) within-dialect different-tone homophones of the color characters (S+T−; e.g. 轰 , hong1, 'boom'), or (4) neutral characters (S−T−; e.g. 贯, guan, 'penetrate') as controls. We tested all the combinations of characters and ink colors. Both groups of participants showed classic Stroop interference for the incongruent conditions. However, only the bilinguals showed Stroop facilitation for the color-congruent conditions. They are slower in production but better at handling conflicts in lexical access. The within-dialect tonal effects were more complex than those found in earlier studies. Only the tonal monolinguals, not the tonal bilinguals, showed weak evidence in support of the retrieval of tonal information in automatic visual word recognition. Between-dialect tonal relations showed no additional effects on tonal bilinguals.

7.1 Introduction

Bilingual visual word recognition has been investigated in depth in earlier studies. It is clear that the bilinguals activate relevant lexical items from both languages and the interlingual activation happens even when the two languages use different types of orthographies. For instance, bilingual Stroop effects have been verified in many studies, where the color naming was in one language and the words were printed in another language, either with the same type of orthography or not (Chen & Ho, 1986; Dyer, 1971; Fang, Tzeng, & Alva, 1981; Kiyak, 1982; Preston & Lambert, 1969). A recent trilingual study further showed that the between-language interference and facilitation are both affected by the similarity of the scripts (Van Heuven, Conklin, Coderre, Guo, & Dijkstra, 2011).All these studies showed robust between-language interference while the interference is usually smaller between languages than within languages (MacLeod, 1991).

However, little is known about the automatic lexical activation by bilinguals who use the same logographic writing system for different languages or dialects, especially with regard to phonological activation. The bilingualism of related Chinese dialects involves a large number of etymologically related translation equivalents (i.e. cognates), which are similar in sound and written with the same Chinese characters. In such cases, one Chinese character can be associated with two similar but distinctive sounds in the mental lexicon of the bilinguals. Moreover, in the bilingualism involving Standard Chinese with a northern Mandarin dialect, such as Jinan Mandarin (JM) (Wu & Chen, 2014), the two interlingual pronunciations for the same Chinese character are usually almost identical in segments but can vary in their tonal similarity. This tonal bilingualism in related dialects is a common phenomenon in China but a special case of bilingualism.

Tonal bilingualism was not taken into consideration in earlier studies on Chinese visual word recognition. For instance, previous Chinese Stroop experiments did not report whether Standard Chinese (Mandarin) is their participants' only Chinese dialect (Li, Lin, Wang, & Jiang, 2013; Spinks, Liu, Perfetti, & Tan, 2000). It may therefore be the case that tonal bilinguals may read Chinese characters in a different way from monolinguals. If so, many questions remain open to answers. First, are tonal bilinguals different from tonal monolinguals in their automatic visual word recognition? Second, which phonological representations are activated in the bilingual mental lexicon by the common Chinese character? Are the different tonal representations from both dialects automatically activated via the same Chinese character?

Stroop-related paradigms have long been used to investigate visual word recognition (MacLeod, 1991). The classical Stroop effect (Stroop, 1935) emerges when participants are shown different words written in different colors. When they are asked to name the word, the ink color has no influence on the word naming time. However, when they are asked to name the ink color, they are unable to suppress the influence from the word. When the word and the ink color are congruent (e.g. 'RED' in red ink), the word will facilitate the color naming relative to an unrelated control word (Dalrymple-Alford, 1972). When the word and the ink color are incongruent (e.g. 'RED' in green ink), the word will interfere with the color naming relative to different types of controls, such as color patches, 'X's, unrelated words, and non-words (MacLeod, 1991). Without specific training (MacLeod & Dunbar, 1988; Stroop, 1935), the ink colors are usually ignored in word naming but the words cannot be ignored in color naming.

The Stroop effect is sensitive to the phonological relations between the printed word and the color name. Earlier studies on alphabetic writing systems verified that when the printed word shares phonemic features with a color word which is incongruent with the ink color, the interference increases (Dalrymple-Alford, 1972) (Dennis & Newstead, 1981; Singer, Lappin, & Moore, 1975; Underwood & Briggs, 1984), and when the printed word shares phonemic features with the color name, the interference is reduced, or the color naming is facilitated, depending on whether color patches or irrelevant words are used as the control condition (Effler, 1978). The effect size increases with the amount of phonemic sharing (Dennis & Newstead, 1981; MacLeod, 1991) and shows an initial letter effect (Dalrymple-Alford, 1972; Dennis & Newstead, 1981; Singer et al., 1975; Underwood & Briggs, 1984). Moreover, comparing pseudo-homophones of color words (e.g. *bloo* for *blue*) with non-words matched for visual similarity and initial phonemic overlap with color words (e.g. *blir* for *blue*) showed that the phonemic effects in alphabetic writing systems are not just a result of orthographic similarity (Dennis & Newstead, 1981).

The phonological effects are neither limited to alphabetic writing systems nor limited to segmental relations. Similar phonemic effects have also been observed in Chinese, which uses a logographic (sometimes also termed as 'ideographic') writing system and has lexical tones. Both segmental and tonal sharing between the printed word and the color character (the orthographic unit that represents a syllable with a specific meaning and tone) showed the phonemic effects, in that segmental homophones of color characters facilitated the naming of congruent colors and interfered with the naming of incongruent colors (Li et al., 2013; Spinks et al., 2000), and additional tonal sharing slightly added to the facilitation from segmental homophones in two of the experiments (Spinks et al., 2000, Experiment 1 and Li et al., 2013). Also, Li et al. (2013) found phonological facilitation based on tonal sharing alone. Using a related picture-word interference paradigm, it has also been found that the distractor and target matching in underlying tonal category and overt tonal realization facilitated picture naming (Nixon, Chen, & Schiller, 2014). Compared with the results using alphabetic scripts, the Stroop interference with Chinese characters is at least of the same strength (Lee & Chan, 2000) (Smith & Kirsner, 1982) if not greater (Biederman & Tsao, 1979; Saalbach & Stern, 2004; Tsao, Wu, & Feustel, 1981), although it has been shown that Chinese Stroop tasks may involve more right hemisphere interference (Tsao et al., 1981). The Stroop phonemic effects in Chinese are also in line with the more general findings, with segmental information carrying more weight than tonal information (Li et al., 2013; Spinks et al., 2000).

The phonological effects found in Stroop paradigms reflect the automatic activation of phonological information in visual word recognition. Although there are different theoretical accounts for the Stroop effect (Cohen, Dunbar, & McClelland, 1990; MacLeod, 1991; Posner & Snyder, 1975), it is now generally agreed that, when the task is color naming, the activation of the printed words is relatively automatic and can escape the attention to some extent (Cohen et al., 1990), differently from when the task is word naming. This automatic phonological activation is also valid in Chinese Stroop paradigms, although the Chinese writing system is logographic. In previous studies (Li et al., 2013; Spinks et al., 2000), the pronunciations of the Chinese characters affected the color naming latency. Together with other findings using the priming paradigm (Perfetti & Zhang, 1991, 1995), the Stroop phonological effects in Chinese indicate that the phonological information carried by the Chinese characters is automatically activated even if the task does not require word naming.

Moreover, compared with the other Stroop-like paradigms (such as the picture-word interference paradigm), the classical color-word paradigm holds a relatively more constant attention demand for the non-word dimension across trials. This allows more detailed manipulations on the word dimension. These features make the Stroop paradigm especially interesting for investigating the automatic activation of phonological information by bilinguals.

In the present study, the phonological effects in Stroop paradigm can be used to differentiate the activations of JM and SC lexical nodes and tonal representations in the automatic visual word recognition. If we find phonological sharing increases facilitation or reduces interference, the corresponding phonological information should be activated. The phonological relation between the printed color character and the ink color can be manipulated within and between dialects, yielding different levels and dimensions of phonological sharing. The different color-character combinations can also serve as controls for one another.

We replicated the Stroop experiment (Li et al., 2013; Spinks et al., 2000) on Jinan tonal bilinguals in Standard Chinese (SC) and Jinan Mandarin (JM), as well as on Beijing tonal monolinguals in SC. Tonal bilinguals and monolinguals both named the ink color of Chinese characters in SC and the bilinguals also named the ink color in JM. Taking the between-dialect conditions into consideration, additional stimuli were added and some stimuli were replaced to avoid unintended between-dialect sharing. As shown in Table1.1, considering the tonal relation of the character and its related color characters within each dialect, the Chinese characters were either

(1) color characters (e.g. 红, hong2, 'red'),

(2) within-dialect homophones of the color characters (S+T+; e.g. 洪, hong2, 'flood'),

(3) within-dialect different-tone homophones of the color characters (S+T−; e.g. 轰, hong1, 'boom'), or

(4) neutral characters (S−T−; e.g. 贯, guan, 'penetrate').

Each within-dialect condition except the neutral characters was shown with both congruent and incongruent ink colors (e.g. 红 'red', 洪 'flood', and 轰 'boom' in red versus in green). Differently from the previous studies (Li et al., 2013; Spinks et al., 2000), which only tested each character with one congruent and one incongruent color, we tested all the combinations of characters and ink colors. With the reaction times of the neutral trials for the same colors as the base-lines, we expect to find Stroop facilitation for the congruent trials and Stroop interference for the incongruent trials, as was found in earlier studies (Li et al., 2013; Spinks et al., 2000). The corresponding statistics on the effects of Stroop congruence are provided in Analysis 1 and the different within-dialect phonological conditions were compared in Analysis 2.

Two comparisons were made to replicate the S−T+ (tone-only) condition tested in Li et al.'s (2013) study in Analysis 2, 3, and 4. First, as shown in Table 1.2, the neutral (S−T−) characters designed for some colors shared the tone with another color (S−T+) [e.g. 贯, guan2, 'penetrate', is S−T− for 红 'red' but share the same tone (S−T+) for '绿' lü2] in both dialects[11].Such tonal congruent and tonal incongruent neutral-character trials were tested against each other for every ink color. Li et al.'s (2013) finding predicts a significant tone-only facilitation of S−T+ trials compared with S−T− trials. Second, as shown in Table 1.3, a S+T− trial presented with an incongruent ink color can share the tone with the name of the ink color or not (e.g. 览, lan3, 'view', S+T− with 蓝, lan2, 'blue', is incongruent with

[11] Note that due to the tonal systematic correspondence across the two dialects, characters from the same tonal category in SC are mostly also from the same tonal category in JM and we only included the stimuli which follow the systematic corresponding rules. For instance, here the tonal marking '2' is referring to both the JM high-falling and SC high-rising tones.

both green and purple ink colors but only shares the tone with the name of purple, zi3). If the tonal information is independently activated in the automatic visual word recognition, such S+T− trials with incongruent ink colors of the same tone (e.g. 览 in purple) should show reduced Stroop interference compared with the other incongruent S+T− trials (e.g. 览 in green).

The effects of the three language modes, SC-monolingual, SC-bilingual, JM-bilingual and their interactions with the within-language condition were examined for the bilingual effects. Bilinguals have been found to be slower in lexical retrieval (Bialystok, 2009; Gollan, Montoya, Fennema-Notestine, & Morris, 2005; Ransdell & Fischler, 1987; Rogers, Lister, Febo, Besing, & Abrams, 2006) but better at solving the conflict of tasks (Bialystok, 2009; Carlson & Meltzoff, 2008; Hilchey & Klein, 2011; Prior & Gollan, 2011), including the conflict of the Stroop task (Bialystok, Craik, & Luk, 2008). However, it remains unclear whether earlier findings on bilinguals of non-tonal languages are applicable to tonal bilinguals of related dialects. If tonal bilinguals are like other bilinguals, we expect the tonal bilinguals to be generally slower than monolinguals in the Stroop task but show less Stroop interference. Moreover, Spinks et al. (2000) and Li et al. (2013) did not specify whether their Mandarin (SC) speakers are tonal monolinguals or bilinguals. The present study will clarify which of their findings are replicable on both native bilinguals and monolinguals and which are only true for one of the speaker groups.

In the present study, we also investigated between-dialect tonal activation by comparing trials which have the same within-dialect tonal relation in SC but different between-dialect tonal relations, as shown in Table 1.4 and Table 1.5. For instance, both 烂, lan4, 'rotten' and 览, lan3, 'view' are S+T− to the color character 蓝, lan2, 'blue' in SC. However, different from 'view', the SC pronunciation of 'rotten' carries a falling tone (Falling), which turns the SC version of 'rotten' to a false friend of the JM pronunciation of 'blue' (JM 'blue' lan2 = /lan(High-falling)/). As another example, 绿, lǜ2, 'green', with falling tones in both dialects, is an identical cognate in JM and SC, but the other color characters carry different tonal contours in JM and SC. If there is cross-dialect tonal activation in automatic visual word recognition, beside the general bilingual effects, we should observe additional differences in regard to these special characters between the two groups of participants (in Analysis 5 and 6).

Table 1.1 Critical trials for the within-Dialect conditions

Condition	Color Characters	S+T+	S−T−	S+T−[a]	S−T− (neutral)
Character	蓝	栏	烂	览	抱
Translation	blue	fence	rotten	view	hold
Frequency [b]	102.59	32.37	48.50	52.81	131.29
N strokes	13	9	9	9	8
Pronunciation SC	lan(Hr)	lan(Hr)	lan(F)	lan(Lr)	pau(F)
Pronunciation JM	lan(Hf)	lan(Hf)	lan(Lf)	lan(Hl)	pau(Lf)
Common pinyin	lan2	lan2	lan4	lan3	bao4
Character	绿	虑	旅/驴		涂
Translation	green	consider	travel/ donkey		smear
Frequency	133.39	180.17	153.50/ 26.45		59.16
N strokes	11	10	10/ 6		10
Pronunciation SC	ly(F)	ly(F)	ly(Lr)/ ly(Hr)		t^{h}u(Hr)
Pronunciation JM	ly(Lf)	ly(Lf)	ly(Hl)/ ly(Hf)		t^{h}u(Hf)
Common pinyin	lü4	lü4	lü3/ lü2		tu2
Character	紫	子	自		鼻
Translation	purple	child	self		nose
Frequency	99.84	4001.12	3113.46		83.87
N strokes	12	3	6		13
Pronunciation SC	tsɿ(Lr)	tsɿ(Lr)	tsɿ(F)		pi(Hr)
Pronunciation JM	tsɿ(Hl)	tsɿ(Hl)	tsɿ(Lf)		pi(Hf)
Common pinyin	zi3	zi3	zi4		bi2
Character	红	洪	轰		贯
Translation	red	flood	boom		penetrate
Frequency	419.08	122.34	79.11		89.37
N strokes	6	9	8		8
Pronunciation SC	xuŋ(Hr)	xuŋ(Hr)	xuŋ(Hl)		kuan(F)
Pronunciation JM	xuŋ(Hf)	xuŋ(Hf)	xuŋ(R)		kuan(Lf)
Common pinyin	hong2	hong2	hong1		guan4
Character	黄	皇	荒	谎	岸
Translation	yellow	emperor	shortage	lie	shore
Frequency	478.04	438.15	106.25	27.59	16.46
N strokes	11	9	9	11	8
Pronunciation SC	xuaŋ(Hr)	xuaŋ(Hr)	xuaŋ(Hl)	xuaŋ(Lr)	an(F)
Pronunciation JM	xuaŋ(Hf)	xuaŋ(Hf)	xuaŋ(R)	xuaŋ(Hl)	an(Lf)
Common pinyin	huang2	huang2	huang1	huang3	an4

a. JM High-falling is undergoing merging with JM High-level

b. Character per million frequencies on the Chinese Text Computing website (Da, 2004; http://lingua.mtsu.edu/chinese-computing/).

c. Abbreviation for tones. SC: Hl = High-level (1), Hr = High-rising (2), Lr = Low-rising (dip tone) (3), F = Falling (4). JM: R=Rising (1), Hf=High-falling (2), Hl=High-level (3), Lf=Low-falling (4)

Table 1.2 S−T− and S−T+ trials combined with different ink colors

Color		S−T+	S−T−
Blue	Character	涂/鼻	抱/贯/岸
Red	Translation	smear/nose	hold/penetrate/shore
Yellow	Frequency	59.16/83.87	131.29/89.37
(SC: Hr	Number of strokes	10/13	8/8/8
JM: Hf)	Pronunciation SC	t^{h}u(Hr)/pi(Hr)	pau(F)/kuan(F)/an(F)
	Pronunciation JM	t^{h}u(Hf)/pi(Hf)	pau(Lf)/kuan(Lf)/an(Lf)
	Common pinyin	tu2/bi2	bao4/guan4/an4
Green	Character	抱/贯/岸	涂/鼻
(SC: F	Translation	hold/penetrate/shore	smear/nose
JM: Lf)	Frequency	131.29/89.37	59.16/83.87
	Number of strokes	8/8/8	10/13
	Pronunciation SC	pau(F)/kuan(F)/an(F)	t^{h}u(Hr)/pi(Hr)
	Pronunciation JM	pau(Lf)/kuan(Lf)/an(Lf)	t^{h}u(Hf)/pi(Hf)
	Common pinyin	bao4/guan4/an4	tu2/bi2

Table 1.3 S+T− trials combined with T− or T+ incongruent ink colors.

S+T− characters		Related color	T+ color	T− color
Character	览			
Translation	view	blue	purple	green/red/yellow
Pronunciation SC	**lan(Lr)**	**lan**(Hr)	tsɿ(**Lr**)	ly(F)/xuŋ(Hr)/xuaŋ(Hr)
Pronunciation JM	**lan(Hl)**	**lan**(Hf)	tsɿ(**Hl**)	ly(Lf)/xuŋ(Hf)/xuaŋ(Hf)
Common pinyin	**lan3**	**lan**2	zi**3**	lü4/hong2/huang3
Character	旅			
Translation	travel	green	purple	blue/red/yellow
Pronunciation SC	**ly(Lr)**	**ly**(F)	tsɿ(**Lr**)	lan(Hr)/xuŋ(Hr)/xuaŋ(Hr)
Pronunciation JM	**ly(Hl)**	**ly**(Lf)	tsɿ(**Hl**)	lan(Hf)/xuŋ(Hf)/xuaŋ(Hf)
Common pinyin	**lü3**	**lü**4	zi**3**	lan2/hong2/huang2
Character	谎			
Translation	lie	yellow	purple	blue/green/red
Pronunciation SC	**xuaŋ(Lr)**	**xuaŋ**(Hr)	tsɿ(**Lr**)	lan(Hr)/ly(F)/xuŋ(Hr)
Pronunciation JM	**xuaŋ(Hl)**	**xuaŋ**(Hf)	tsɿ(**Hl**)	lan(Hf)/ly(Lf)/xuŋ(Hf)
Common pinyin	**huang3**	**huang**2	zi**3**	lan2/lü4/hong2

Table 1.4 Test pairs for the between-dialect tonal relation (1): within-dialect S+T− to the same corresponding color characters, S+T+ v.s. S+T− between-dialect false friends.

	S+T+ between dialects	S+T− between dialects
Character	烂	览
Translation	rotten	view
Frequency [b]	48.50	52.81
N. strokes	9	9
Pronunciation SC	lan(F)	lan(Lr)
Pronunciation JM	lan(Lf)	lan(Hl)
Common pinyin	lan4	lan3
Within-dialect condition	S+T− to the ColChar. ‘blue’	S+T− to the ColChar. ‘blue’
Notes	SC lan(F) (rotten) ≈ JM lan(Hf) (blue)	
Character	驴	旅
Translation	donkey	travel
Frequency [b]	26.45	153.50
N. strokes	6	10
Pronunciation SC	ly(Hr)	ly(Lr)
Pronunciation JM	ly(Hf)	ly(Hl)
Common pinyin	lü2	lü3
Within-dialect condition	S+T− to the ColChar. ‘green’	S+T− to the ColChar. ‘green’
Notes	JM ly(Hf) (donkey) ≈ SC ly(F) (green)	
Character	荒	谎
Translation	shortage	lie
Frequency [b]	106.25	27.59
N. strokes	9	11
Pronunciation SC	xuaŋ(Hl)	xuaŋ(Lr)
Pronunciation JM	xuaŋ(R)	xuaŋ(Hl)
Common pinyin	huang1	huang3
Within-dialect condition	S+T− to the ColChar. ‘yellow’	S+T− to the ColChar. ‘yellow’
Notes	SC xuaŋ(Hl)(shortage) ≈ JM xuaŋ(Hf) (yellow)	

ColChar. = Color Character; N. strokes = Number of Strokes

Table 1.5 Test sets for the between-dialect tonal relation (2): color characters, as S+T+ v.s. S+T− cognates between dialects, and S+T+ homophones to the corresponding color characters, as S+T+ v.s. S+T− false friends between dialects.

Between-Dial. color cognates	S+T+	S+T−			
Character	绿	蓝	紫	红	黄
Translation	green	blue	purple	red	yellow
Frequency [b]	133.39	102.59	99.84	419.08	478.04
N. strokes	11	13	12	6	11
Pronun. SC	ly(F)	lan(Hr)	tsɿ(Lr)	xuŋ(Hr)	xuaŋ(Hr)
Pronun. JM	ly(Lf)	lan(Hf)	tsɿ(Hl)	xuŋ(Hf)	xuaŋ(Hf)
Common pinyin	lü4	lan2	zi3	hong2	huang3
Within-dialect condition	ColChar. 'green'	ColChar. 'blue'	ColChar. 'purple'	ColChar. 'red'	ColChar. 'yellow'
Notes	JM ly(Lf) (green) ≈ SC ly(F) (green)				
Between-Dial. false friends	**S+T+**	**S+T−**			
Character	虑	栏	子	洪	皇
Translation	consider	fence	child	flood	emperor
Frequency [b]	180.17	32.37	4001.12	122.34	438.15
N. strokes	10	9	3	9	9
Pronun. SC	ly(F)	lan(Hr)	tsɿ(Lr)	xuŋ(Hr)	xuaŋ(Hr)
Pronun. JM	ly(Lf)	lan(Hf)	tsɿ(Hl)	xuŋ(Hf)	xuaŋ(Hf)
Common pinyin	lü4	lan2	zi3	hong2	huang3
Within-dialect condition	S+T+ to the ColChar. 'green'	S+T+ to the ColChar. 'blue'	S+T+ to the ColChar. 'purple'	S+T+ to the ColChar. 'red'	S+T+ to the ColChar.' yellow'
Notes	JM ly(Lf) (consider) ≈ SC ly(F) (green)				

ColChar. = Color Character; N. strokes = Number of Strokes

7.2 Experiment

7.2.1 Participants

Forty-eight native tonal monolinguals of SC from Beijing (7 male and 41 female, aged between 19 and 30, M = 22.73, SD =2.95) and 54 native SC-JM tonal bilinguals from Jinan (16 male and 38 female, the age ranged from 19 to 36, M = 22.70, SD = 3.85, 44 SC dominant or balanced, 10 JM dominant) participated in this experiment in exchange for payment. Both groups are right-handed, received their literacy educations in SC, and have learned some English in school. Four participants from the Jinan group and 15 participants from the Beijing group also have some knowledge of other non-tonal foreign languages, such as French and German.

7.2.2 Design and stimuli

An unbalanced mixed design was adopted. The stimuli were presented in five different ink colors (blue, green, purple, red, and yellow) including 230 (23 characters × five colors × two repetitions) critical trials and ten neutral training trials. Within the 23 characters, four were related to the color character of ‘blue’, four were related to the color character of ‘green’, three were related to the color character of ‘purple’, three were related to the color character of ‘red’, four were related to the color character of ‘yellow’, and the remaining five were neutral characters each assigned to one color character. The five or four characters related to the same color character include the color character, the S+T+ character, the S+T− character, JM merging S+T− character (when available), and neutral character (see Table 1.1for the stimulus characteristics). Each non-neutral character was congruent with one color and incongruent with the remaining four colors. Additional within-dialect and between-dialect relations were considered separately (see Table 1.2, 1.3, and 1.4 for details) in Analyses 2 to 6. Beijing monolinguals of SC were tested with all the stimuli in SC mode and Jinan bilinguals were tested with the same stimuli in both SC and JM modes.

7.2.3 Procedure

The experiment was implemented using the E-Prime software (Schneider, Eschman, & Zuccolotto, 2002). Participants named the color of the characters shown on the screen as quickly and accurately as possible. Each trial started with the presentation of a fixation cross that appeared in the center of the screen for 1,000 ms, followed by the target character printed in 48-point SimSun font, which disappeared after 2,000 ms. Then the following trial started. A recording was made from the appearance of each target character until the appearance of the next character. Critical trials were preceded by ten neutral training trials. The two repetitions of the critical trials were split into two blocks and the trials within each block appeared in different randomized orders for each participant. The order of the trials in the whole experiment was recorded for further analysis. Half of the bilinguals were first tested in the SC mode and then in the JM mode and the other half were first tested in the JM mode and then in the SC mode. The language mode was prompted by the dialect of the auditory instruction and five auditory examples of color naming. The bilinguals had a short break and other tasks (first in the previously tested language mode and then in the coming language mode) between the two Stroop experiments in different modes to avoid abrupt switching. The monolinguals were tested with exactly the same procedure (with auditory instruction and other tasks before) but only in the SC mode.

The naming latencies of the recordings were automatically measured with a Praat (Boersma & Weenink, 2014) script (Pacilly, 2010) based on the intensity of the sound pressure. Then a trained phonetician (the first author) listened to each recording, looked at the waveform and spectrogram, and manually corrected any errors in the marking. The naming accuracy of each recording was also manually marked in this process.

7.2.4 Analysis and discussion

Six sets of linear mixed-effect (LME) models were built to investigate the Stroop effects (Analysis 1), within-dialect segmental effects (Analysis 2), within-dialect tonal effects (Analysis 2, 3, 4), and between-dialect tonal effects (Analysis 5, 6). Reaction time (RT) analysis was based on the correct trials only. To improve the distribution of the data, RT data were log-transformed. Naming latency outliers were excluded for each participant using a distribution based approach (van der Loo, 2010), method I) on the log transformed naming latency. *Trial Order in the Same Color* and *Trial Distance from the Same Color* were calculated for each trial using the trial order data. Table 2 shows descriptive statistics for RTs and error rates organized by within-dialect condition and language modes. The reaction times in the congruent conditions were subtracted from reaction times in the neutral conditions for facilitation (negative) and interference (positive) effects.

Since the design was unbalanced, we performed linear mixed-effect (LME) analysis on different subsets of the log-transformed reaction times to investigate the influences and interactions of different between- and within-participant predictors. The analyses were performed using R (R_Core_Team, 2013), lme4 (Bates, Maechler, Bolker, & Walker, 2013), and lmerTest (Kuznetsova, Brockhoff, & Christensen, 2013). The LME models are summarized in the Appendix. The significance was calculated with Satterthwaite approximation for degrees of freedom (Kuznetsova et al., 2013; SAS, 1978) but the more transparent numeric degrees of freedom were reported. Separate models were used to analyze congruent and incongruent trials. Random terms include by-item and by-participant intercepts or slopes for the effect of *Trial*, *Trial Distance from the Same Color*, and/or *Trial Order in the Same Color,* selected via model comparison based on likelihood ratio tests. The post-hoc contrasts between conditions were calculated with the lmerTest package and the significance was marked in Table 2, 3.1 and 3.2. We performed six sets of LME analyses as shown in the following part.

7.2.5 Results

Statistics of all the LME models are summarized in the Appendices. The rest of the results are presented as follows.

Analysis 1 Stroop Effects. To investigate the classical Stroop congruence effects, the first LME analysis compared each non-neutral within-dialect condition with the corresponding neutral characters. In these models, *Within-Dialect Condition* (a non-neutral condition versus the corresponding neutral condition), *Mode*, *Target Color*, *Trial Order in the Same Color*, *Trial Distance from the Same Color,* and their interactions were the fixed predictors.

The main effects of *Within-Dialect Condition* were significant in all the models. Compared with the neutral condition, significant facilitations emerged for all the congruent color characters and significant interference emerged for all the incongruent color characters. The main effects of *Mode* were significant in all the models, except the model comparing JM tonal-merging characters with the neutral characters presented with congruent colors. The post-hoc analysis of Differences of Least Squares Means (DLSM) showed that bilinguals named colors generally more slowly than monolinguals but the difference between the bilinguals' SC and JM modes was insignificant. The interaction between *Within-Dialect Condition* and *Mode* was significant in all the models, except the two models comparing the (S+T−) and JM tonal-merging characters with the neutral characters presented with congruent colors. The post-hoc analysis of DLSM showed that the congruent conditions facilitated the bilinguals more than the monolinguals and the incongruent conditions affected the bilinguals less than the monolinguals. Different from the bilinguals, the monolinguals showed no significant Stroop facilitation but only Stroop interference, as shown in Table 2.

The Stroop interference and facilitation is consistent with the earlier findings (Li et al., 2013) (Spinks et al., 2000) and indicate that phonological information in Chinese is activated automatically in visual word recognition. Tonal bilinguals are slower than tonal monolinguals in the Stroop task but they benefit more from the congruent conditions and suffered less from the incongruent conditions. This is consistent with the other earlier findings that bilinguals are slower in lexical retrieval (Bialystok, 2009; Gollan et al., 2005; Ransdell & Fischler, 1987; Rogers et al., 2006) but better at solving conflicts of tasks (Bialystok, 2009; Bialystok et al., 2008; Carlson & Meltzoff, 2008; Hilchey & Klein, 2011; Prior & Gollan, 2011). The Stroop interference of both bilinguals and monolinguals was consistent with Spinks et al.'s (2000) findings. The Stroop facilitation of the tonal bilinguals was also consistent with the earlier findings (Li et al., 2013; Spinks et al., 2000). However, the tonal monolinguals showed no such Stroop facilitation. Since the previous studies did not specify whether their Mandarin speakers had a background in other Chinese dialects, the Stroop facilitations found by Spinks et al. (2000) and Li et al. (2013) may be specifically due to tonal bilingualism instead of the usage of tone.

Table 2 Response times of correct trials (RTs, with SDs in parentheses) and errors (with SDs in parentheses) in each within-dialect condition

Condition	JM RT (ms)	JM Errors (%)	JM Stroop Effects	SC-bi RT (ms)	SC-bi Errors (%)	SC-bi Stroop Effects	SC-mono RT (ms)	SC-mono Errors (%)	SC-mono Stroop Effects
Cong. ColChar.	706 (193)	0.2 (1.4)	-20 ***	688 (177)	0.4 (2.0)	-38 ***	700 (193)	0.0 (0.0)	19 ns.
Cong. S+T+	686 (176)	0.0 (0.0)	-40 ***	692 (173)	0.6 (2.4)	-34 ***	683 (174)	0.2 (1.4)	2 ns.
Cong. S+T−	701 (187)	0.7 (2.3)	-25 ***	708 (172)	0.2 (1.2)	-18 **	688 (172)	0.7 (2.3)	7 ns.
Cong. S+T− JM merging	685 (169)	0.0 (0.0)	-41 ***	673 (162)	0.0 (0.0)	-53 ***	674 (157)	0.0 (0.0)	-7 ns.
InC. ColChar.	821 (227)	3.5 (5.4)	95 ***	810 (220)	2.6 (3.2)	84 ***	828 (220)	3.0 (3.2)	147 ***
InC. S+T+	757 (195)	1.7 (3.0)	31**	752 (187)	1.2 (2.0)	26**	741 (192)	1.7 (2.8)	60***
InC. S+T−	752 (194)	1.2 (2.3)	26 **	744 (185)	0.7 (1.1)	18 *	730 (183)	0.9 (1.5)	49 ***
InC. S+T− JM merging	746 (205)	1.0 (2.3)	20 **	736 (183)	1.1 (3.0)	10 ns.	722 (174)	0.5 (1.7)	41 ***
S−T− (neutral controls)	726 (199)	0.4 (2.0)		726 (199)	0 (0)		681 (157)	0.4 (2.9)	

ns. $p > .05$; * $p < .05$; ** $p < .01$; *** $p < .001$.
Cong. = Congruent; ColChar. = Color Character; InC. = Incongruent.

Analysis 2 Segmental and (Lack of) Tonal Effects. To investigate the within-dialect phonological Stroop effects, the second LME analysis excluded neutral trials and compared different within-dialect conditions listed in Table 1.1, with congruent and incongruent conditions analyzed in separate models. This analysis sheds lights on the different roles of segmental and tonal information in visual word recognition. In these models, *Within-Dialect Condition* (color characters/homophones of the color characters/different-tone homophones of the color characters/different-tone homophones of the color characters with potential tonal merging in JM), *Mode*, *Target Color*, *Trial*, *Trial Distance from the Same Color*, and their interactions were the fixed predictors.

The main effect of *Within-Dialect Condition* was significant in the model for the incongruent conditions but insignificant in the model for the congruent conditions. The main effect of Mode was significant in both models, showing similar bilingual disadvantage of lexical access as in Analysis 1. The interaction of *Within-Dialect Condition* and *Mode* was significant in the model for the incongruent conditions but insignificant in the model for the congruent conditions. The descriptive statistics of each within-dialect condition are shown in Table2. In the post-hoc analysis of DLSM, the Stroop interference from color characters was greater than that from the three types of homophones. However, whether the homophone shared the same tone with the corresponding color character did not affect the strength of Stroop interference, except that the bilinguals in SC mode showed greater interference with S+T+ homophones than with S+T− homophones with potential tonal merging in JM. The post-hoc analysis on the model for congruent trials showed few significant contrasts, with only two exceptions. First, when bilinguals performed in SC mode, the Stroop facilitation was significantly greater for the color characters than for the S+T− homophones. Second, when bilinguals performed in the JM mode the Stroop facilitation was significantly smaller for the color characters than for the S+T+ homophones.

The stronger Stroop interference from color characters is consistent with the earlier study by Spinks (2000) and can be attributed to the semantic and lexical activation of the characters. However, the stronger Stroop facilitation from color characters (Li et al., 2013; Spinks et al., 2000) was only partially replicated by the bilinguals but not at all by the monolinguals, indicating that the Stroop facilitation found earlier may be specific to Chinese tonal bilinguals. Actually, as was also shown in Analysis 1, monolinguals showed no significant Stroop facilitation. As for the Stroop facilitation with the bilinguals, the pattern was also inconsistent in different modes. Only the bilinguals' Stroop facilitations in SC mode were similar to earlier findings (Li et al., 2013; Spinks et al., 2000). Instead, in JM mode it is the S+T+ homophones that showed the greatest Stroop facilitation. The different strength of facilitation between S+T+ and S+T− homophones found by Li (2013) and Spinks (2000, Exp. 1) was not replicated in any mode or either group of participants. Thus although the results of Analysis 1 support the activation of phonological information of the characters, no evidence was found in Analysis 2 in support of additional tonal activation beside the activation of the segmental structure.

Analysis 3 & 4 Tonal effects. The third and fourth LME analysis further investigated the effect of tonal information within the target dialect. The data were stratified according to the target colors in the third analysis. A set of LME models specifically compared S−T+ and S−T− trials for each target color (as shown in Table 1.2, e.g. 贯, guan4, 'penetrate', is S−T−, but 鼻, bi2, 'nose', is S−T+ for the target color red, hong2). In these models, *Same Tone* (the character is S−T− / S−T+ with the ink color), *Mode*, *Trial*, *Trial Distance from the Same Color*, and their interactions were the fixed predictors. Similarly, in the fourth analysis the trials shown in Table 1.3 were stratified according to the language mode (SC-bilingual, JM-bilingual, & SC-monolingual). A set of LME models specifically compared T− and T+ incongruent ink colors combined with S+T− characters (e.g. 览, lan3, 'view', S+T− with the color character 蓝, lan2, 'blue', is S−T− for the target color green, lü2, but S−T+for the target color purple, zi3) in each mode. In these models, *Color* (T+ color / T− color), *Within-Dialect Condition* (S+T− character / neutral character), *Trial*, *Trial Distance from the Same Color*, and their interactions were the fixed predictors.

In Analysis 3 the main effects and interactions of *Same Tone* and *Mode* were insignificant with most ink colors. As shown by the descriptive statistics and the significance of the post hoc DLSM contrasts in Table 3.1, compared with common neutral (S−T−) characters, characters sharing the tone alone (S−T+) with target ink color did not facilitate color naming. Instead when the ink color was yellow, the ink color was produced significantly slower with S−T+ characters than with S−T− characters in SC modes.

Table 3.1 Response times of correct trials (RTs, with SDs in parentheses) in S−T− and S−T+ trials combined with each color

	JM			SC-bi			SC-mono		
	S−T−	S−T+ [a]	Effect T+	S−T−	S−T+	Effect T+	S−T−	S−T+	Effect T+
blue	769 (175)	789 (179)	20 ns.	760 (186)	795 (190)	35 ns.	738 (170)	761 (191)	23 ns.
green	752 (222)	742 (192)	-10 ns.	773 (187)	757 (180)	-16 ns.	722 (168)	745 (176)	23 ns.
red	641 (164)	658 (162)	17 ns.	653 (162)	653 (162)	0 ns.	624 (169)	642 (149)	18.
yellow	677 (188)	695 (197)	18 ns.	661 (183)	689 (186)	28*	640 (152)	682 (193)	42*

ns. $p > .05$; * $p < .05$; . $p < 0.1$

a. The S−T+ characters are 'hold', 'penetrate', and 'shore' for green and 'smear' and 'nose' for the other colors. The S+T− characters for green and the other colors are the reverse.

These results are in contrast with the tone-alone Stroop facilitations found by Lin et al. (2013). In the present study the tone-alone effect was generally absent and when it is significant, the effect was interference instead of facilitation. The difference could be attributed to the fact that we used different S−T+ characters. However, our findings at least suggest that the tone-alone effect in automatic visual word recognition is not robust.

Nevertheless, we did find new evidence in support of tonal activation in Analysis 4. The crucial trials in Analysis 4 were homophone characters which shared the segmental structure but not the tone (S+T−) with the relevant color character and shared the tone but not the segmental structure (S−T+) with the ink color (e.g. 览, lan3, 'view', S+T− with 蓝, lan2, 'blue', is S−T+ with the ink color name, zi3, 'purple').The deviation of these crucial trials from the neutral trials with the same ink color (e.g. the deviation of 览, lan3, 'view' in the T+ color, purple, from the neutral character 鼻, bi2, 'nose' in purple) was taken and the size of interference and compared with the deviation of the other incongruent trials (with the same S+T− character as in the crucial trials) from corresponding neutral trials (e.g. the deviation of 览, lan3, 'view' in a T− color, green, from the neutral character 涂, tu2, 'smear' in green). As expected, the main effects of *Color* were significant in all the models. However, since the ink colors are generally different in naming latencies (as shown in Analysis 1), the main effect of *Color* is not necessarily due to the difference in tonal sharing. On the other hand, the main effects of *Within-Dialect Condition* (S+T− character / neutral character) were only significant in the models for the monolinguals' data and the models for the character 谎, huang3, 'lie'. As was also shown earlier in Analysis 1, the bilinguals generally received less interference in the incongruent trials. Correspondingly in the models of Analysis 4, the contrasts between S+T− characters and neutral characters did not reach significance for the bilinguals. The interactions between *Color* and *Within-Dialect Condition* were also insignificant except in the model for the monolinguals' color naming with the character 谎 as the distracter. Crucially, post-hoc DLSM contrasts (in Table 3.2 and Figure 1), however, showed that the monolinguals reduced the Stroop interference for the crucial trials (S+T− characters combined with S−T+ ink colors), except when the related color or ink color was yellow.

Thus, when the S+T− trials shared the tone with the incongruent ink color [e.g. 览, lan3, 'view', related to blue, in purple (zi3)], the monolinguals showed reduced interference. This finding is in support of tonal activation in automatic visual word recognition. However, this tonal effect was on the one hand conditioned by the related and target colors and on the other hand restricted to monolinguals. Taken together with the absence of tonal effects in Analyses 2 and 3, only tonal monolinguals but not tonal bilinguals may retrieve some tonal information in automatic visual word recognition.

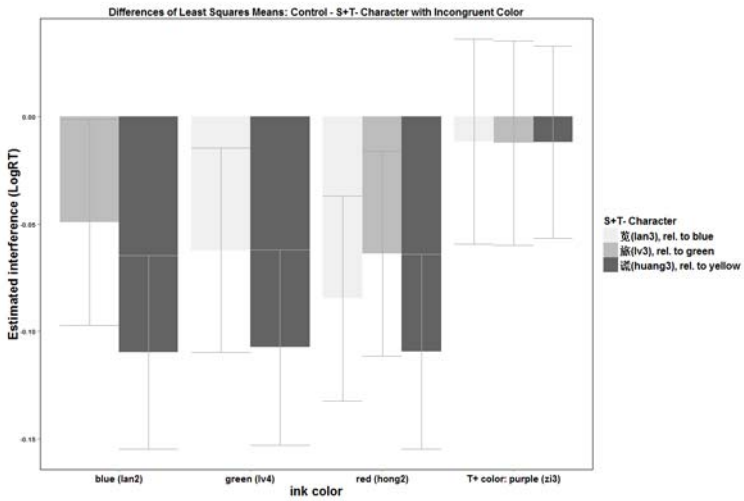

Figure 1. *Estimated interference in log-transformed RT, measured as the DLSM contrasts between the estimated RTs of the neutral trials and the S+T− incongruent trials for the same ink color, e.g. 涂, tu2, 'smear' in green (neutral trial) vs. 览, lan3, 'view', S+T− to 蓝, lan2, 'blue', in green (S+T− incongruent trial). The grey-scale filling of the bars represents S+T− characters and the bars are clustered according to the ink color. Note that negative values indicate that the trial of interest is slower than the corresponding neutral trial, and the size of the negative bars indicates the size of interference.*

Table 3.2 Additional Tone-specific effects of incongruent S+T− trials (mean RTs of the corresponding neutral controls in parenthesis)

Incongruent ink colors		green	**purple**	red	yellow
		(S−T−)	**(S−T+)**	(S−T−)	(S−T−)
Character	览	JM:	JM:	JM:	JM:
Translation	view	753	786	695	689
Pronunciation SC	lan(Lr)	(749)	(770)	(664)	(699)
Pronunciation JM	lan(Hl)	SC-bi:	SC-bi:	SC-bi:	SC-bi:
Common pinyin	lan3	770	751*	648	666
Related Color	blue	(768)	(789)	(638)	(671)
Within-Dialect	S+T−	SC-mono:	SC-mono:	SC-mono:	SC-mono:
Between-Dialect		740 *	736	657*	671
		(699)	(734)	(598)	(648)
Incongruent ink colors		blue	**purple**	red	yellow
		(S−T−)	**(S−T+)**	(S−T−)	(S−T−)
Character	旅	JM:	JM:	JM:	JM:
Translation	travel	804*	793	676	711.88
Pronunciation SC	ly(Lr)	(749)	(770)	(664)	(699)
Pronunciation JM	ly(Hl)	SC-bi:	SC-bi:	SC-bi:	SC-bi:
Common pinyin	lü3	778	772	665	675
Related Color	green	(766)	(789)	(638)	(671)
Within-Dialect	S+T−	SC-mono:	SC-mono:	SC-mono:	SC-mono:
Between-Dialect		768*	747	637*	683
		(728)	(734)	(598)	(648)
Incongruent ink colors		green	**purple**	red	blue
		(S−T−)	**(S−T+)**	(S−T−)	(S?T−)
Character	谎	JM:	JM:	JM:	JM:
Translation	lie	765*	784	696	804*
Pronunciation SC	xuaŋ(Lr)	(749)	(770)	(664)	(749)
Pronunciation JM	xuaŋ(Hl)	SC-bi:	SC-bi:	SC-bi:	SC-bi:
Common pinyin	huang3	791	786	689*	787
Related Color	yellow	(768)	(789)	(638)	(766)
Within-Dialect	S+T−	SC-mono:	SC-mono:	SC-mono:	SC-mono:
Between-Dialect		769*	742	652*	814*
		(699)	(734)	(598)	(728)

* mean RT is different from the mean RT of the corresponding neutral control ($p < 0.05$);

Analysis 5 & 6. The fifth and sixth LME analyses aimed to investigate between-dialect tonal activation. The fifth LME analysis tested the S+T+ between-dialect false friends against their S+T− counterparts (as shown in Table 1.4) considering their interaction with the dialect mode. In these models, *Between-Dialect Condition* (S+T+ false friend of the corresponding color character/S+T− false friend of the corresponding color character), *Mode*, *Trial*, *Trial Distance from the Same Color*, and their interactions were the fixed predictors.

The main effects of *Between-Dialect Condition* and *Mode* were significant in the models for the incongruent trials but insignificant in the models for the congruent trials. The interactions of *Between-Dialect Condition* and *Mode* were insignificant in all the models. This means any differences across between-dialect conditions by bilinguals were also shown in the models for monolinguals. Thus the differences found across different between-dialect conditions were not due to bilingualism but other factors, possibly the inherent differences between the specific characters.

The sixth LME analysis tested the color character, which is an S+T+ cognate or an S+T+ false friend against the other between-dialect S+T− counterparts (as shown in Table 1.5) considering their interaction with the dialect mode. In these models, *Between-Dialect Condition* (S+T+ cognate or false friend of the corresponding color character/S+T− cognate or false friend of the corresponding color character) *Mode*, *Trial*, *Trial Distance from the Same Color*, and their interactions were the fixed predictors.

The main effects of *Between-Dialect Condition* were significant in the model for the congruent cognate and the models for false-friend trials. The main effects of *Mode* were significant in the models for the incongruent trials but insignificant in the models for the congruent trials. However, similar to what was found in Analysis 5, the interactions of *Between-Dialect Condition* and *Mode* were insignificant in all the models, which means the significance of *Between-Dialect Condition* cannot be attributed to bilingualism. Taken together, the between-dialect tonal relations had no additional effects on tonal bilinguals.

7.3 General discussion

Tonal bilinguals are different from tonal monolinguals in automatic visual word recognition. First, tonal bilinguals named colors generally slower than monolinguals (as shown in Analyses 1 & 2 and Table 2), which is consistent with previous findings of bilingual lexical disadvantage on bilingual productions (Bialystok, 2009; Martin et al., 2012; Ransdell & Fischler, 1987). However, another study by Wu and colleagues (Wu, Chen, Van Heuven, & Schiller, in prep)[12] instead found lexical advantage in the same groups of participants in auditory lexical decision. This suggests that the tonal bilinguals' lexical disadvantage may be restricted to production, unlike the bilinguals using different languages.

Second, tonal bilinguals are less sensitive to tonal conditions. Only tonal monolinguals but not tonal bilinguals showed weak evidence in support of retrieval of tonal information (as in Analysis 4 and Table 3.2). Also, between-dialect tonal

[12] Chapter 4 in this thesis

relations showed no additional effects with tonal bilinguals compared with tonal monolinguals (as in Analyses 5 and 6). The tonal bilinguals' lack of sensitivity to tonal relations appears inconsistent with previous findings (Li et al., 2013; Nixon et al., 2014), which did find tonal effects in Stroop and Stroop-like paradigms. Moreover, our previous studies on JM-SC bilinguals' lexical decision (Wu, Chen, Van Heuven, & Schiller, 2014) and word naming (Wu & Chen, 2014) also suggest that the tonal bilinguals do make use of tonal information to distinguish tonal minimal pairs and lexical variants. However, most previous findings either did not take tonal bilingualism into consideration or adopted other paradigms. Note that the visual word recognition in the Stroop paradigm is largely automatic (Cohen et al., 1990) and the SC-JM pronunciations of the same character, if different, are only different in tone. It is reasonable then, to consider the possibility that these tonal bilinguals are better at redirecting their attention away from the Chinese characters while naming the ink color and maintain a shallower processing of the Chinese characters when it is beneficial. As shown in earlier studies, tonal information is retrieved more slowly than segmental information (Ye & Connine, 1999; Zhang & Damian, 2009). The tonal bilinguals might have already completed the color naming before the visual word decoding reaches the tonal information of the character. Thus the tonal bilinguals' lack of tonal sensitivity in the Stroop paradigm may actually reflect their fine-tuned attention control, which benefits their handling of Stroop interference.

Indeed, we found more evidence in support of the tonal bilinguals' advantage in handling the conflicts of tasks (as in Analysis 1 and Table 2). On the one hand, tonal bilinguals benefited more from the congruent conditions and suffered less from the incongruent conditions. On the other hand, only tonal bilinguals enjoyed Stroop facilitation but tonal monolinguals did not. The findings in the two previous studies which did not distinguish tonal bilinguals from tonal monolinguals (Li et al., 2013; Spinks et al., 2000) are mostly consistent with the tonal bilinguals' responses in SC mode in the current study. Hence we suppose Spinks et al. (2000) and (Li et al., 2013) might have actually used tonal bilinguals. It is not surprising to see the tonal bilinguals' advantage in handling the character-color incongruence, considering the well-known bilingual advantage in conflict resolution (Bialystok, 2009; Carlson & Meltzoff, 2008; Hilchey & Klein, 2011; Prior & Gollan, 2011).Similar bilingual advantages were also found in previous studies using Stroop tasks (Bialystok et al., 2008), although they used a different type of control condition.

It is even more interesting to see that only tonal bilinguals but not tonal monolinguals responded faster to congruent trials than to neutral-character trials (as shown in Analysis 1 and Table 2). The tonal monolinguals' lack of Stroop facilitation is very different from what Spinks et al. (2000) and Li et al. (2013) found and this cannot be simply attributed to the difference in the speakers' knowledge of English, as a foreign language. All the participants in the two previous studies and the current study learned English at school, and the proficiency can be ranked from high to low as follows: Chinese student in the US (Li et al., 2013; Spinks et al., 2000), Beijing SC tonal monolinguals, and JM-SC tonal bilinguals. If English proficiency were the cause of the inconsistency in Stroop facilitation, we would have seen a more similar pattern between the tonal monolinguals and the Chinese students in the US, which is not what we found. Nevertheless, another explanation may be more reasonable. Besides the advantages in conflict solving, bilinguals have also shown advantages in using alerting cues (Costa, Hernández, Costa-Faidella, & Sebastián, 2009; Costa, Hernández, & Sebastián-Gallés, 2008). The visual word forms are processed faster than ink colors in the Stroop paradigm (MacLeod, 1991). Thus the congruent characters can serve as alerting cues for the target colors compared with irrelevant characters. The tonal bilinguals presumably make better use of these cues than the tonal monolinguals. Note that the tonal monolinguals are also late Chinese-English bilinguals but this bilingualism did not bring them any facilitation in these congruent trials. Thus if the advantage we found is a bilingual alerting advantage, this alerting advantage should be sensitive to the status of the cue in their bilingual situation. The tonal bilinguals and tonal monolinguals are not different in whether they know more than one language. However, the tonal bilinguals use Chinese characters for both of their dialects and they can benefit from Chinese characters as alerting cues. The tonal monolinguals instead use a different orthography for English and do not benefit from Chinese characters as alerting cues.

Considering phonological activation, both phonological interference and phonological facilitation were found with the tonal bilinguals in Analysis 2 (also shown in Table 2), just as was found with the Chinese international students tested in previous studies (Li et al., 2013; Spinks et al., 2000). Thus, tonal bilinguals activate phonological information automatically in visual word recognition, just as the other Chinese speakers (Seidenberg, 1985; Tan & Perfetti, 1997; Zhou & Marslen-Wilson, 1999). However, the bilinguals did not show any evidence in support of tone-specific activation in any of the models. Neither were the effects from S+T+ characters significantly different from S+T− characters (Analysis 2 and Table 2), nor were the effects from S−T+ characters significantly different from S−T− characters (Analysis 3 and Table 3.1), which is different from the small tonal effect found on the tonal monolinguals (Analysis 4 and Table 3.2) and the previous monolingual findings in a picture-word interference experiment (a similar paradigm) (Nixon et al., 2014). Moreover, the between-dialect tonal relation showed no bilingual effects, with neither Analyses 5 nor 6 providing any support for cross-dialect tonal activation. It is unlikely that the tonal bilinguals do not make use of tonal information in lexical access, since we found plenty of within-dialect and between-dialect tonal effects on the same group of bilinguals (Wu & Chen, 2014; Wu et al., 2014, in prep). The lack of tonal activation may rather be related to the control of attention. For these tonal bilinguals, the two pronunciations of the same Chinese character are usually only different in tone. It could be that the tonal bilinguals, when reading silently and recognizing visual words automatically, maintain a shallower phonological processing compared with tonal monolinguals. Such arrangement can help the bilinguals avoid tone-based bilingual lexical competition and retrieve the lexical meaning more economically.

The tonal bilinguals also showed some scattered differences across the two language modes. The bilinguals' Stroop facilitation showed different patterns in different language modes (as shown in Analyses 1& 2 and Table 2). When the colors were named in SC, it was the color characters that triggered the greatest Stroop facilitation, similar to previous findings (Li et al., 2013; MacLeod, 1991; Spinks et al., 2000) and very reasonable, because the color characters share both phonological and semantic information with the congruent ink color. However, when the colors were named in JM, it was the S+T+ homophones that triggered the greatest Stroop facilitation, even greater than the Stroop facilitation triggered by the color characters. This finding is unusual and needs further replication. Is it possible that the semantic information of the Chinese characters was not activated in JM mode? This is unlikely because in that case the color characters would be equivalent to the S+T+ homophones and no difference in RT should emerge between the two conditions. Since the Stroop facilitation from the color characters still existed but was reduced, it is more likely that the additional semantic information from the color characters introduced interference in JM mode. This effect can be either interpreted semantically or in light of interlingual lexical competition. The color character represents exactly the same concept as the ink color (e.g. *RED* for the red ink). Many studies have shown that they are different from the semantic associates, which in Stroop-like tasks sometimes trigger semantic interference and sometimes do not (Finkbeiner & Caramazza, 2006; Starreveld & La Heij, 1995). If the reduced facilitation from the color characters is due to semantic interference, similar interference should also appear on the semantic associates. Since the current study did not include characters, which are semantic associates of color names as Spinks et al. (2000) did, further research is necessary to clarify this question. The interlingual lexical competition hypothesis is another explanation for the reduction of facilitation from the color characters. The Chinese character first activates the SC representation of the color name, which is different from the JM representation the tonal bilingual is trying to produce according to the language mode. The SC and JM translation equivalents, one activated by the color character and the other activated by the ink color, compete for lexical selection and counterweigh part of the phonological facilitation. The color character activates the unwanted SC representation of the color word via both the semantic route and the phonological route, but the S+T+ homophones of color characters only activate the same unwanted SC representation via the phonological route. Thus the unwanted SC representation of the color word is activated more by the color characters and introduced more interference in the JM color naming. This findings interesting, considering the fact that most tonal bilinguals received literacy education in SC and were not formally taught to read in JM. However, all of them can read aloud fluently in JM. How they manage to read Chinese characters in JM remains unclear but their automatic visual word recognition in the JM mode is obviously different from that in the SC mode. It could be that the visual word recognition in JM is actually mediated by the SC visual word recognition but not vice versa. This hypothesis can explain the asymmetrical facilitation from color characters in different language modes. When the bilinguals see a Chinese character, the SC representation is always automatically activated, but the JM representation needs mediation.

To sum up, the current study used the Stroop paradigm to investigate the role of lexical tones in automatic visual word recognition by a particular type of bilingual, namely the tonal bilinguals of two closely related Chinese dialects which use the same orthography and segmental structures for the translation equivalents. Beside the classical bilingual lexical disadvantage and executive advantage, our findings also corroborated the theory that phonological information carried by Chinese characters is automatically activated in visual word recognition, which is in line with previous findings. The tonal bilinguals showed similar sensitivity to segmental information as the tonal monolinguals. However, the tonal bilinguals seem to reduce their depth of visual language processing specifically in the tonal aspect, which would help them to a large extent avoid the conflicting tonal information from different dialects. Moreover, the dialect, which is rarely used in literacy education showed an unusual pattern in Stroop facilitation and this finding is discussed in light of bilingual lexical competition. Our study investigated previously neglected possibilities of bilingual visual word recognition and our findings provide new links between the process of lexical prosody and bilingual executive control.

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Appendices. Summary of the mixed effects models

Appendix 1. The model comparing the color characters with the neutral characters on LogRTs of congruent trials

Fixed effects	Df	F	p
Within-dialect condition (color characters/ neutral characters)	**1**	**14.658**	**<0.001**
Mode (SC by Beijing monolinguals/ JM/ SC by Jinan bilinguals)	2	3.099	<0.05
Color (blue/ green/ purple/red/yellow)	4	127.074	<0.001
Trial order in the same color (centralized)	1	27.212	<0.001
Trial distance from the same color (centralized)	1	39.222	<0.001
Within-dialect condition ×Mode	2	7.87	<0.001
Within-dialect condition ×Color	4	5.966	<0.001
Mode ×Color	8	2.765	<0.01
Within-dialect condition ×Trial order in the same color (centralized)	1	0.161	>0.05(ns)
Mode ×Trial order in the same color (centralized)	2	0.098	>0.05(ns)
Color ×Trial order in the same color (centralized)	4	1.506	>0.05(ns)
Within-dialect condition ×Trial distance from the same color (centralized)	1	0	>0.05(ns)
Mode ×Trial distance from the same color (centralized)	2	3.052	<0.05
Color ×Trial distance from the same color (centralized)	4	1.235	>0.05(ns)
Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	1	0.329	>0.05(ns)
Within-dialect condition ×Mode ×Color	8	0.572	>0.05(ns)
Within-dialect condition ×Mode ×Trial order in the same color (centralized)	2	2.703	>0.05(ns)
Within-dialect condition ×Color ×Trial order in the same color (centralized)	4	2.064	>0.05(ns)
Mode ×Color ×Trial order in the same color (centralized)	8	2.666	<0.01
Within-dialect condition ×Mode ×Trial distance from the same color (centralized)	2	0.238	>0.05(ns)
Within-dialect condition ×Color ×Trial distance from the same color (centralized)	4	0.926	>0.05(ns)
Mode ×Color ×Trial distance from the same color (centralized)	8	0.736	>0.05(ns)
Within-dialect condition ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	1	2.822	>0.05(ns)
Mode ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	2	0.073	>0.05(ns)
Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	4	1.741	>0.05(ns)
Within-dialect condition ×Mode ×Color ×Trial order in the same color (centralized)	8	0.71	>0.05(ns)
Within-dialect condition ×Mode ×Color ×Trial distance from the same color (centralized)	8	0.215	>0.05(ns)
Within-dialect condition ×Mode ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	2	0.64	>0.05(ns)
Within-dialect condition ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	4	1.089	>0.05(ns)
Mode ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	8	0.491	>0.05(ns)
Within-dialect condition ×Mode ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	8	0.678	>0.05(ns)
Random effects		χ^2	
(1 + Trial distance from the same color (centralized) | Participant)	2	10.165	<0.01

Appendix 2. The model comparing the (S+T+) characters with the neutral characters on LogRTs of congruent trials

Fixed effects	Df	F	p
Within-dialect condition (homophones of the color characters/neutral characters	**1**	**32.339**	**<0.001**
Mode (SC by Beijing monolinguals/ JM/ SC by Jinan bilinguals)	2	3.567	<0.05
Color (blue/ green/ purple/red/yellow)	4	151.408	<0.001
Trial order in the same color (centralized)	1	18.061	<0.001
Trial distance from the same color (centralized)	1	67.744	<0.001
Within-dialect condition ×Mode	2	6.913	<0.01
Within-dialect condition ×Color	4	2.805	<0.05
Mode ×Color	8	2.043	<0.05
Within-dialect condition ×Trial order in the same color (centralized)	1	0.027	>0.05(ns)
Mode ×Trial order in the same color (centralized)	2	1.314	>0.05(ns)
Color ×Trial order in the same color (centralized)	4	3.012	<0.05
Within-dialect condition ×Trial distance from the same color (centralized)	1	0.624	>0.05(ns)
Mode ×Trial distance from the same color (centralized)	2	1.385	>0.05(ns)
Color ×Trial distance from the same color (centralized)	4	1.177	>0.05(ns)
Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	1	0.09	>0.05(ns)
Within-dialect condition ×Mode ×Color	8	1.352	>0.05(ns)
Within-dialect condition ×Mode ×Trial order in the same color (centralized)	2	0.417	>0.05(ns)
Within-dialect condition ×Color ×Trial order in the same color (centralized)	4	0.375	>0.05(ns)
Mode ×Color ×Trial order in the same color (centralized)	8	2.415	<0.05
Within-dialect condition ×Mode ×Trial distance from the same color (centralized)	2	4.572	<0.05
Within-dialect condition ×Color ×Trial distance from the same color (centralized)	4	1.141	>0.05(ns)
Mode ×Color ×Trial distance from the same color (centralized)	8	0.919	>0.05(ns)
Within-dialect condition ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	1	4.246	<0.05
Mode ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	2	0.038	>0.05(ns)
Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	4	0.545	>0.05(ns)
Within-dialect condition ×Mode ×Color ×Trial order in the same color (centralized)	8	1.951	<0.05
Within-dialect condition ×Mode ×Color ×Trial distance from the same color (centralized)	8	0.761	>0.05(ns)
Within-dialect condition ×Mode ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	2	0.555	>0.05(ns)
Within-dialect condition ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	4	1.453	>0.05(ns)
Mode ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	8	0.984	>0.05(ns)
Within-dialect condition ×Mode ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	8	0.678	>0.05(ns)
Random effects		χ^2	
(1 + Trial order in the same color (centralized) | Participant)	2	7.944	<0.05

Appendix 3. The model comparing the (S+T−) with the neutral characters on LogRTs of congruent trials

Fixed effects	Df	F	p
Within-dialect condition (different-tone homophones of the color characters/ neutral characters)	**1**	**21.133**	**<0.001**
Mode (SC by Beijing monolinguals/ JM/ SC by Jinan bilinguals)	2	6.336	<0.01
Color (blue/ green/ purple/red/yellow)	4	178.456	<0.001
Trial order in the same color (centralized)	1	15.071	<0.001
Trial distance from the same color (centralized)	1	40.07	<0.001
Within-dialect condition ×Mode	2	2.957	>0.05(ns)
Within-dialect condition ×Color	4	8.182	<0.001
Mode ×Color	8	1.321	>0.05(ns)
Within-dialect condition ×Trial order in the same color (centralized)	1	0.988	>0.05(ns)
Mode ×Trial order in the same color (centralized)	2	2.255	>0.05(ns)
Color ×Trial order in the same color (centralized)	4	0.945	>0.05(ns)
Within-dialect condition ×Trial distance from the same color (centralized)	1	0.013	>0.05(ns)
Mode ×Trial distance from the same color (centralized)	2	0.541	>0.05(ns)
Color ×Trial distance from the same color (centralized)	4	0.876	>0.05(ns)
Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	1	0.579	>0.05(ns)
Within-dialect condition ×Mode ×Color	8	1.995	<0.05
Within-dialect condition ×Mode ×Trial order in the same color (centralized)	2	0.129	>0.05(ns)
Within-dialect condition ×Color ×Trial order in the same color (centralized)	4	2.111	>0.05(ns)
Mode ×Color ×Trial order in the same color (centralized)	8	0.809	>0.05(ns)
Within-dialect condition ×Mode ×Trial distance from the same color (centralized)	2	4.897	<0.01
Within-dialect condition ×Color ×Trial distance from the same color (centralized)	4	0.554	>0.05(ns)
Mode ×Color ×Trial distance from the same color (centralized)	8	1.468	>0.05(ns)
Within-dialect condition ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	1	2.244	>0.05(ns)
Mode ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	2	0.304	>0.05(ns)
Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	4	0.282	>0.05(ns)
Within-dialect condition ×Mode ×Color ×Trial order in the same color (centralized)	8	1.844	>0.05(ns)
Within-dialect condition ×Mode ×Color ×Trial distance from the same color (centralized)	8	0.462	>0.05(ns)
Within-dialect condition ×Mode ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	2	0.272	>0.05(ns)
Within-dialect condition ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	4	0.275	>0.05(ns)
Mode ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	8	0.267	>0.05(ns)
Within-dialect condition ×Mode ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	8	1.575	>0.05(ns)
Random effects		χ^2	
(1 + Trial distance from the same color (centralized) | Participant)	2	11.690	<0.01

Appendix 4. The model comparing the JM tonal-merging characters with the neutral characters on LogRTs of congruent trials

Fixed effects	Df	F	p
Within-dialect condition (JM tonal-merging characters V.S. neutral characters)	**1**	**24.177**	**<0.001**
Mode (SC by Beijing monolinguals/ JM/ SC by Jinan bilinguals)	2	1.378	>0.05 (ns)
Color (blue/yellow)	1	188.615	<0.001
Trial order in the same color (centralized)	1	11.708	<0.001
Trial distance from the same color (centralized)	1	13.155	<0.001
Within-dialect condition ×Mode	2	0.766	>0.05 (ns)
Within-dialect condition ×Color	1	2.233	>0.05 (ns)
Mode ×Color	2	3.522	<0.05
Within-dialect condition ×Trial order in the same color (centralized)	1	2.905	>0.05 (ns)
Mode ×Trial order in the same color (centralized)	2	0.037	>0.05 (ns)
Color ×Trial order in the same color (centralized)	1	0.039	>0.05 (ns)
Within-dialect condition ×Trial distance from the same color (centralized)	1	0.05	>0.05 (ns)
Mode ×Trial distance from the same color (centralized)	2	0.913	>0.05 (ns)
Color ×Trial distance from the same color (centralized)	1	0.06	>0.05 (ns)
Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	1	0.453	>0.05 (ns)
Within-dialect condition ×Mode ×Color	2	0.13	>0.05 (ns)
Within-dialect condition ×Mode ×Trial order in the same color (centralized)	2	0.864	>0.05 (ns)
Within-dialect condition ×Color ×Trial order in the same color (centralized)	1	3.552	>0.05 (ns)
Mode ×Color ×Trial order in the same color (centralized)	2	0.194	>0.05 (ns)
Within-dialect condition ×Mode ×Trial distance from the same color (centralized)	2	4.488	<0.05
Within-dialect condition ×Color ×Trial distance from the same color (centralized)	1	2.298	>0.05 (ns)
Mode ×Color ×Trial distance from the same color (centralized)	2	0.094	>0.05 (ns)
Within-dialect condition ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	1	0.079	>0.05 (ns)
Mode ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	2	0.079	>0.05 (ns)
Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	1	0.166	>0.05 (ns)
Within-dialect condition ×Mode ×Color ×Trial order in the same color (centralized)	2	2.313	>0.05 (ns)
Within-dialect condition ×Mode ×Color ×Trial distance from the same color (centralized)	2	1.968	>0.05 (ns)
Within-dialect condition ×Mode ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	2	0.239	>0.05 (ns)
Within-dialect condition ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	1	0.002	>0.05 (ns)
Mode ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	2	0.026	>0.05 (ns)
Within-dialect condition ×Mode ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	2	2.747	>0.05 (ns)
Random effects		χ^2	
1 + Trial order in the same color (centralized) | Participant	2	14.210	<0.001

Appendix 5. The model comparing the color characters with the neutral characters on LogRTs of incongruent trials

Fixed effects	Df	F	p
Within-dialect condition (color characters/neutral characters)	**1**	**123.384**	**<0.001**
Mode (SC by Beijing monolinguals/ JM/ SC by Jinan bilinguals)	2	13.988	<0.001
Color (blue/ green/ purple/red/yellow)	4	32.009	<0.001
Trial order in the same color (centralized)	1	2.715	>0.05(ns)
Trial distance from the same color (centralized)	1	28.482	<0.001
Within-dialect condition ×Mode	2	21.591	<0.001
Within-dialect condition ×Color	4	1.969	>0.05(ns)
Mode ×Color	8	1.62	>0.05(ns)
Within-dialect condition ×Trial order in the same color (centralized)	1	9.407	<0.01
Mode ×Trial order in the same color (centralized)	2	2.078	>0.05(ns)
Color ×Trial order in the same color (centralized)	4	2.117	>0.05(ns)
Within-dialect condition ×Trial distance from the same color (centralized)	1	0.063	>0.05(ns)
Mode ×Trial distance from the same color (centralized)	2	3.972	<0.05
Color ×Trial distance from the same color (centralized)	4	0.854	>0.05(ns)
Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	1	0.991	>0.05(ns)
Within-dialect condition ×Mode ×Color	8	1.556	>0.05(ns)
Within-dialect condition ×Mode ×Trial order in the same color (centralized)	2	1.066	>0.05(ns)
Within-dialect condition ×Color ×Trial order in the same color (centralized)	4	2.41	<0.05
Mode ×Color ×Trial order in the same color (centralized)	8	1.839	>0.05(ns)
Within-dialect condition ×Mode ×Trial distance from the same color (centralized)	2	2.288	>0.05(ns)
Within-dialect condition ×Color ×Trial distance from the same color (centralized)	4	0.315	>0.05(ns)
Mode ×Color ×Trial distance from the same color (centralized)	8	1.292	>0.05(ns)
Within-dialect condition ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	1	1.545	>0.05(ns)
Mode ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	2	0.606	>0.05(ns)
Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	4	0.642	>0.05(ns)
Within-dialect condition ×Mode ×Color ×Trial order in the same color (centralized)	8	1.657	>0.05(ns)
Within-dialect condition ×Mode ×Color ×Trial distance from the same color (centralized)	8	0.798	>0.05(ns)
Within-dialect condition ×Mode ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	2	0.061	>0.05(ns)
Within-dialect condition ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	4	0.671	>0.05(ns)
Mode ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	8	0.262	>0.05(ns)
Within-dialect condition ×Mode ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	8	0.819	>0.05(ns)
Random effects		χ^2	
1 + Trial order in the same color (centralized) | Participant	2	23.443	<0.001
1 + Trial distance from the same color (centralized) |StimuliID	2	10.389	<0.01

Appendix 6. The model comparing the (S+T+) characters with the neutral characters on LogRTs of incongruent trials

Fixed effects	Df	F	p
Within-dialect condition (homophones of the color characters /neutral characters)	**1**	**23.19**	**<0.001**
Mode (SC by Beijing monolinguals/ JM/ SC by Jinan bilinguals)	2	17.66	<0.001
Color (blue/ green/ purple/red/yellow)	4	56.548	<0.001
Trial order in the same color (centralized)	1	10.783	<0.01
Trial distance from the same color (centralized)	1	69.969	<0.001
Within-dialect condition ×Mode	2	6.038	<0.01
Within-dialect condition ×Color	4	2.015	>0.05(ns)
Mode ×Color	8	1.785	>0.05(ns)
Within-dialect condition ×Trial order in the same color (centralized)	1	1.81	>0.05(ns)
Mode ×Trial order in the same color (centralized)	2	0.992	>0.05(ns)
Color ×Trial order in the same color (centralized)	4	2.777	<0.05
Within-dialect condition ×Trial distance from the same color (centralized)	1	0.08	>0.05(ns)
Mode ×Trial distance from the same color (centralized)	2	2.775	>0.05(ns)
Color ×Trial distance from the same color (centralized)	4	2.636	<0.05
Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	1	0.736	>0.05(ns)
Within-dialect condition ×Mode ×Color	8	2.259	<0.05
Within-dialect condition ×Mode ×Trial order in the same color (centralized)	2	0.672	>0.05(ns)
Within-dialect condition ×Color ×Trial order in the same color (centralized)	4	2.401	<0.05
Mode ×Color ×Trial order in the same color (centralized)	8	1.63	>0.05(ns)
Within-dialect condition ×Mode ×Trial distance from the same color (centralized)	2	4.453	<0.05
Within-dialect condition ×Color ×Trial distance from the same color (centralized)	4	1.532	>0.05(ns)
Mode ×Color ×Trial distance from the same color (centralized)	8	0.924	>0.05(ns)
Within-dialect condition ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	1	3.135	>0.05(ns)
Mode ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	2	1.427	>0.05(ns)
Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	4	0.525	>0.05(ns)
Within-dialect condition ×Mode ×Color ×Trial order in the same color (centralized)	8	1.689	>0.05(ns)
Within-dialect condition ×Mode ×Color ×Trial distance from the same color (centralized)	8	1.058	>0.05(ns)
Within-dialect condition ×Mode ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	2	0.528	>0.05(ns)
Within-dialect condition ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	4	0.507	>0.05(ns)
Mode ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	8	0.828	>0.05(ns)
Within-dialect condition ×Mode ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	8	1.039	>0.05(ns)
Random effects		χ^2	
1 + Trial (centralized) | Participant	2	67.230	<0.001
1 | StimuliID	1	31.571	<0.001

Appendix 7. The model comparing the (S+T−) with the neutral characters on LogRTs of incongruent trials

Fixed effects	Df	F	p
Within-dialect condition (different-tone homophones of the color characters/ neutral characters)	**1**	**18.593**	**<0.001**
Mode (SC by Beijing monolinguals/ JM/ SC by Jinan bilinguals)	2	20.157	<0.001
Color (blue/ green/ purple/red/yellow)	4	52.573	<0.001
Trial order in the same color (centralized)	1	13.242	<0.001
Trial distance from the same color (centralized)	1	69.918	<0.001
Within-dialect condition ×Mode	2	5.929	<0.01
Within-dialect condition ×Color	4	0.728	>0.05(ns)
Mode ×Color	8	2.606	<0.01
Within-dialect condition ×Trial order in the same color (centralized)	1	3.74	>0.05(ns)
Mode ×Trial order in the same color (centralized)	2	2.237	>0.05(ns)
Color ×Trial order in the same color (centralized)	4	2.452	<0.05
Within-dialect condition ×Trial distance from the same color (centralized)	1	0.047	>0.05(ns)
Mode ×Trial distance from the same color (centralized)	2	3.936	<0.05
Color ×Trial distance from the same color (centralized)	4	1.985	>0.05(ns)
Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	1	3.735	>0.05(ns)
Within-dialect condition ×Mode ×Color	8	1.249	>0.05(ns)
Within-dialect condition ×Mode ×Trial order in the same color (centralized)	2	0.528	>0.05(ns)
Within-dialect condition ×Color ×Trial order in the same color (centralized)	4	2.748	<0.05
Mode ×Color ×Trial order in the same color (centralized)	8	2.012	<0.05
Within-dialect condition ×Mode ×Trial distance from the same color (centralized)	2	1.963	>0.05(ns)
Within-dialect condition ×Color ×Trial distance from the same color (centralized)	4	3.164	<0.05
Mode ×Color ×Trial distance from the same color (centralized)	8	1.239	>0.05(ns)
Within-dialect condition ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	1	1.77	>0.05(ns)
Mode ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	2	0.983	>0.05(ns)
Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	4	0.375	>0.05(ns)
Within-dialect condition ×Mode ×Color ×Trial order in the same color (centralized)	8	1.369	>0.05(ns)
Within-dialect condition ×Mode ×Color ×Trial distance from the same color (centralized)	8	0.47	>0.05(ns)
Within-dialect condition ×Mode ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	2	0.591	>0.05(ns)
Within-dialect condition ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	4	0.458	>0.05(ns)
Mode ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	8	1.04	>0.05(ns)
Within-dialect condition ×Mode ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	8	0.432	>0.05(ns)
Random effects		χ^2	
1 + Trial (centralized) | Participant	2	77.775	<0.0001
1 | StimuliID	1	37.909	<0.001

Appendix 8. The model comparing the JM tonal-merging characters with the neutral characters on LogRTs of incongruent trials

Fixed effects	Df	F	p
Within-dialect condition (JM tonal-merging characters/neutral characters)	**1**	**37.024**	**<0.001**
Mode (SC by Beijing monolinguals/ JM/ SC by Jinan bilinguals)	2	5.335	<0.01
Color (blue/ green/ purple/red/yellow)	4	173.313	<0.001
Trial order in the same color (centralized)	1	7.635	<0.01
Trial distance from the same color (centralized)	1	39.554	<0.001
Within-dialect condition ×Mode	2	8.773	<0.001
Within-dialect condition ×Color	4	7.554	<0.001
Mode ×Color	8	3.863	<0.001
Within-dialect condition ×Trial order in the same color (centralized)	1	3.412	>0.05(ns)
Mode ×Trial order in the same color (centralized)	2	1.685	>0.05(ns)
Color ×Trial order in the same color (centralized)	4	0.529	>0.05(ns)
Within-dialect condition ×Trial distance from the same color (centralized)	1	0.803	>0.05(ns)
Mode ×Trial distance from the same color (centralized)	2	3.048	<0.05
Color ×Trial distance from the same color (centralized)	4	1.432	>0.05(ns)
Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	1	2.994	>0.05(ns)
Within-dialect condition ×Mode ×Color	8	0.885	>0.05(ns)
Within-dialect condition ×Mode ×Trial order in the same color (centralized)	2	0.279	>0.05(ns)
Within-dialect condition ×Color ×Trial order in the same color (centralized)	4	3.939	<0.01
Mode ×Color ×Trial order in the same color (centralized)	8	1.446	>0.05(ns)
Within-dialect condition ×Mode ×Trial distance from the same color (centralized)	2	5.046	<0.01
Within-dialect condition ×Color ×Trial distance from the same color (centralized)	4	1.802	>0.05(ns)
Mode ×Color ×Trial distance from the same color (centralized)	8	1.232	>0.05(ns)
Within-dialect condition ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	1	1.376	>0.05(ns)
Mode ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	2	0.038	>0.05(ns)
Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	4	0.379	>0.05(ns)
Within-dialect condition ×Mode ×Color ×Trial order in the same color (centralized)	8	1.678	>0.05(ns)
Within-dialect condition ×Mode ×Color ×Trial distance from the same color (centralized)	8	0.673	>0.05(ns)
Within-dialect condition ×Mode ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	2	3.721	<0.05
Within-dialect condition ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	4	0.814	>0.05(ns)
Mode ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	8	0.664	>0.05(ns)
Within-dialect condition ×Mode ×Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	8	0.666	>0.05(ns)
Random effects		χ^2	
1 + Trial order in the same color (centralized) | Participant	2	11.324	<0.01

Appendix 9. The model comparing different within-dialect conditions on LogRTs of congruent trials

Fixed effects	Df	F	p
Within-dialect condition color characters/ homophones of the color characters/ different-tone homophones of the color characters/ different-tone homophones of the color characters with potential tonal merging in JM)	**3**	**1.269**	**>0.05(ns)**
Mode (SC by Beijing monolinguals/ JM/ SC by Jinan bilinguals)	2	9.502	<0.001
Trial (centralized)	1	10.868	<0.01
Trial distance from the same color (centralized)	1	88.171	<0.001
Within-dialect condition ×Mode	6	1.745	>0.05(ns)
Within-dialect condition ×Trial (centralized)	3	1.401	>0.05(ns)
Mode ×Trial (centralized)	2	0.363	>0.05(ns)
Within-dialect condition ×Trial distance from the same color (centralized)	3	0.708	>0.05(ns)
Mode ×Trial distance from the same color (centralized)	2	2.532	>0.05(ns)
Trial (centralized) ×Trial distance from the same color (centralized)	1	3.714	>0.05(ns)
Within-dialect condition ×Mode ×Trial (centralized)	6	1.04	>0.05(ns)
Within-dialect condition ×Mode ×Trial distance from the same color (centralized)	6	2.36	<0.05
Within-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	3	0.697	>0.05(ns)
Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	0.18	>0.05(ns)
Within-dialect condition ×Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	6	0.404	>0.05(ns)
Random effects		χ^2	
1 +Trial (centralized) | Participant	2	44.346	<0.0001
1 | Color	1	1029.653	<0.001

Appendix 10. The model comparing different within-dialect conditions on LogRTs of incongruent trials

Fixed effects	Df	F	p
Within-dialect condition (color characters/ homophones of the color characters/ different-tone homophones of the color characters)	**3**	**79.161**	**<0.001**
Mode (SC by Beijing monolinguals/ JM/ SC by Jinan bilinguals)	2	58.136	<0.001
Trial (centralized)	1	3.123	>0.05(ns)
Trial distance from the same color (centralized)	1	227.712	<0.001
Within-dialect condition ×Mode	6	8.156	<0.001
Within-dialect condition ×Trial (centralized)	3	4.618	<0.01
Mode ×Trial (centralized)	2	2.543	>0.05(ns)
Within-dialect condition ×Trial distance from the same color (centralized)	3	1.104	>0.05(ns)
Mode ×Trial distance from the same color (centralized)	2	0.067	>0.05(ns)
Trial (centralized) ×Trial distance from the same color (centralized)	1	1.283	>0.05(ns)
Within-dialect condition ×Mode ×Trial (centralized)	6	0.632	>0.05(ns)
Within-dialect condition ×Mode ×Trial distance from the same color (centralized)	6	2.458	<0.05
Within-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	3	0.532	>0.05(ns)
Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	0.864	>0.05(ns)
Within-dialect condition ×Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	6	1.512	>0.05(ns)
Random effects		χ^2	
1 +Trial (centralized) | Participant	2	189.357	<0.001
1 | StimuliID	1	163.154	<0.001
1 | Color	1	147.771	<0.001

Appendix 11. The model comparing the S−T− and S−T+ trials combined with blue ink color on LogRTs

Fixed effects	Df	F	p
Same Tone (the character is S−T− / S−T+ with the ink color)	2	2.081	>0.05 (ns)
Mode (SC by Beijing monolinguals/ JM/ SC by Jinan bilinguals)	1	2.118	>0.05 (ns)
Trial (centralized)	1	0.11	>0.05 (ns)
Trial distance from the same color (centralized)	2	37.134	<0.001
Same Tone ×Mode	1	0.918	>0.05 (ns)
Same Tone ×Trial (centralized)	2	7.991	<0.01
Mode ×Trial (centralized)	1	1.687	>0.05 (ns)
Same Tone ×Trial distance from the same color (centralized)	2	0.121	>0.05 (ns)
Mode ×Trial distance from the same color (centralized)	1	1.314	>0.05 (ns)
Trial (centralized) ×Trial distance from the same color (centralized)	2	0.101	>0.05 (ns)
Same Tone ×Mode ×Trial (centralized)	2	0.656	>0.05 (ns)
Same Tone ×Mode ×Trial distance from the same color (centralized)	1	0.662	>0.05 (ns)
Same Tone ×Trial (centralized) ×Trial distance from the same color (centralized)	2	0.69	>0.05 (ns)
Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	1.093	>0.05 (ns)
Same Tone ×Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	1.548	>0.05 (ns)
Random effects		χ^2	
1+Trial (centralized) |Participant	2	1375	<0.01
1|StimuliID	1	5.89	<0.05

Appendix 12. The model comparing the S−T− and S−T+ trials combined with green ink color on LogRTs

Fixed effects	Df	F	p
Same Tone (the character is S−T− / S−T+ with the ink color)	1	0.053	>0.05 (ns)
Mode (SC by Beijing monolinguals/ JM/ SC by Jinan bilinguals)	2	5.848	<0.01
Trial (centralized)	1	0.291	>0.05 (ns)
Trial distance from the same color (centralized)	1	34.151	<0.001
Same Tone ×Mode	2	2.757	>0.05 (ns)
Same Tone ×Trial (centralized)	1	0.562	>0.05 (ns)
Mode ×Trial (centralized)	2	0.21	>0.05 (ns)
Same Tone ×Trial distance from the same color (centralized)	1	1.21	>0.05 (ns)
Mode ×Trial distance from the same color (centralized)	2	4.423	<0.05
Trial (centralized) ×Trial distance from the same color (centralized)	1	0.01	>0.05 (ns)
Same Tone ×Mode ×Trial (centralized)	2	0.518	>0.05 (ns)
Same Tone ×Mode ×Trial distance from the same color (centralized)	2	2.139	>0.05 (ns)
Same Tone ×Trial (centralized) ×Trial distance from the same color (centralized)	1	0.317	>0.05 (ns)
Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	2.799	>0.05 (ns)
Same Tone ×Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	3.901	<0.05
Random effects		χ^2	
1+ Trial distance from the same color (centralized)|Participant	2	6.49	<0.05
1|StimuliID	1	13.79	<0.0001

Appendix 13. The model comparing the S−T− and S−T+ trials combined with red ink color on LogRTs

Fixed effects	Df	F	p
Same Tone (the character is S−T− / S−T+ with the ink color)	1	2.1887	>0.05 (ns)
Mode (SC by Beijing monolinguals/ JM/ SC by Jinan bilinguals)	2	2.3996	>0.05 (ns)
Trial (centralized)	1	0.3809	<0.05
Trial distance from the same color (centralized)	1	5.8	>0.05 (ns)
Same Tone ×Mode	2	2.0872	<0.05
Same Tone ×Trial (centralized)	1	5.6343	>0.05 (ns)
Mode ×Trial (centralized)	2	2.4177	>0.05 (ns)
Same Tone ×Trial distance from the same color (centralized)	1	0.607	>0.05 (ns)
Mode ×Trial distance from the same color (centralized)	2	0.9421	>0.05 (ns)
Trial (centralized) ×Trial distance from the same color (centralized)	1	0.0464	>0.05 (ns)
Same Tone ×Mode ×Trial (centralized)	2	1.7124	>0.05 (ns)
Same Tone ×Mode ×Trial distance from the same color (centralized)	2	0.6642	>0.05 (ns)
Same Tone ×Trial (centralized) ×Trial distance from the same color (centralized)	1	0.0092	>0.05 (ns)
Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	0.6429	>0.05 (ns)
Same Tone ×Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	0.3248	>0.05 (ns)
Random effects		χ^2	
1+ Trial (centralized)|Participant	2	2.60	0.273
1|StimuliID	1	3.71	0.054

Appendix 14. The model comparing the S−T− and S−T+ trials combined with yellow ink color on LogRTs

Fixed effects	Df	F	p
Same Tone (the character is S−T− / S−T+ with the ink color)	1	27.6397	<0.001
Mode (SC by Beijing monolinguals/ JM/ SC by Jinan bilinguals)	2	4.449	<0.05
Trial order in the same color (centralized)	1	2.7757	>0.05 (ns)
Trial distance from the same color (centralized)	1	28.1628	<0.001
Same Tone ×Mode	2	1.0661	>0.05 (ns)
Same Tone ×Trial order in the same color (centralized)	1	2.7956	>0.05 (ns)
Mode ×Trial order in the same color (centralized)	2	4.0379	<0.05
Same Tone ×Trial distance from the same color (centralized)	1	1.3057	>0.05 (ns)
Mode ×Trial distance from the same color (centralized)	2	1.4558	>0.05 (ns)
Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	1	0.0178	>0.05 (ns)
Same Tone ×Mode ×Trial order in the same color (centralized)	2	0.4635	>0.05 (ns)
Same Tone ×Mode ×Trial distance from the same color (centralized)	2	0.3022	>0.05 (ns)
Same Tone ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	1	0.0487	>0.05 (ns)
Mode ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	2	0.4977	>0.05 (ns)
Same Tone ×Mode ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	2	1.6626	>0.05 (ns)
Random effects		χ^2	
1+ Trial order in the same color (centralized)|Participant	2	8.00	<0.05

Appendix 15. The model comparing the S+T− character 览 combined with T− versus T+ incongruent ink colors on LogRTs of incongruent trials in JM mode

Fixed effects	Df	F	p
Color (T+ color ‘purple’/ T− color-’green’/ ‘red’/ ‘yellow’)	3	34.29	<0.001
Within-dialect condition (S+T− character 览/ neutral character 鼻 for purple, 涂 for ‘green’, 贯 for ‘red’, 岸 for ‘yellow’)	1	0.148	>0.05 (ns)
Trial (centralized)	1	12.052	<0.001
Trial distance from the same color (centralized)	1	4.609	<0.05
Color ×Within-dialect condition	3	0.883	>0.05 (ns)
Color ×Trial (centralized)	3	1.248	>0.05 (ns)
Within-dialect condition ×Trial (centralized)	1	0.031	>0.05 (ns)
Color ×Trial distance from the same color (centralized)	3	1.703	>0.05 (ns)
Within-dialect condition ×Trial distance from the same color (centralized)	1	0.657	>0.05 (ns)
Trial (centralized) ×Trial distance from the same color (centralized)	1	0.046	>0.05 (ns)
Color ×Within-dialect condition ×Trial (centralized)	3	0.774	>0.05 (ns)
Color ×Within-dialect condition ×Trial distance from the same color (centralized)	3	2.491	>0.05 (ns)
Color ×Trial (centralized) ×Trial distance from the same color (centralized)	3	0.11	>0.05 (ns)
Within-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	1	0.782	>0.05 (ns)
Color ×Within-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	3	0.771	>0.05 (ns)
Random effects		χ^2	
1 | Participant	1	138.18	<0.001

Appendix 16. The model compare the S+T− character 览 combined with T− versus T+ incongruent ink colors on LogRTs of incongruent trials in SC-bilingual mode

Fixed effects	Df	F	p
Color (T+ color ‘purple’/ T− color × ‘green’/ ‘red’/ ‘yellow’)	3	67.205	<0.001
Within-dialect condition (S+T− character 览/ neutral character 鼻 for purple, 涂 for ‘green’, 贯 for ‘red’, 岸 for ‘yellow’)	1	0.061	>0.05 (ns)
Trial (centralized)	1	2.35	>0.05 (ns)
Trial distance from the same color (centralized)	1	14.697	<0.001
Color ×Within-dialect condition	3	1.834	>0.05 (ns)
Color ×Trial (centralized)	3	1.088	>0.05 (ns)
Within-dialect condition ×Trial (centralized)	1	3.09	>0.05 (ns)
Color ×Trial distance from the same color (centralized)	3	0.473	>0.05 (ns)
Within-dialect condition ×Trial distance from the same color (centralized)	1	4.184	<0.05
Trial (centralized) ×Trial distance from the same color (centralized)	1	2.166	>0.05 (ns)
Color ×Within-dialect condition ×Trial (centralized)	3	0.156	>0.05 (ns)
Color ×Within-dialect condition ×Trial distance from the same color (centralized)	3	0.554	>0.05 (ns)
Color ×Trial (centralized) ×Trial distance from the same color (centralized)	3	0.109	>0.05 (ns)
Within-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	1	1.283	>0.05 (ns)
Color ×Within-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	3	0.751	>0.05 (ns)
Random effects		χ^2	
1 | Participant	1	101.25	<0.001

Appendix 17. The model comparing the S+T− character 览 combined with T− versus T+ incongruent ink colors on LogRTs of incongruent trials in SC-monolingual mode

Fixed effects	Df	F	p
Color (T+ color 'purple'/ T− color × 'green'/ 'red'/ 'yellow')	3	45.057	<0.001
Within-dialect condition (S+T− character 览/ neutral character 鼻 for purple, 涂 for 'green', 贯 for 'red', 岸 for 'yellow')	1	13.535	<0.001
Trial (centralized)	1	0.083	>0.05 (ns)
Trial distance from the same color (centralized)	1	2.919	>0.05 (ns)
Color ×Within-dialect condition	3	2.099	>0.05 (ns)
Color ×Trial (centralized)	3	1.441	>0.05 (ns)
Within-dialect condition ×Trial (centralized)	1	0.67	>0.05 (ns)
Color ×Trial distance from the same color (centralized)	3	0.071	>0.05 (ns)
Within-dialect condition ×Trial distance from the same color (centralized)	1	0.12	>0.05 (ns)
Trial (centralized) ×Trial distance from the same color (centralized)	1	0.75	>0.05 (ns)
Color ×Within-dialect condition ×Trial (centralized)	3	5.007	<0.01
Color ×Within-dialect condition ×Trial distance from the same color (centralized)	3	1.222	>0.05 (ns)
Color ×Trial (centralized) ×Trial distance from the same color (centralized)	3	0.534	>0.05 (ns)
Within-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	1	1.717	>0.05 (ns)
Color ×Within-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	3	1.331	>0.05 (ns)
Random effects		χ^2	
1 | Participant	1	-1.81	1

Appendix 18. The model comparing the S+T− character 旅 combined with T− versus T+ incongruent ink colors on LogRTs of incongruent JM trials

Fixed effects	Df	F	p
Color (T+ color 'purple'/ T− color × 'blue'/ 'red'/ 'yellow')	3	51.874	<0.001
Within-dialect condition (S+T− character 旅/ neutral character 鼻 for purple, 抱 for 'blue', 贯 for 'red', 岸 for 'yellow')	1	3.333	>0.05 (ns)
Trial (centralized)	1	7.403	<0.01
Trial distance from the same color (centralized)	1	10.452	<0.01
Color ×Within-dialect condition	3	1.398	>0.05 (ns)
Color ×Trial (centralized)	3	3.146	<0.05
Within-dialect condition ×Trial (centralized)	1	2.28	>0.05 (ns)
Color ×Trial distance from the same color (centralized)	3	2.896	<0.05
Within-dialect condition ×Trial distance from the same color (centralized)	1	4.508	<0.05
Trial (centralized) ×Trial distance from the same color (centralized)	1	0.041	>0.05 (ns)
Color ×Within-dialect condition ×Trial (centralized)	3	1.893	>0.05 (ns)
Color ×Within-dialect condition ×Trial distance from the same color (centralized)	3	1.384	>0.05 (ns)
Color ×Trial (centralized) ×Trial distance from the same color (centralized)	3	3.089	<0.05
Within-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	1	0.304	>0.05 (ns)
Color ×Within-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	3	0.904	>0.05 (ns)
Random effects		χ^2	
1+ Trial (centralized)|Participant	2	13.39	<0.01

Appendix 19. The model comparing the S+T− character 旅 combined with T− versus T+ incongruent ink colors on LogRTs of incongruent SC-bilingual trials

Fixed effects	Df	F	p
Color (T+ color ‘purple’/ T− color × ‘blue’/ ‘red’/ ‘yellow’)	3	70.994	<0.001
Within-dialect condition (S+T− character 旅/ neutral character 鼻 for purple, 抱 for ‘blue’, 贯 for ‘red’, 岸 for ‘yellow’)	1	1.739	>0.05 (ns)
Trial (centralized)	1	5.737	<0.05
Trial distance from the same color (centralized)	1	20.489	<0.001
Color ×Within-dialect condition	3	0.64	>0.05 (ns)
Color ×Trial (centralized)	3	1.261	>0.05 (ns)
Within-dialect condition ×Trial (centralized)	1	1.721	>0.05 (ns)
Color ×Trial distance from the same color (centralized)	3	1.431	>0.05 (ns)
Within-dialect condition ×Trial distance from the same color (centralized)	1	0.551	>0.05 (ns)
Trial (centralized) ×Trial distance from the same color (centralized)	1	0.223	>0.05 (ns)
Color ×Within-dialect condition ×Trial (centralized)	3	0.155	>0.05 (ns)
Color ×Within-dialect condition ×Trial distance from the same color (centralized)	3	0.429	>0.05 (ns)
Color ×Trial (centralized) ×Trial distance from the same color (centralized)	3	0.428	>0.05 (ns)
Within-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	1	3.89	<0.05
Color ×Within-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	3	1.408	>0.05 (ns)
Random effects		χ^2	
1+ Trial (centralized)|Participant	2	3.85	>0.05

Appendix 20. The model comparing the S+T− character 旅 combined with T− versus T+ incongruent ink colors on LogRTs of incongruent trials in SC-monolingual mode

Fixed effects	Df	F	p
Color (T+ color ‘purple’/ T− color × ‘blue’/ ‘red’/ ‘yellow’)	3	67.551	<0.001
Within-dialect condition (S+T− character 旅/ neutral character 鼻 for purple, 抱 for ‘blue’, 贯 for ‘red’, 岸 for ‘yellow’)	1	8.297	<0.01
Trial order in the same color (centralized)	1	1.615	>0.05 (ns)
Trial distance from the same color (centralized)	1	20.563	<0.001
Color ×Within-dialect condition	3	1.092	>0.05 (ns)
Color ×Trial order in the same color (centralized)	3	0.78	>0.05 (ns)
Within-dialect condition ×Trial order in the same color (centralized)	1	0.245	>0.05 (ns)
Color ×Trial distance from the same color (centralized)	3	0.226	>0.05 (ns)
Within-dialect condition ×Trial distance from the same color (centralized)	1	10.876	<0.01
Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	1	0.006	>0.05 (ns)
Color ×Within-dialect condition ×Trial order in the same color (centralized)	3	6.803	<0.001
Color ×Within-dialect condition ×Trial distance from the same color (centralized)	3	0.062	>0.05 (ns)
Color ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	3	0.281	>0.05 (ns)
Within-dialect condition ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	1	2.289	>0.05 (ns)
Color ×Within-dialect condition ×Trial order in the same color (centralized) ×Trial distance from the same color (centralized)	3	1.528	>0.05 (ns)
Random effects		χ^2	
1+ Trial order in the same color (centralized) | Participant	1	13.34	<0.001

Appendix 21. The model comparing the S+T− character 谎 combined with T− versus T+ incongruent ink colors on LogRTs of incongruent trials in JM mode

Fixed effects	Df	F	p
Color (T+ color 'purple'/ T− color × 'blue'/'green'/ 'red'/ 'yellow')	3	36.214	<0.001
Within-dialect condition (S+T− character 谎/ neutral character 抱 for 'blue', 涂 for 'green', 鼻 for 'purple', 贯 for 'red')	1	12.642	<0.001
Trial (centralized)	1	3.596	>0.05 (ns)
Trial distance from the same color (centralized)	1	11.386	<0.001
Color ×Within-dialect condition	3	1.858	>0.05 (ns)
Color ×Trial (centralized)	3	1.022	>0.05 (ns)
Within-dialect condition ×Trial (centralized)	1	0.826	>0.05 (ns)
Color ×Trial distance from the same color (centralized)	3	3.872	<0.01
Within-dialect condition ×Trial distance from the same color (centralized)	1	1.681	>0.05 (ns)
Trial (centralized) ×Trial distance from the same color (centralized)	1	0.468	>0.05 (ns)
Color ×Within-dialect condition ×Trial (centralized)	3	1.448	>0.05 (ns)
Color ×Within-dialect condition ×Trial distance from the same color (centralized)	3	2.459	>0.05 (ns)
Color ×Trial (centralized) ×Trial distance from the same color (centralized)	3	0.139	>0.05 (ns)
Within-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	1	1.012	>0.05 (ns)
Color ×Within-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	3	0.845	>0.05 (ns)
Random effects		χ^2	
1 | Participant	1	83.66	<0.001

Appendix 22. The model comparing the S+T− character 谎 combined with T− versus T+ incongruent ink colors on LogRTs of incongruent trials in SC-bilingual mode

Fixed effects	Df	F	p
Color (T+ color 'purple'/ T− color × 'blue'/'green'/ 'red'/ 'yellow')	3	46.391	**<0.001**
Within-dialect condition (S+T− character 谎/ neutral character 抱 for 'blue', 涂 for 'green', 鼻 for 'purple', 贯 for 'red')	1	9.389	**<0.01**
Trial (centralized)	1	7.158	<0.01
Trial distance from the same color (centralized)	1	12.665	<0.001
Color ×Within-dialect condition	3	1.664	>0.05 (ns)
Color ×Trial (centralized)	3	1.062	>0.05 (ns)
Within-dialect condition ×Trial (centralized)	1	1.897	>0.05 (ns)
Color ×Trial distance from the same color (centralized)	3	0.906	>0.05 (ns)
Within-dialect condition ×Trial distance from the same color (centralized)	1	5.441	<0.05
Trial (centralized) ×Trial distance from the same color (centralized)	1	0.014	>0.05 (ns)
Color ×Within-dialect condition ×Trial (centralized)	3	0.351	>0.05 (ns)
Color ×Within-dialect condition ×Trial distance from the same color (centralized)	3	0.221	>0.05 (ns)
Color ×Trial (centralized) ×Trial distance from the same color (centralized)	3	0.409	>0.05 (ns)
Within-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	1	2.355	>0.05 (ns)
Color ×Within-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	3	0.642	>0.05 (ns)
Random effects		χ^2	
1 | Participant	1	126.16	<0.001

Appendix 23. The model compare the S+T− character 谎 combined with T− versus T+ incongruent ink colors on LogRTs of incongruent trials in SC-monolingual mode

Fixed effects	Df	F	p
Color (T+ color 'purple'/ T− color × 'blue'/'green'/ 'red'/ 'yellow')	3	70.72	<0.001
Within-dialect condition (S+T− character 谎/ neutral character 抱 for 'blue', 涂 for 'green', 鼻 for 'purple', 贯 for 'red')	1	54.164	<0.001
Trial (centralized)	1	0.056	>0.05 (ns)
Trial distance from the same color (centralized)	1	0.845	>0.05 (ns)
Color ×Within-dialect condition	3	4.503	<0.01
Color ×Trial (centralized)	3	0.666	>0.05 (ns)
Within-dialect condition ×Trial (centralized)	1	0.479	>0.05 (ns)
Color ×Trial distance from the same color (centralized)	3	0.753	>0.05 (ns)
Within-dialect condition ×Trial distance from the same color (centralized)	1	0.647	>0.05 (ns)
Trial (centralized) ×Trial distance from the same color (centralized)	1	0.003	>0.05 (ns)
Color ×Within-dialect condition ×Trial (centralized)	3	2.683	<0.05
Color ×Within-dialect condition ×Trial distance from the same color (centralized)	3	0.595	>0.05 (ns)
Color ×Trial (centralized) ×Trial distance from the same color (centralized)	3	0.49	>0.05 (ns)
Within-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	1	2.825	>0.05 (ns)
Color ×Within-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	3	0.111	>0.05 (ns)
Random effects		χ^2	
1 | Participant	1	9.68	<0.01

Appendix 24. The model investigating the interaction of Mode and the between-dialect condition on LogRTs of incongruent trials with blue ink color

Fixed effects	Df	F	p
Between-dialect condition (S+T+ false friend of the corresponding color character(烂)/ S+T− false friend of the corresponding color character (览))	1	39.628	<0.001
Mode (SC by Beijing monolinguals/ JM/ SC by Jinan bilinguals)	2	3.571	<0.05
Trial (centralized)	1	4.392	<0.05
Trial distance from the same color (centralized)	1	20.986	<0.001
Between-dialect condition ×Mode	**2**	0.084	**>0.05(ns)**
Between-dialect condition ×Trial (centralized)	1	0.009	>0.05(ns)
Mode×Trial (centralized)	2	1.281	>0.05(ns)
Between-dialect condition ×Trial distance from the same color (centralized)	1	0.039	>0.05(ns)
Mode×Trial distance from the same color (centralized)	2	0.867	>0.05(ns)
Trial (centralized) ×Trial distance from the same color (centralized)	1	0.557	>0.05(ns)
Between-dialect condition ×Mode ×Trial (centralized)	2	1.17	>0.05(ns)
Between-dialect condition ×Mode ×Trial distance from the same color (centralized)	2	1.91	>0.05(ns)
Between-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	1	0.326	>0.05(ns)
Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	1.551	>0.05(ns)
Between-dialect condition ×Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	2.166	>0.05(ns)
Random effects		χ^2	
1 | Participant	1	816.78	<0.001
1 | Color	1	354.59	<0.001

Appendix 25. The model investigating the interaction of Mode and the between-dialect condition on LogRTs of congruent trials with blue ink color

Fixed effects	Df	F	p
Between-dialect condition (S+T+ false friend of the corresponding color character(烂)/ S+T− false friend of the corresponding color character (览))	1	2.6773	>0.05(ns)
Mode	2	0.2365	>0.05(ns)
Trial (centralized)	1	2.743	>0.05(ns)
Trial distance from the same color (centralized)	1	4.1986	<0.05
Between-dialect condition ×Mode	2	0.8759	>0.05(ns)
Between-dialect condition ×Trial (centralized)	1	0.4364	>0.05(ns)
Mode×Trial (centralized)	2	1.7094	>0.05(ns)
Between-dialect condition ×Trial distance from the same color (centralized)	1	0	>0.05(ns)
Mode×Trial distance from the same color (centralized)	2	1.2275	>0.05(ns)
Trial (centralized) ×Trial distance from the same color (centralized)	1	0.004	>0.05(ns)
Between-dialect condition ×Mode ×Trial (centralized)	2	0.8356	>0.05(ns)
Between-dialect condition ×Mode ×Trial distance from the same color (centralized)	2	1.8123	>0.05(ns)
Between-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	1	2.0186	>0.05(ns)
Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	2.1947	>0.05(ns)
Between-dialect condition ×Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	0.0801	>0.05(ns)
Random effects		χ^2	
1 | Participant	1	15.15	<0.001

Appendix 26. The model investigating the interaction of Mode and the between-dialect condition on LogRTs of incongruent trials with yellow ink color

Fixed effects	Df	F	p
Between-dialect condition (S+T+ false friend of the corresponding color character(荒)/ S+T− false friend of the corresponding color character (谎))	1	5.5308	<0.01
Mode (SC by Beijing monolinguals/ JM/ SC by Jinan bilinguals)	2	3.6248	<0.01
Trial (centralized)	1	1.7352	>0.05(ns)
Trial distance from the same color (centralized)	1	20.6441	<0.001
Between-dialect condition ×Mode	2	0.7057	>0.05(ns)
Between-dialect condition ×Trial (centralized)	1	0.1695	>0.05(ns)
Mode×Trial (centralized)	2	2.2653	>0.05(ns)
Between-dialect condition ×Trial distance from the same color (centralized)	1	0.0134	>0.05(ns)
Mode×Trial distance from the same color (centralized)	2	2.915	>0.05(ns)
Trial (centralized) ×Trial distance from the same color (centralized)	1	0.1867	>0.05(ns)
Between-dialect condition ×Mode ×Trial (centralized)	2	1.6649	>0.05(ns)
Between-dialect condition ×Mode ×Trial distance from the same color (centralized)	2	6.4513	<0.01
Between-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	1	2.363	>0.05(ns)
Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	2.1425	>0.05(ns)
Between-dialect condition ×Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	5.1322	<0.01
Random effects		χ^2	
1 | Participant	1	876.06	<0.001
1 | Color	1	309.16	<0.001

Appendix 27. The model investigating the interaction of Mode and the between-dialect condition on LogRTs of congruent trials with yellow ink color

Fixed effects	Df	F	p
Between-dialect condition (S+T+ false friend of the corresponding color character(荒)/ S+T− false friend of the corresponding color character (谎))	1	2.6096	>0.05(ns)
Mode (SC by Beijing monolinguals/ JM/ SC by Jinan bilinguals)	2	1.1472	>0.05(ns)
Trial (centralized)	1	0.021	>0.05(ns)
Trial distance from the same color (centralized)	1	13.638	<0.001
Between-dialect condition ×Mode	2	3.1512	<0.05
Between-dialect condition ×Trial (centralized)	1	1.4148	>0.05(ns)
Mode×Trial (centralized)	2	1.4	>0.05(ns)
Between-dialect condition ×Trial distance from the same color (centralized)	1	0.1018	>0.05(ns)
Mode×Trial distance from the same color (centralized)	2	1.4791	>0.05(ns)
Trial (centralized) ×Trial distance from the same color (centralized)	1	0.0046	>0.05(ns)
Between-dialect condition ×Mode ×Trial (centralized)	2	0.7688	>0.05(ns)
Between-dialect condition ×Mode ×Trial distance from the same color (centralized)	2	0.4793	>0.05(ns)
Between-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	1	0.2155	>0.05(ns)
Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	2.6039	>0.05(ns)
Between-dialect condition ×Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	0.7844	>0.05(ns)
Random effects		χ^2	
1 | Participant	1	12.010	<0.001

Appendix 28. The model investigating the interaction of Mode and the between-dialect condition on LogRTs of incongruent trials with green ink color

Fixed effects	Df	F	p
Between-dialect condition (S+T+ false friend of the corresponding color character(驴)/ between language homophones with different tone (旅))	1	33.462	<0.001
Mode (SC by Beijing monolinguals/ JM/ SC by Jinan bilinguals)	2	3.598	<0.05
Trial (centralized)	1	4.017	<0.05
Trial distance from the same color (centralized)	1	51.676	<0.001
Between-dialect condition ×Mode	**2**	**1.866**	**>0.05(ns)**
Between-dialect condition ×Trial (centralized)	1	0.137	>0.05(ns)
Mode×Trial (centralized)	2	0.204	>0.05(ns)
Between-dialect condition ×Trial distance from the same color (centralized)	1	2.189	>0.05(ns)
Mode×Trial distance from the same color (centralized)	2	4.527	<0.05
Trial (centralized) ×Trial distance from the same color (centralized)	1	1.514	>0.05(ns)
Between-dialect condition ×Mode ×Trial (centralized)	2	0.324	>0.05(ns)
Between-dialect condition ×Mode ×Trial distance from the same color (centralized)	2	0.84	>0.05(ns)
Between-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	1	0.008	>0.05(ns)
Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	2.349	>0.05(ns)
Between-dialect condition ×Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	1.587	>0.05(ns)
Random effects		χ^2	
1 + Trial (centralized)| Participant	2	7.193	<0.05
1 | Color	1	473.81	<0.001

Appendix 29. The model investigating the interaction of Mode and the between-dialect condition on LogRTs of congruent trials with green ink color

Fixed effects	Df	F	p
Between-dialect condition (S+T+ false friend of the corresponding color character(驴)/ between language homophones with different tone (旅))	1	0.3051	>0.05(ns)
Mode (SC by Beijing monolinguals/ JM/ SC by Jinan bilinguals)	2	1.0845	>0.05(ns)
Trial (centralized)	1	2.598	>0.05(ns)
Trial distance from the same color (centralized)	1	8.0267	<0.01
Between-dialect condition ×Mode	**2**	**0.8536**	**>0.05(ns)**
Between-dialect condition ×Trial (centralized)	1	1.3967	>0.05(ns)
Mode×Trial (centralized)	2	2.8052	>0.05(ns)
Between-dialect condition ×Trial distance from the same color (centralized)	1	4.0011	<0.05
Mode×Trial distance from the same color (centralized)	2	1.885	>0.05(ns)
Trial (centralized) ×Trial distance from the same color (centralized)	1	0.8296	>0.05(ns)
Between-dialect condition ×Mode ×Trial (centralized)	2	2.4631	>0.05(ns)
Between-dialect condition ×Mode ×Trial distance from the same color (centralized)	2	2.6056	>0.05(ns)
Between-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	1	0.5199	>0.05(ns)
Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	2.6901	>0.05(ns)
Between-dialect condition ×Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	0.0838	>0.05(ns)
Random effects		χ^2	
1 | Participant	1	-1.21	1

Appendix 30. The model investigating the interaction of Mode and the between-dialect condition on LogRTs of incongruent color character trials

Fixed effects	Df	F	p
Between-dialect condition (S+T+ color cognates 'green'/ S+T+ color cognates ×' blue/ purple/ red/ yellow')	4	1.512	>0.05(ns)
Mode (SC by Beijing monolinguals/ JM/ SC by Jinan bilinguals)	2	9.876	<0.001
Trial (centralized)	1	1.099	>0.05(ns)
Trial distance from the same color (centralized)	1	57.701	<0.001
Between-dialect condition ×Mode	8	1.401	>0.05(ns)
Between-dialect condition ×Trial (centralized)	4	1.519	>0.05(ns)
Mode×Trial (centralized)	2	2.288	>0.05(ns)
Between-dialect condition ×Trial distance from the same color (centralized)	4	3.071	<0.05
Mode×Trial distance from the same color (centralized)	2	2.808	>0.05(ns)
Trial (centralized) ×Trial distance from the same color (centralized)	1	1.27	>0.05(ns)
Between-dialect condition ×Mode ×Trial (centralized)	8	1.832	>0.05(ns)
Between-dialect condition ×Mode ×Trial distance from the same color (centralized)	8	0.762	>0.05(ns)
Between-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	4	0.159	>0.05(ns)
Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	0.647	>0.05(ns)
Between-dialect condition ×Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	8	0.721	>0.05(ns)
Random effects		χ^2	
1+Trial.crl|Participant	2	7.389	<0.05
1|StimuliID	1	15.197	<0.001
1 | Color	1	32.916	<0.001

Appendix 31. The model investigating the interaction of Mode and the between-dialect condition on LogRTs of congruent color character trials

Fixed effects	Df	F	p
Between-dialect condition (S+T+ color cognates 'green'/ S+T+ color cognates ×' blue/ purple/ red/ yellow')	4	58.867	<0.001
Mode (SC by Beijing monolinguals/ JM/ SC by Jinan bilinguals)	2	1.108	>0.05(ns)
Trial (centralized)	1	13.332	<0.001
Trial distance from the same color (centralized)	1	23.378	<0.001
Between-dialect condition ×Mode	**8**	**1.056**	**>0.05(ns)**
Between-dialect condition ×Trial (centralized)	4	1.281	>0.05(ns)
Mode×Trial (centralized)	2	1.369	>0.05(ns)
Between-dialect condition ×Trial distance from the same color (centralized)	4	0.953	>0.05(ns)
Mode×Trial distance from the same color (centralized)	2	0.964	>0.05(ns)
Trial (centralized) ×Trial distance from the same color (centralized)	1	0.758	>0.05(ns)
Between-dialect condition ×Mode ×Trial (centralized)	8	1.143	>0.05(ns)
Between-dialect condition ×Mode ×Trial distance from the same color (centralized)	8	0.365	>0.05(ns)
Between-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	4	2.23	>0.05(ns)
Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	0.141	>0.05(ns)
Between-dialect condition ×Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	8	0.433	>0.05(ns)
Random effects		χ^2	
1 | Participant	1	15.937	<0.001

Appendix 32. The model investigating the interaction of Mode and the between-dialect condition on LogRTs of incongruent S+T+ trials

Fixed effects	Df	F	p
Between-dialect condition (S+T+ false friend of the corresponding color character 虑/ S+T− false friend of the corresponding color character ×栏/ 子/ 洪/ 皇)	4	15.594	<0.001
Mode (SC by Beijing monolinguals/ JM/ SC by Jinan bilinguals)	2	13.914	<0.001
Trial (centralized)	1	6.389	<0.05
Trial distance from the same color (centralized)	1	100.192	<0.001
Between-dialect condition ×Mode	**8**	**1.452**	**>0.05(ns)**
Between-dialect condition ×Trial (centralized)	4	2.148	>0.05(ns)
Mode×Trial (centralized)	2	1.168	>0.05(ns)
Between-dialect condition ×Trial distance from the same color (centralized)	4	0.181	>0.05(ns)
Mode×Trial distance from the same color (centralized)	2	0.491	>0.05(ns)
Trial (centralized) ×Trial distance from the same color (centralized)	1	7.228	<0.01
Between-dialect condition ×Mode ×Trial (centralized)	8	0.774	>0.05(ns)
Between-dialect condition ×Mode ×Trial distance from the same color (centralized)	8	1.682	>0.05(ns)
Between-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	4	5.288	<0.001
Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	1.165	>0.05(ns)
Between-dialect condition ×Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	8	1.63	>0.05(ns)
Random effects		χ^2	
1+Trial.crl|Participant	2	38.49	<0.001
1 | Color	1	1173.1	<0.001

Appendix 33. The model investigating the interaction of Mode and the between-dialect condition on LogRTs of congruent S+T+ trials

Fixed effects	Df	F	p
Between-dialect condition (S+T+ false friend of the corresponding color character 虑/ S+T− false friend of the corresponding color character ×栏/子/洪/ 皇)	4	75.856	<0.001
Mode (SC by Beijing monolinguals/ JM/ SC by Jinan bilinguals)	2	1.49	>0.05(ns)
Trial (centralized)	1	8.233	<0.01
Trial distance from the same color (centralized)	1	43.733	<0.001
Between-dialect condition ×Mode	**8**	**0.829**	**>0.05(ns)**
Between-dialect condition ×Trial (centralized)	4	1.217	>0.05(ns)
Mode×Trial (centralized)	2	0.4	>0.05(ns)
Between-dialect condition ×Trial distance from the same color (centralized)	4	0.14	>0.05(ns)
Mode×Trial distance from the same color (centralized)	2	3.792	<0.05
Trial (centralized) ×Trial distance from the same color (centralized)	1	3.593	>0.05(ns)
Between-dialect condition ×Mode ×Trial (centralized)	8	2.905	<0.01
Between-dialect condition ×Mode ×Trial distance from the same color (centralized)	8	1.135	>0.05(ns)
Between-dialect condition ×Trial (centralized) ×Trial distance from the same color (centralized)	4	1.61	>0.05(ns)
Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	2	0.001	>0.05(ns)
Between-dialect condition ×Mode ×Trial (centralized) ×Trial distance from the same color (centralized)	8	1.146	>0.05(ns)
Random effects		χ^2	
1 | Participant	1	80.488	<0.001