Visual Context Modulates L2 Long-Term Structural Priming for the Chinese *Ba* Construction

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<ABSTRACT>

This study investigates how visual context influences second language (L2) long-term structural priming for the Chinese *ba* construction. The experiment consisted of a baseline phase, an exposure phase, an immediate posttest, and a delayed posttest. L2 Chinese learners (N = 120) were assigned to 1 of 4 groups for the exposure manipulation. The 3 experimental

groups were exposed to simultaneous text and audio stimuli using the *ba* construction, accompanied by different visual contexts: a TV episode for the video group, isolated pictures for the picture group and no nonlinguistic context for the text group. The picture and the video groups showed a greater increase in production of the *ba* construction from the baseline to the immediate posttest than the text group, but only the video group continued producing higher rates of the *ba* construction in the delayed posttest after a 3-day interval. The production of the *ba* construction remained unchanged for the control group throughout the experiment. We conclude that visual context enhances L2 structural priming and that the continuous video context can support long-term priming effects. This is the first study to directly compare the magnitude of L2 long-term structural priming in different visual contexts, shedding light on the mechanism by which context facilitates L2 learning.

<END ABSTRACT>

Keywords: visual context; long-term structural priming; *ba* construction; L2 syntactic development; usage-based approaches

In the past decade, structural priming has captured the common interests of psychologists (Bock, 1986; Pickering & Branigan, 1998; see Pickering & Ferreira, 2008, for a review) and second language (L2) researchers (Jackson, 2018). It is recognized as a cognitive repetition phenomenon whereby language comprehension or production is facilitated by prior exposure

to a particular syntactic structure (Pickering & Ferreira, 2008). For example, comprehending a double object (DO) sentence (e.g., *The sailor gave the monk a banana*) increases the probability of encoding the next transfer event with a DO rather than a prepositional object (PO) structure (e.g., *The sailor gave a banana to the monk*). It has been argued that structural priming is a form of implicit learning that leads to a long-term strengthening of message-to-syntax connections (Chang, Dell, & Bock, 2006; Chang et al., 2000; Ferreira & Bock, 2006). L2 structural priming research largely focuses on its facilitative role in L2 construction learning. There is ample evidence that structural priming helps L2 learners produce difficult or less developed syntactic structures, which potentially benefits L2 syntactic development (e.g., Kim & McDonough, 2008; McDonough, 2006; McDonough & De Vleeschauwer, 2012; McDonough & Mackey, 2008; Shin & Christianson, 2012). More recent research has observed long-term or cumulative priming effects in L2 sentence production (Hwang & Shin, 2019; Jackson & Ruf, 2017, 2018; Kaan & Chun, 2018; Shin & Christianson, 2012) and comprehension (Wei et al., 2019), indicating that L2 learners adapt their language representations to recent experience through implicit learning.

Given that structural priming is an important means of learning L2 linguistic forms, it is crucial to examine in which circumstances priming persists and leads to long-term L2 syntactic development (Jackson, 2018). Prior work has suggested that the longevity of structural priming might be constrained by various factors, such as the abstractness of syntactic representations, structure preference in the native language (L1), complexity of the

target structure and individual learner characteristics (e.g. Jackson & Ruf, 2017, 2018; McDonough, 2006; Shin & Christianson, 2012). Due to the complexity of this issue, more research is called on to clarify the conditions under which priming "is most successful for promoting long-term learning" (Jackson, 2018, p. 547) or "yields the strongest persistence" (Kaan & Chun, 2018, p. 240). Meanwhile, it is advocated to investigate long-term structural priming in languages other than English, especially those which have been seldom considered in priming research (Jackson, 2018).

The current study aims to contribute to this line of inquiry by examining the impact of nonlinguistic visual contexts on L2 long-term structural priming for the Chinese *ba* construction. Until recently, L2 structural priming studies have used isolated and decontextualized stimuli, leaving unaddressed whether context has a role to play in the persistence of L2 structural priming. Moreover, investigating structural priming in decontextualized conditions is at odds with the general agreement that L2 acquisition is context-dependent (e.g., Douglas Fir Group, 2016; Ellis, 2019; Eskildsen, 2009; Larsen–Freeman, 2020; Wang & Wang, 2015), giving rise to the doubts on the generalizability of the research findings thus obtained to the real-world L2 learning (Jackson, 2018).

In particular, usage-based approaches to L2 acquisition hold that "language is learned through the participatory experience of processing language during embodied interaction in social and cultural contexts" (Ellis, 2019, p. 45). It is argued that engagement in these

contexts mobilizes all available semiotic resources—such as linguistic, prosodic, interactional, nonverbal, graphic, pictorial, and auditory resources—and thereby nonlinguistic, multimodal resources afforded by the contexts are crucial to language learning (Douglas Fir Group, 2016). We thus have good reason to assume that L2 structural priming, as a form of implicit learning, might be affected by nonlinguistic visual contexts. The goal of the current study was to explore this hypothesis by comparing the effects of prime sentences presented within a video story to matched prime sentences illustrated with static pictures or presented in the absence of visual context.

We also explored the possibility that the degree to which visual context boosts linguistic alignment is modulated by the continuity of the context. Specifically, we examined whether continuity of the protagonist, objects, and setting, as expressed both by the prime sentences and by an accompanying video with a coherent story (i.e., the video context), provide additional benefits to long-term structural priming, over and above those benefits offered by isolated sentences presented with static images (i.e., the picture context).

We concentrated on L2 learning of the Chinese *ba* construction (e.g., *Xiao-mao Ba yu chidiao le* 'The little cat ate the fish up'), a structure that is unique to Chinese. In contrast with the typical subject–verb–object (SVO) word order of Chinese, the *ba* construction follows SOV order and its use is restricted by grammatical, semantic, and pragmatic constraints (Wen, 2006). Not surprisingly, the *ba* construction poses great challenges for L2

learners of Chinese (Du, 2006; Wen, 2010; Xu, 2011). Investigation of long-term structural priming by using this structure therefore allows us to examine whether structural priming is a universal implicit learning mechanism and how it facilitates L2 development of marked structures.

<A>THEORETICAL BACKGROUND

<B>*Longevity of Structural Priming and L2 Learning*

Structural priming is a ubiquitous and robust psychological phenomenon as evidenced by the fact that speakers tend to use syntactic structures that were previously heard or produced, even when the initial and subsequent utterances have different content words, closed-class elements, and thematic compositions and share no topical or pragmatic similarities (see Pickering & Ferreira, 2008, for a review). There are two general accounts of structural priming: a residual activation account (e.g., Branigan, Pickering, & Cleland, 1999; Pickering & Branigan, 1998) and an implicit learning account (e.g., Bock & Griffin, 2000; Chang et al., 2006; Jaeger & Snider, 2013; Reitter, Keller, & Moore, 2011). The residual activation account suggests that structural priming results from the transient activation of a recently processed syntactic structure and therefore structural priming effects are predicted to be short-lived (e.g., Branigan et al., 1999; Pickering & Branigan, 1998).

The implicit learning account maintains that structural priming is a form of implicit learning, which tunes the language processing system to previous experience (e.g., Bock &

Griffin, 2000; Chang et al., 2006; Jaeger & Snider, 2013). In other words, structural priming causes relatively long-lasting experience-dependent adaptations to the systems of language production. The direct evidence for the implicit learning account is that structural priming occurs not only after exposure to the immediately preceding prime sentences but also after a longer interval, extending over several sentences, perhaps as much as several weeks (e.g., Bock & Griffin, 2000; Chang et al., 2006). For instance, in a series of studies, Kaschak and colleagues (e.g., Kaschak, Kutta, & Coyle, 2014; Kaschak, Kutta, & Schatschneider, 2011) reported that structural priming effects accumulated across utterances and that probabilistic distribution of English ditransitive construction in the exposure phase could affect participants' use of that construction in subsequent production even after a 1-week interval.

Likewise, long-term effects of structural priming have been observed in L2 learners. Shin and Christianson (2012) investigated structural priming for L2 English DO constructions and separated phrase-verb constructions (e.g., *The man is taking the coat off*). It turned out that priming effects in the long-lag condition resulted in increased production of the DO structure during a second testing session 1 day later. Similarly, Kim and McDonough (2016) found that less proficient adult L2 speakers exhibited priming of the passive construction both immediately and at a delayed posttest after 2 weeks. Kaan and Chun (2018) found that Korean-speaking learners of English produced more POs after they were exposed to more POs in the preceding context of English.

However, the longevity of L2 structural priming appears to be conditional and restrictive. McDonough (2006) investigated L2 structural priming of the English DO construction and found immediate priming effects when participants were exposed exclusively to DO primes—but the exposure had no effect on their subsequent production immediately after the priming. The lack of long-term priming was attributed to L2 learners' incomplete DO representations. Jackson and Ruf (2017) observed no persistence of the priming for adverb–verb–subject word order with locative phrases in L2 German, which is less preferred in the participants' L1 (English). In addition, learner characteristics (McDonough & Vleeschauwer, 2012) and repetition of the primes (Gámez & Vasilyeva, 2015; Jackson & Ruf, 2018; Kim & McDonough, 2016) have been found to influence the degree to which L2 structural priming persists.

To summarize, previous research indicates that structural priming has the potential of facilitating L2 syntactic development but its long-term effects might be constrained by multiple factors. However, there are two research gaps in the existing studies. The first gap is that the evidence for L2 structural priming as implicit learning so far mainly comes from dative or passive and active alternations in English or typologically similar languages like Dutch, German, and French. Prior work shows that processing mechanisms (such as the preference to order heavier constituents before lighter ones) might be language-specific (Jaeger & Norcliffe, 2009; Hwang & Shin, 2019). More pertinently, persistence of structural priming appears to be mediated by specific structures (Shin & Christianson, 2012; Jackson &

Ruf, 2017). Therefore, more structures from languages other than English should be examined to determine whether structural priming can serve as a ubiquitous and robust mechanism that accounts for L2 acquisition of typologically diverse languages (Hwang & Shin, 2019). The Chinese *ba* construction is an ideal test ground for this issue since it is a language-specific structure that is difficult for L2 learners of Chinese.

The second gap is that the existing studies were mostly conducted in decontextualized conditions despite the fact that language learning is typically embedded in contexts, which are accomplished by means of both linguistic and nonlinguistic multimodal resources (Douglas Fir Group, 2016; Ellis, 2019; Jackson, 2018). Therefore, the results might have limited implications for L2 learning, which stresses the ability to use L2 forms appropriately in real contexts.

<B>*Visual Context, Language Processing, and Structural Priming*

There is evidence that nonlinguistic visual context can impact language processing in general and structural priming in particular. For example, listeners use visual context to resolve both syntactic ambiguities (Spivey et al., 2002) and referential ambiguities (e.g. Burmester, 2018; Sedivy et al., 1999), and faces can cue Spanish–Catalan bilinguals' word retrieval (Woumans et al., 2015). Similar patterns have been detected in L2 processing. Zhang et al. (2013) found that visual cues of Chinese culture, such as faces or iconic Chinese symbols (e.g., the Great Wall), disrupted Chinese immigrants' English fluency. In addition,

priming with such visual cues resulted in faster recognition of Chinese-to-English literal translations and increased use of these literal translations in an object-naming task. Results of this research are consistent with the understanding that language users employ various semiotic resources, which include visual, graphic, and auditory modes of meaning making (Kress, 2010).

Furthermore, the relationship between visual contexts and structural priming has been suggested by the interactive alignment model (IAM; Pickering & Garrod, 2004), which holds that the mental representations of interlocutors become aligned during a dialogue, both at linguistic levels (e.g., phonological, lexical, syntactic, and semantic) and the 'situation model' level (i.e., information about time, space, protagonists, objects, causality, etc.), thereby reducing the processing load in dialogue. According to the IAM, alignment is also a cognitive repetition phenomenon and the mechanism of the alignment at the linguistic levels is structural priming. The IAM highlights the interconnections between alignment at different levels and posits that alignment at one level leads to aligned representations at other levels, such that alignment of situation models is facilitated by the interlocutors repeating each other's linguistic choices at the lexical, syntactic, and referential levels. It thus can be inferred from the IAM that strengthening the alignment at the situation-model level should boost alignment at the linguistic levels.

Although the construction of a situation model is largely dependent on language users' comprehension of linguistic input, it also involves their understanding of the nonlinguistic visual cues afforded by the co-present interactional environment. As pointed out by Zwaan and Radvansky (1998), nonlinguistic visual information like graphs and tables helps incorporate information derived from texts into an integrated situation model. They further argued that contextual cues can assist in readers' connecting incoming event to the tokens for protagonists and objects that form the 'meat' of situation models. This same mechanism could explain how visual context modulates the magnitude and persistence of L2 structural priming, even in long-term priming paradigms that do not involve dialogue. Although the IAM was developed to account for mechanistic psychology of dyadic conversations, Pickering and Garrod (2004) proposed that there is a 'dialogue continuum' with monologue at one end and fully interactive dialogue at the other and that the same mechanisms are involved in dialogue and monologue (also see Barr & Keysar, 2004). It has been demonstrated that the IAM can be applied to the interaction in L2 written production wherein L2 learners aligned with the input text at both the situation-model and linguistic levels when completing an English story (e.g., Wang & Wang, 2015; Peng, Wang, & Lu, 2018).

Critically, the richness of contextual cues has been claimed to modulate the magnitude of alignment. As argued by Wang and Wang (2015), alignment is a continuum and the magnitude of alignment depends on the intensity of the interaction between L2 learners

and the input, with more intense interaction leading to stronger alignment. It is the richness of the contextual information involved in online processing of input that determines the intensity of interaction (Wang, 2010). For example, Cai and Wang (2017) investigated the alignment in three groups of Chinese learners of English who retold a story after receiving the text-plus-video input, video input, and text-only input respectively. It turned out that the text-plus-video-input group outperformed the other two in reusing the words and phrases in the input story because the multimodal contextual information provided by the video could engage the learners more deeply in the interaction with the input.

Taken together, this line of research suggests that the cues of nonlinguistic contexts facilitate the construction of situation models, resulting in stronger linguistic alignment. Thus, compared with decontextualized prime sentences, prime sentences accompanied by visual context (e.g., video and pictures) would give rise to stronger structural priming, thereby promoting L2 syntactic development more successfully. One important objective of the present study was to test this hypothesis.

Another important issue explored in this article was whether the contextual boost effect on long-term structural priming would be modulated by the continuity of context, operationalized as whether the context has a coherent storyline. Zwaan and Radvansky (1998) argued that processing load can be ameliorated if the incoming event is easily integrated into the evolving situation model and the easiness pertains to the extent to which

the incoming event shares indexes (like protagonists, object, time, or spatial relationships) with the current state of the situation model. This suggests that the continuity of context (whether the contexts share indexes with previous events) may have additive effects on the construction of the situation model.

More direct evidence for the impact of context continuity on the strength and persistence of structural priming comes from Travis, Torres Cacoullos, & Kidd (2017). They found that the within- and between-language priming of Spanish first-person subject *yo* was strongest in the continuous subject context where the clause immediately preceding the target clause had a coreferential first-person subject compared with a discontinuous subject context where the continuity of the reference of the prime *yo* was broken by the presence of non-co-referential subjects.

The facilitative effect of context continuity on structural priming is supported by the impact of topic continuity on sentence processing. Note that the continuous visual context may entail topic continuity of the prime sentences—namely, the tendency to talk about the same topic in multiple utterances that are contiguous in time (Frank, Tenenbaum, & Fernald, 2013). According to Givón (1983), topic continuity in discourse is concerned with referent introduction and maintenance and is basically realized through linguistic devices such as zero, pronominal, and nominal anaphors. It has been documented in the literature that language processing is susceptible to topic continuity. Using event-related potential (ERP)

measures, Hung and Schumacher (2012) tested Chinese question–answer pairs consisting of topic and nontopic questions followed by different continuations (i.e., topic continuity, topic shift, novel topic). The results suggest that information processing tends to be guided by the informational demands associated with topicality (N400: topic shift > novel topic > topic continuity; late positivity: topic shift > novel topic/topic continuity).

When exploring the impact of visual context on L2 long-term structural priming, another issue worthy of scrutiny is whether and to what degree structural priming evoked in particular contexts (e.g., exposure to primes accompanied by static pictures) can persist flexibly when the context of subsequent production is altered (e.g., describing the scenarios of a video clip). Addressing this issue of flexibility helps determine whether the long-term adaptation of L2 syntactic representations is restricted to specific learning conditions. If so, this failure to generalize across different visual contexts sharply reduces the practical importance of L2 structural priming for L2 learning.

<A>THE CURRENT STUDY

The present study examined whether and how visual context influences L2 long-term structural priming for the Chinese *ba* construction and the impact of long-term structural priming on L2 syntactic development. Visual contexts were provided by pictures and videos, which demonstrated the key components of the situation model, such as setting, protagonists, entities, and actions embedded in the prime sentences. A fundamental difference between the

picture context and the video context lies with whether there was a coherent storyline. The picture contexts were totally unrelated and isolated. For example, one picture depicted the scenario that a little girl put some coins into a saving pot while another depicted the scenario that a man unfastened his tie (see the prime sentences in Appendix A). The scenarios involved different settings and protagonists and didn't take place in a particular order that matched a coherent narrative story. In contrast, the video clip (extracted from the British sitcom *Mr. Bean*) depicted a complete comic story that happened to Mr. Bean. Two types of visual contexts were thus provided: a discontinuous context represented by isolated pictures and a continuous context represented by a video clip.

In addition, we investigated whether priming effects can generalize across verbs and contexts. The first issue is concerned with whether structural priming helps learners generalize the *ba* construction to verbs that were not encountered in the exposure phase. To date, whether and to what extent structural priming facilitates generalization of L2 constructions has been underexplored. Shin (2015) reported that L2 structural priming could help Korean learners of English generalize DO dative and phrasal-verb constructions to novel verbs. The present study extended this research to L2 learning of the Chinese-specific *ba* construction and moved further to explore what type of context is favorable to the generalization. The context generalization issue concerned whether the structural priming effects derived from a particular visual context (e.g., repetition of prime sentences

accompanied by a picture) can persist when the type of visual context of subsequent production differs (e.g., describing video scenarios instead of pictures).

In summary, three types of visual context were employed in the present study: zero visual context (priming with text only), picture context, and video context. As can be seen from Table 1, all three types of context provided linguistic cues since linguistic examples of the *ba* construction in both text and aural form were embedded in them. Meanwhile, the picture and the video contexts provided a nonlinguistic visual context for the sentences containing the *ba* construction, which arguably increases participants' engagement and facilitates the construction of a situation model for the sentences. The video context provided the continuity of context and topic, further supporting a situation model. Additionally, we assume that the video context is the most engaging because of the vividness, dynamics, and funny plot of the TV episode.

<INSERT TABLE 1 ABOUT HERE>

TABLE 1

Characteristics of Different Types of Visual Contexts

Visual context	Linguistic cues	Visual cues	Engaging	Context continuity	Topic continuity
Zero (text only)	+	-	Low	N/A	-

Picture	+	+	Middle	-	-
Video	+	+	High	+	+

The current study was guided by the following research questions and predictions:

RQ1. Does the type of visual context presented with the prime affect the immediate and long-term cumulative structural priming for the Chinese *ba* construction in L2 production?

RQ2. If we find immediate or long-term cumulative priming, does it generalize beyond the verbs used in the exposure phase?

RQ3. Does L2 structural priming for the *ba* construction accumulated in the video context persist when the subsequent production switches to a static picture context, and vice versa?

Drawing on the implications from previous theoretical and empirical research, we made the following predictions:

P1. More engaging and continuous context facilitates comprehension, thereby giving rise to stronger priming effects, with the most priming in the video context and the least priming in the text condition.

P2. The priming effects for the *ba* construction generalize beyond the verbs in the exposure phase. Further, the presence of the visual contexts could facilitate the generalization of the *ba* construction across verbs.

P3. There should be stronger immediate and long-term cumulative priming effects when the context conditions match across the exposure phase and the production phase.

<A>METHOD

<B>*Participants*

Participants of the current study were 120 international students (53 females and 67 males) enrolled in a variety of undergraduate and postgraduate programs (e.g. medicine, engineering, management, and business) at a university in Northwest China. Their ages ranged from 19 to 25 years old (M = 21.57; SD = 1.83). Their average length of residence in China was 23.97 months (SD = 7.63) and average length of learning Chinese was 22.70 months (SD = 8.40). They had all completed at least 1 year of mandatory Chinese classes (6 hours per week). Sixty-eight of them had received the HSK III certificate and the other 52 had passed HSK IV.[1] Their Chinese proficiency was evaluated to be at the intermediate level by their Chinese teachers. Their L1s included Arabic, Urdu, English, Thai, Korean, Malay, French, and Hindi, among others. Each participant received a gift after the experiment. They were randomly assigned to three experimental groups and a control group, with 30

participants in each. Table 2 presents the biographical information for participants in different groups.

<INSERT TABLE 2 ABOUT HERE>

TABLE 2

Biographical Information of Participants by Group

Group	Age (*SD*)	Mean LOR in China (*SD*)	Mean length of learning Chinese (*SD*)
Control (*N* = 30)	22.80 (2.10)	25.57 (8.67)	24.71 (8.34)
Text only (*N* = 30)	22.53 (1.84)	21.69 (6.48)	22.52 (9.21)
Picture (*N* = 30)	21.87 (2.00)	23.54 (5.24)	23.31 (6.07)
Video (*N* = 30)	21.77 (1.67)	25.19 (8.81)	21.56 (9.27)

Note. SD = standard deviation; LOR = length of residence.

<B>*The Target Construction*

The target structure was the Chinese *ba* construction, the basic structure of which is NP_1 + *ba* + NP_2 + V + X. The first noun phrase (NP_1) is the subject or topic, while *ba* and NP_2 are located between the subject and the verb. NP_2 can be either the patient or the theme

of the verb. Unlike typical Chinese sentences which follow the order of SVO, the word order of the *ba* construction is S-*ba*-OV. SVO and *ba* constructions can alternate with one another (though not always) as illustrated in Examples (1-3).

(1) a. *Zhangsan Ba fangzi chai-le.* (*ba* construction)

Zhangsan *BA* house pull-down-ASP

b. *Zhangsan chai-le fangzi.* (SVO construction)

Zhangsan pulled-down-ASP house

'John pulled down the house.'

(2) a. *Wo Ba didi dai dao gongyuan.* (*ba* construction)

I *BA* younger brother take to park

b. *Wo dai didi dao gonguan.* (SVO construction)

I take younger brother to park

'I took my younger brother to the park.'

(3) a. *Haizi Ba wo ku de xinfan.* (*ba* construction)

Kid *BA* me cry *DE* heart-disturbed

b. *Haizi ku de wo xinfan.* (SVO construction)

Kid cry *DE* me heart-disturbed.

'The kid cried so much that I got disturbed.'

Another distinctive linguistic feature of the *ba* construction is that it has syntactic, semantic, and pragmatic constraints. Syntactically, the construction must have a complement to specify the affectedness of the *ba*-NP caused by the verb (Wen, 2010, p.74). The verb complement X has various forms, such as the perfective marker *–le*, a prepositional phrase (dative or locative), and a resultative verb complement (Examples [1–3], respectively). Semantically, the construction must satisfy [+telic] and [+perfective] requirements (Huang & Yang, 2004; Li & Bowerman, 1998). Typically, the [+telic] requirement is satisfied by the verb or verb compound that denotes an end state while the [+perfective] requirement is satisfied by the aspect marker *–le* in Chinese (Hsu, 2014). Pragmatically, the construction highlights the notion "what has happened to the NP behind Ba" conveyed by the postverb complement (Wen, 2010, p. 75).

Apart from the noncanonical word order and partial productivity, the input frequency of the *ba* construction is much lower than the SVO structure that can alternate with it, with 92% for SVO and 6%–8% for the *ba* construction in adult production (Sun & Givón, 1985; Wei, 1989). These factors conspire to make the *ba* construction notoriously difficult for both L1 and L2 learners. Cheung (1992) reported that Chinese-speaking children of 5 years old have not yet fully mastered it (also see Jespon, 1989). In the same vein, L2 learners have been

found to avoid using the *ba* construction. For instance, Wen (2006) observed that the *ba* construction was rarely used in the speech of the beginning English-speaking learners of Chinese. Du (2004) showed that L2 Chinese learners produced fewer *ba* sentences than native speakers of Chinese. Even for L2 learners at advanced levels, the production of the *ba* construction is 86% less than that by native speakers in the same mandatory contexts (Liu, Qian, & Wang, 2002).

Some L1 structural priming studies have been carried out using the *ba* construction as the target structure to investigate the development of abstract syntactic representation among Chinese-speaking children of different age groups (e.g., Hsu, 2014; 2018). These studies indicate that L1 children demonstrate immediate and cumulative structural priming of the *ba* construction from 3 years old. To the best of our knowledge, no L2 studies have ever investigated long-term structural priming of the *ba* construction. Addressing this issue, however, can provide insight into both L2 structural priming research and L2 acquisition of the *ba* construction.

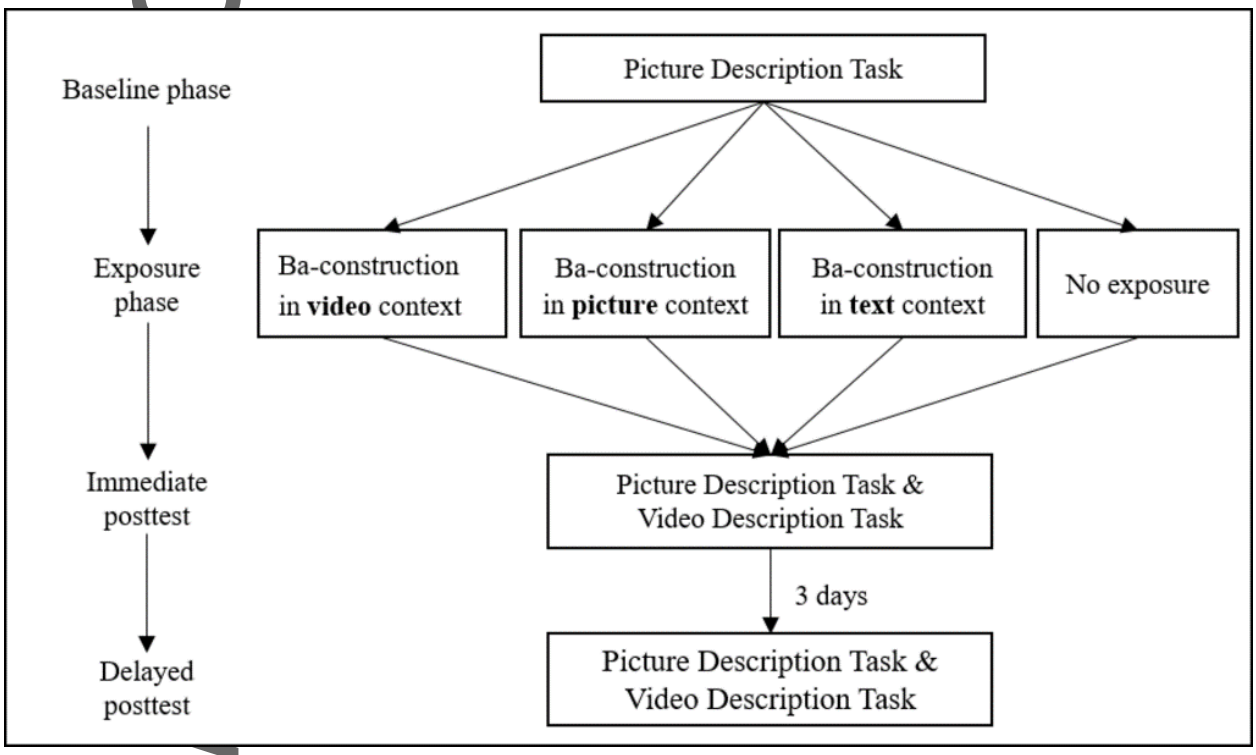
<B>*Research Design and Procedure of the Study*

The current study adopted a pretest–immediate-posttest–delayed-posttest experimental design (see Figure 1). All participants experienced four phases: baseline, exposure, immediate posttest, and delayed posttest.

<INSERT FIGURE 1 ABOUT HERE>

FIGURE 1

Overview of the Experiment



In the baseline phase, we assessed participants' pre-exposure use of the *ba* construction via a picture description task consisting of 12 items. As illustrated in Figure 2A, the items of the picture description task denoted transitive events that could be described by using either an SVO (e.g., *nvren guanshang le men* 'The woman closed the door') or an S–*ba*–OV structure (e.g., *nvren Ba men guanshang le*).

< INSERT FIGURE 2 ABOUT HERE >

FIGURE 2

Sample Items From the Picture Description Task (A) and the Video Description Task (B)

(A) 

(B) 

Note. The English equivalent of the verb in the picture and the snapshot is *close*.

In the exposure phase, participants of different groups were treated differently. The three experimental groups were exposed to 18 prime sentences containing the *ba* construction presented both visually and auditorily. The visual contexts of the prime sentences for the three groups were varied: For the text group, no visual context was provided, while for the picture group and the video group, the prime sentences were accompanied by isolated pictures and the video proportion of a TV episode, respectively. Participants were instructed to repeat the sentences upon hearing and seeing them. Notably, the audio in the video context condition was muted, and only the visually presented sentence was to be repeated. The control group received no input in this phase. In the immediate posttest, all four groups

completed a picture description task and a video description task in which they could use the *ba* or non-*ba* construction at will. Each task consisted of 12 items. The video description task consisted of 12 very short video clips, each depicting an action that could be described by using either an SVO (e.g., *Douxiansheng guanshang le che men* 'Mr. Bean closed the door of the car') or an S–*ba*–OV structure (e.g., *Douxiansheng Ba chemen guanshang le*). See Figure 2B for an example.

The first three phases were conducted consecutively within the same day in a single session. The exposure phase lasted about 15 minutes and the whole session lasted for approximately 45 minutes. Three days later, all participants completed the second session—namely, the delayed posttest. Like in the immediate posttest, a picture description task and a video description task were again employed in the delayed posttest but the tasks in the two stages were different. In both sessions, participants were tested individually in front of a computer in a sound-attenuated room. The exposure and test materials were presented with Windows Media Player. The whole experiment was audiotaped.

We measured the amount of immediate cumulative structural priming in different contexts by comparing the production of the *ba* construction in the baseline phase and the immediate posttest. The persistence of the priming effects was determined by examining whether the proportion of the *ba* construction in the delayed posttest stage was still larger than that in the baseline phase. In order to examine whether long-term structural priming

effects can generalize across verbs (RQ2) and visual contexts (RQ3), we manipulated verb overlap and context-type match as two within-subjects variables.

When manipulating the verb-overlap condition, we used two sets of target verbs in the immediate and the delayed posttests: Half of the verbs appeared in both the exposure phase and the posttests and constituted the verb-overlap condition, the other half of the verbs appeared only in the posttests but not in the exposure phase, forming the nonoverlap condition.

The context-match condition was varied by manipulating the visual context type of the prime sentences. For the video group, the video description task matched with their experience during the exposure phase in terms of visual context type and therefore constituted a context-type match, although the content of the videos employed in the different phases was not the same. In turn, the picture description task constituted a context-type mismatch for the video group. Correspondingly, for the picture group, the picture description task constituted a context-type match whereas the video description task constituted a context-type mismatch.

<B>*Materials for the Exposure Phase*

The prime sentences for the three experimental groups were 18 sentences containing the *ba* construction with 18 different verbs (e.g., *Douxiansheng Ba baobao baozou le* 'Mr. Bean took the baby away'). While the actions (the target verbs) depicted by the prime

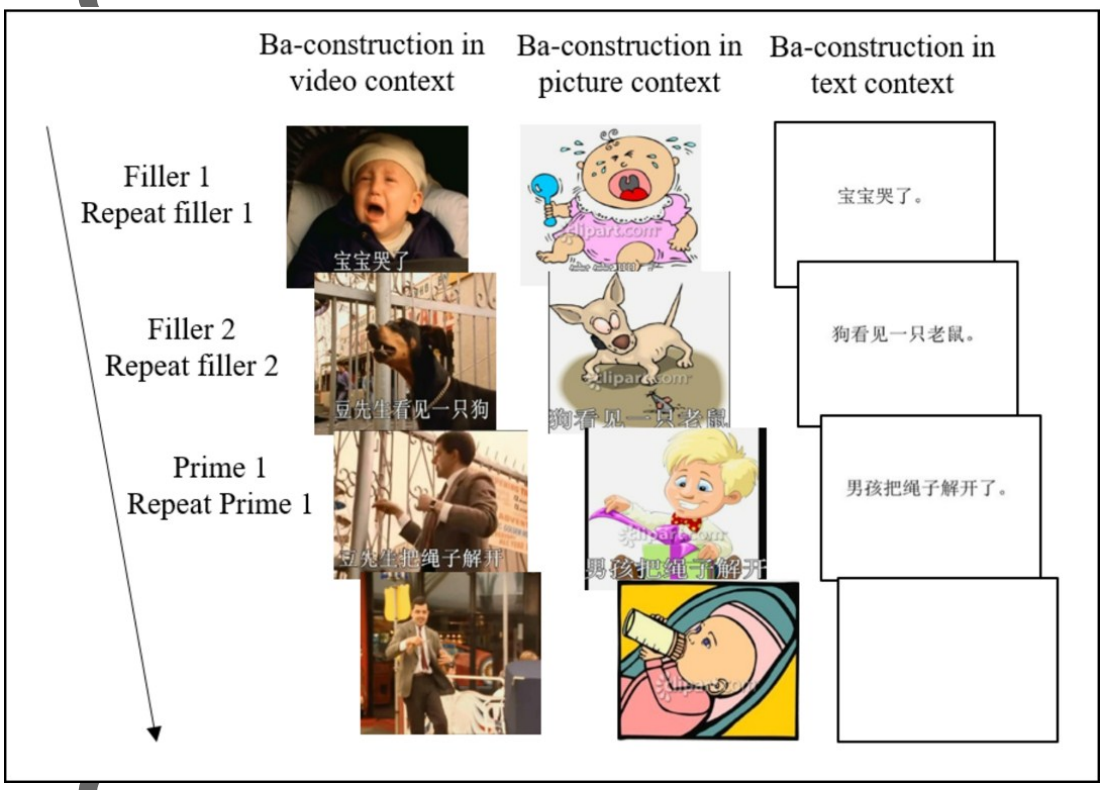
sentences were basically the same for all three groups, the agents and patients of the *ba* construction for the video group were changed to match the scenarios in the video clips. For example, the prime sentence for the text and picture groups was *Mama Ba baobao daizou le* (‘The mother took the baby away’), but the corresponding sentence for the video group was *Douxiansheng Ba baobao daizou le* (‘Mr. Bean took the baby away’) (see Figure 3). There were also 23 fillers that were a mixture of non-*ba* transitive (e.g., *Douxiansheng faxian le baobao* ‘Mr. Bean found the baby’) and intransitive constructions. Changes were also made to the subjects and objects of the fillers for the video group. See Appendix A for a complete list of the prime sentences and fillers.

The visual contexts accompanying the prime sentences were varied. For the video group, the input sentences were presented visually as subtitles in a video clip extracted from the episode “Mind the Baby” of the British comedy *Mr. Bean*, which narrated how Mr. Bean encountered a baby left alone and what happened to them in an amusement park. The duration of each subtitle was 15 s and the video clip lasted for 12 min 45 s.

<INSERT FIGURE 3 ABOUT HERE>

FIGURE 3

Sample Trials in the Video Context, Picture Context, and Text Context



Note. The English translation of Filler 1 for all three contexts is 'The baby cried;' the English translation of Filler 2 for the video context is 'Mr. Bean saw a dog;' the English translation of Filler 2 for the picture and text contexts is 'The dog saw a mouse;' the English translation of Prime 1 for the video context is 'Mr. Bean unfastened the rope;' the English translation of Prime 1 for the picture and text contexts is 'The boy unfastened the rope.'

For the picture group, the input sentences were presented visually at the bottom of the pictures (see Figure 3). The content of the sentences matched the scenarios illustrated by the

pictures. The duration of each picture on the screen was 15 s. In order to keep the length of the exposure phase for the experimental groups equal, 10 pictures without sentences were randomly inserted between the 41 pictures with sentences. As a result, the picture group was shown 51 pictures in total.

For the text group, the input sentences were presented visually on the otherwise blank slides of a PowerPoint presentation. The duration of each slide on the screen was 15 s. Ten blank slides were inserted between the 41 slides with sentences in order to balance the lengths of the exposure phase for the experimental groups.

The input sentences for the three groups were audiotaped by the same voice (a female Chinese native speaker) with medium loudness and speech rate. Then the visual and audio materials for each group were integrated into a video clip using the video editing software Corel Video Studio X8. The video clips for all three groups lasted for 12 min 45 s.

<B>*Production Tasks*

As mentioned previously, both picture and video description tasks were employed to elicit participants' production of the *ba* construction prior to or after the exposure phase. Each task consisted of 12 items involving 12 different target verbs. In the picture description task, each item was presented as a picture with a verb written in Chinese with its *pinyin* (see Figure 2A). Participants were instructed to describe the picture with a simple sentence that included the target verb. In the video description task, the item was presented with a video scenario

(see Figure 2B). The procedure and requirements of the task were basically the same with those of the picture description task.

The target verbs for the picture description task and video description task were identical. They were selected by the following steps: First, the top 50 most frequent verbs in the *ba* construction used by Chinese native speakers were listed based on a Chinese native speaker corpus. Likewise, a wordlist of the top 50 frequent verbs used by L2 Chinese learners in *ba* construction was made based on an L2 Chinese learner corpus.[2] Second, we compared the L1 and L2 wordlists and selected the overlapping verbs. Third, the selected verbs were compared with the wordlists for the HSK III and HSK IV and those beyond the HSK wordlists were deleted to make sure that all the verbs were familiar to the participants. Finally, 12 verbs of concrete actions that could be depicted visually were selected (see Appendix B). Half of the target verbs overlapped with the verbs in the prime sentences (*fang* 'put,' *reng* 'throw,' *tui* 'push,' *nazou* 'take away,' *cang* 'hide,' *tuo* 'take off') while the other half were new verbs (*dao* 'pour,' *gua* 'hang,' *gei* 'give,' *guan* 'close,' *song* 'send,', *dakai* 'open') that were not encountered in the exposure phase.

For the picture description task, we constructed two sets of picture–verb pairs. Each set contained 12 pictures and 12 target verbs. The pictures for the same target verb in the two sets depicted the same event but differed in the agent or the patient. For example, the pictures for target verb *dao* 'pour' in both sets illustrated the event of someone pouring liquid into a

container, but in one picture the agent was a waitress while in the other it was a little girl. The pictures were downloaded from Clipart.com (http://www.clipart.com/en/) and at the bottom of each picture, there was a target verb that had to be included when describing the picture. The order of these two sets of picture–verb pairs was counterbalanced in the baseline phase and the immediate posttest phase. The items in the baseline phase and the delayed posttest were identical.

Similarly, the video description task used in the immediate posttest and the delayed posttest consisted of two sets of video–verb pairs. They were extracted from *Mr. Bean* but not from the same episode as the one used in the exposure phase. Similar to the design of the picture description task, the two video clips for the same verb demonstrated the same action but with different agents or patients. These two versions of video clips were counterbalanced in the immediate posttest and the delayed posttest.

The picture and video description tasks were carried out in separate blocks and the order of the two blocks was counterbalanced across participants and conditions.

<B>*Scoring and Statistical Analysis*

All the verbal responses produced by participants in the baseline phase, the immediate posttest, and the delayed posttest were transcribed and coded as a *ba* or non-*ba* construction. If the sentence structure was N_1 + *ba* + N_2 + transitive verb + complement, with N_1 being the agent, N_2 the patient, and the verbal complement appropriate for the transitive verb, it was

coded as a *ba* construction and scored as 1. The other sentences structures (e.g., SVO) were coded as non-*ba* constructions and scored as 0. Since ungrammatical *ba* constructions were rare (25 in 6,960 responses), we classified them into the non-*ba* construction category. Coding was conducted manually by two graduate students of linguistics who were native speakers of Mandarin. They first coded 10% of the responses together and the interrater reliability of Cohen's kappa was .99. Disagreements were resolved through discussion. Then the two raters coded the remaining 90% of the data independently.

We employed the lme4 package (Bates et al., 2015) of R software (R Development Core Team, 2019) to model the binary choice of target construction (*ba* construction = 1 vs. non-*ba* construction = 0). The glmer function for generalized linear mixed effects (GLME) models was used to specify the binominal option. Our RQs necessitated a total of eight models: Models 1–3 tested the priming effect for the experimental groups and the effect of visual context (RQ1); Models 4–6 examined the effect of verb overlap for the experimental groups respectively (RQ2); and Models 7–8 tested the context independence of L2 structural priming (RQ3). For model selection, we employed the maximal random effects structure justified by the design, following Barr et al. (2013). We included all possible by-item and by-participant random intercepts and random slopes for the main effects in the fixed model. If the model failed to converge, we simplified the random effects structure, by first removing random correlations and then random slopes that accounted for the least variance, until the model converged.

For Models 1–3 addressing RQ1, the fixed factors were group (control, text, picture, and video) and phase (baseline, immediate posttest, and delayed posttest). The phase factor was Helmert coded (baseline [–0.5] vs. immediate posttest [0.5]; baseline [–0.5] vs. delayed posttest [0.5]). This contrast compared the production of the *ba* construction in the baseline against that in the immediate posttest, to test the immediate cumulative priming, and compared the *ba* construction production in the baseline against that in the delayed posttest, to test the long-term cumulative priming. For group, we constructed different contrasts in Models 1–3. In Model 1, the control group was contrasted with the three experimental groups as a whole (control [0.75] vs. experimental [–0.75]) to confirm that priming effects were observed after L2 learners were exposed to *ba* construction primes regardless of visual context types; in Model 2, the control group was contrasted with each experimental group (control [–0.25] vs. text [0.75]; control [–0.25] vs. picture [0.75]; control [–0.25] vs. video [0.75]) to assess the magnitude of priming effects in each experimental group; in Model 3, contrasts were formed between successive pairs of group (control [–0.5] vs. text [0.5]; text [0.5] vs. picture [–0.5]; picture [0.5] vs. video [–0.5]) to test whether the priming effects vary with the type of visual contexts.

For RQ2, we constructed three separate models containing the data of the text group (Model 4), the picture group (Model 5), and the video group (Model 6), respectively. These three models addressed the question of whether the priming of the *ba* construction is verb-specific or verb-general for each experimental group. Model 4–6 included fixed effects

of Helmert-coded phase (baseline vs. immediate posttest, baseline vs. delayed posttest), verb overlap (overlap [–0.5] vs. nonoverlap [0.5]), and the interaction between phase and verb overlap.

Models 7 and 8 tested whether the priming effects for the *ba* construction depend upon having the same type of visual context during the exposure phase and the subsequent production tasks. Since no visual context was involved in the input for the text group, it was excluded from this analysis. These two models were fit using the data from the picture group and the video group in the immediate posttest (Model 7) and the delayed posttest (Model 8), respectively. Task (picture description [–0.5] vs. video description [0.5]), group (picture [–0.5] vs. video [0.5]), and Task × Group were entered as the fixed effects.

<A>RESULTS

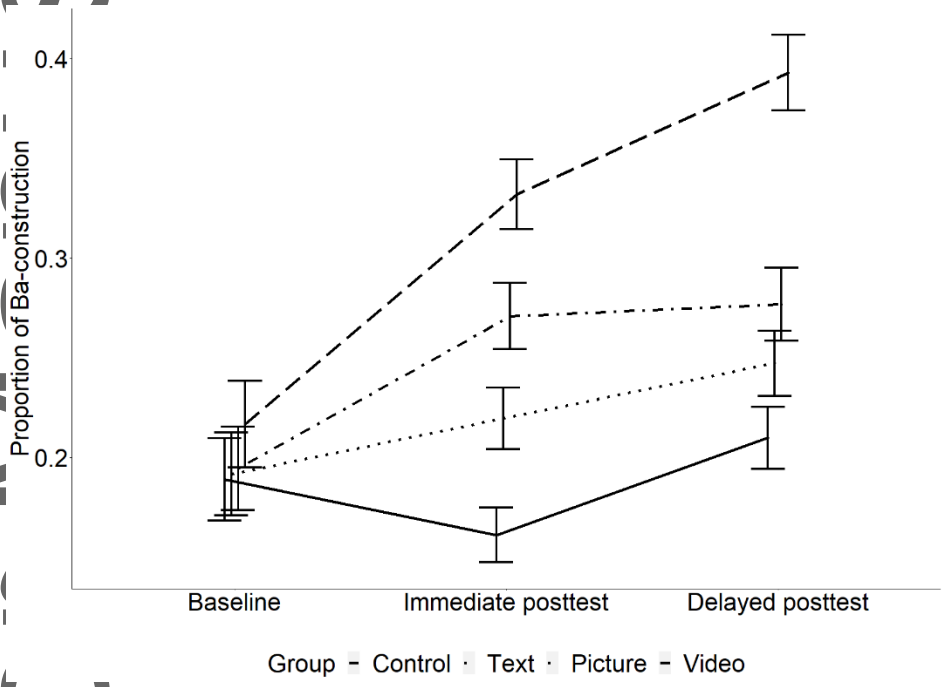
Figure 4 displays the proportions of the *ba* construction produced by the experimental groups and the control group in the baseline phase, the immediate posttest, and the delayed posttest. There appears to be no increase in *ba*-construction production for the control group from the baseline to the immediate posttest. In contrast, all three experimental groups exhibited increased *ba*-construction production after the exposure phase, indicating the occurrence of the immediate and long-term cumulative structure priming. As predicted, the degree of priming appears to vary with the type of visual contexts, with the strongest priming

in the video context, especially at the delayed posttest. These predictions were evaluated in the statistical models described here.

<INSERT FIGURE 4 ABOUT HERE>

FIGURE 4

Production of *Ba* Construction Across Groups and Phases



Note. Error bars indicate standard errors.

Before examining the effects of the visual context, two preliminary analyses were conducted. First, we verified that there were no differences among groups in the production of the *ba* construction in the baseline phase (see Appendix C for details). Second, Model 1 confirmed that the immediate and long-term cumulative priming were observed when

comparing the three experimental groups as a whole with the control group. Then, the predictions generated by our three RQs were tested in Models 2–8. The category of participants' response (i.e., 0 or 1, reflecting the absence or presence of the *ba* construction) was entered as the dependent variable in all models.

<B>*The Immediate and Long-Term Cumulative Structural Priming Effects Across Groups*

Model 1 tested whether there were structural priming effects across groups. The final version of Model 1 included only random intercepts for participants and for items:

Model <- glmer (Response ~ Phase*Group + (1|Item) + (1|Participant), data = dataset, family = binomial, control = glmerControl(optimizer = "bobyqa"))

The results of Model 1 are summarized in Table 3. The predicted immediate and long-term cumulative priming effects of the three experimental groups as a whole relative to the control group are bolded, and statistically significant effects are indicated by an asterisk. Specifically, the three experimental groups exhibited an overall significant immediate cumulative priming effect, Estimate = –0.03, SE = 0.01, $p < .001$, as compared with the control group. Moreover, the long-term cumulative priming effect of the experimental groups was also significant, Estimate = –0.20, SE = 0.01, $p = .04$. In addition to the predicted priming effects, more *ba* constructions were produced in total in the delayed posttest phase than in the baseline, Estimate = –0.86, SE = 0.12, $p < .001$.

<INSERT TABLE 3 ABOUT HERE>

TABLE 3

Immediate and Long-Term Priming Effects for the Control Group Versus the Three Experimental Groups (Model 1)

Fixed effects	Estimate	*SE*	*p*
(Intercept)	–2.38	0.33	0.00
Group: Experimental vs. control	0.01	0.02	0.58
Phase (immediate): Immediate posttest vs. baseline	–0.16	0.12	0.21
Phase (long term): Delayed posttest vs. baseline	–-0.86	0.12	0.00***
G × P: Group × Immediate	**–0.03**	**0.01**	**0.00***
G × P: Group × Long-term	**–0.20**	**0.01**	**0.04***

Note. G = group; P = phase.

*** $p < .001$. * $p < .05$.

Model 2 tested the occurrence of immediate and long-term cumulative priming of the *ba* construction in each experimental group compared with the control group. As the model

did not converge until we removed all random slopes, the final random effects of Model 2 included only by-participant and by-item random intercepts:

Model <- glmer (Response ~ Phase*Group + (1|Item) + (1|Participant), data = dataset, family = binomial, control = glmerControl(optimizer = "bobyqa"))

As shown in Table 4, all the experimental groups exhibited significant immediate priming effect compared with the control group: Control vs. Text × Immediate, Estimate = 0.62, *SE* = 0.30, $p = .04$; Control vs. Picture × Immediate, Estimate = 1.19, *SE* = 0.31, $p < .001$; Control vs. Video × Immediate, Estimate = 1.33, *SE* = 0.30, $p < .001$). Crucially, only the video group showed significant long-term priming compared with the control group, Estimate = 1.14, *SE* = 0.30, $p < .001$.

<INSERT TABLE 4 ABOUT HERE>

TABLE 4

Comparison of Immediate and Long-Term Priming Effects for the Control Group Versus Each Experimental Group (Model 2)

Fixed effects	Estimate	*SE*	*p*
(Intercept)	–2.46	0.30	0.00
Group: Control vs. text	0.05	0.11	0.45

Group: Control vs. picture	–0.73	0.11	0.70
Group: Control vs. video	0.53	0.70	0.05
Phase (immediate): Immediate posttest vs. baseline	0.28	0.71	0.64
Phase (long term): Delayed posttest vs. baseline	**1.35**	**0.70**	**0.00*** **
G × P: Control vs. Text × Immediate	**0.76**	**0.31**	**0.01***
G × P: Control vs. Text × Long-term	0.28	0.30	0.36
G × P: Control vs. Picture × Immediate	**1.40**	**0.32**	**0.00*** **
G × P: Control vs. Picture × Long-term	0.42	0.32	0.19
G × P: Control vs. Video × Immediate	**1.01**	**0.30**	**0.00*** **
G × P: Control vs. Video × Long-term	**–0.64**	**0.30**	**0.04***

Note. G = group; P = phase.

*** $p < .001$. * $p < .05$.

Model 3 tested whether the priming effects vary with the type of visual contexts. The final model included only random intercepts for participants and items:

Model <- glmer (Response ~ Phase*Group + (1|Item) + (1|Participant), data = dataset, family = binomial, control = glmerControl(optimizer = "bobyqa"))

The bolded effects confirm most aspects of the predicted pattern (see Table 5). It was reconfirmed that the text group exhibited immediate (but not long-term) priming, compared with the control group, Estimate = –1.59, *SE* = 0.39, $p < .01$. The picture group exhibited more immediate priming than the text group, Estimate = –1.65, *SE* = 0.42, $p < .01$, but the picture group did not differ from the text group in terms of (the absence of) long-term priming, Estimate = 0.50, *SE* = 0.42, $p = 0.24$. Finally, the video group and the picture group showed equivalent immediate priming, Estimate = –0.44, *SE* = 0.34, $p = .19$, but the video group showed greater long-term priming than the picture group, Estimate = 1.30, *SE* = 0.35, $p < .01$.

<INSERT TABLE 5 ABOUT HERE>

TABLE 5

Comparison of Immediate and Long-Term Priming Effects Between Successive Pairs of Group (Model 3)

Fixed effects	Estimate	*SE*	*p*
(Intercept)	–2.46	0.30	0.00
Group: Control vs. text	–1.08	0.86	0.21
Group: Text vs. picture	–1.09	0.99	0.27

Group: Picture vs. video	–1.61	0.85	0.06
Phase (Immediate): Immediate posttest vs. baseline	0.05	0.11	0.64
Phase (Long-term): Delayed posttest vs. baseline	–0.73	0.11	0.00***
G × P: Control vs. Text × Immediate	**–1.59**	**0.39**	**0.00*** **
G × P: Control vs. Text × Long-term	–0.03	0.39	0.93
G × P: Text vs. Picture × Immediate	**–1.65**	**0.42**	**0.00*** **
G × P: Text vs. Picture × Long-term	0.50	0.42	0.24
G × P: Picture vs. Video × Immediate	–0.44	0.34	0.19
G × P: Picture vs. Video × Long-term	**1.30**	**0.35**	**0.00*** **

Note. G = group; P = phase.

*** $p < .001$.

In summary, these results confirmed the predicted effects of visual context on L2 structural priming. In particular, the visual context together with prime sentences could enhance the magnitude of L2 cumulative structural priming, whether it was video or picture context. However, persistence of the cumulative structural priming effects was modulated by

the type of visual context in that only the priming accumulated in the video context could persist over 3 days.

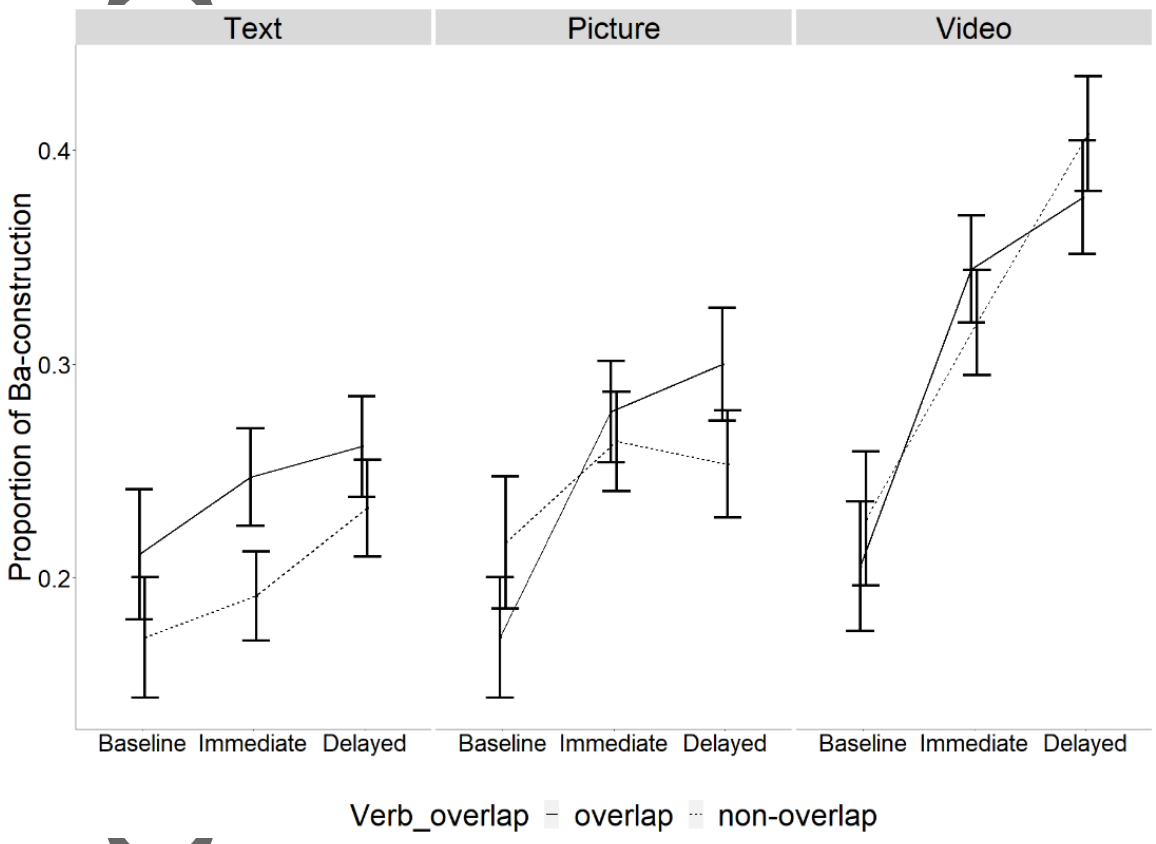
<B>*Generalization of L2 Cumulative Structural Priming*

To further explore the impact of structural priming on long-term learning, we examined whether the priming is verb-specific or verb-general (RQ 2). Figure 5 shows the proportions of the *ba* construction produced by the three experimental groups in the verb-overlap and verb-nonoverlap conditions in each phase.

<INSERT FIGURE 5 ABOUT HERE>

FIGURE 5

Proportions of *Ba* Construction Produced by Each Experimental Group in Verb-Overlap and Verb-Nonoverlap Conditions



Note. overlap = verb-overlap condition; nonoverlap = verb-nonoverlap condition; Baseline = baseline phase; Immediate = immediate posttest; Delayed = delayed posttest. Error bars indicate standard errors.

To test whether and how verb overlap affected the immediate and long-term priming of the three experimental groups, Models 4–6 were fit to the data of the text group, picture group, and video group, respectively. The random effects structures of the three models were

identical, including by-participant and by-item intercepts, and by-participant random slopes for verb overlap and the random correlations were dropped due to the convergence problem:

Model <- glmer (Response ~ Phase*Verb_overlap + (1|Item) + (1|Participant) + (0+Verb_overlap|Participant), data = dataset, family = binomial, control = glmerControl(optimizer = "bobyqa"))

The summary of the fixed effects of the three models is illustrated in Appendix D.

As expected, there was no significant effect of verb overlap (*p*s > .05) and it did not interact with immediate priming for any experimental group (*p*s > .05). The interaction between verb overlap and long-term priming was not significant for the text group, or the video group either (*p*s > .05) but this interaction was unexpectedly significant for the picture group, Estimate = 0.89, *SE* = 0.45, *p* = .049, indicating that the long-term priming of the *ba* construction in the picture context was stronger in the verb-overlap condition than in the verb-nonoverlap condition.

<B>*Context Dependence of L2 Structural Priming*

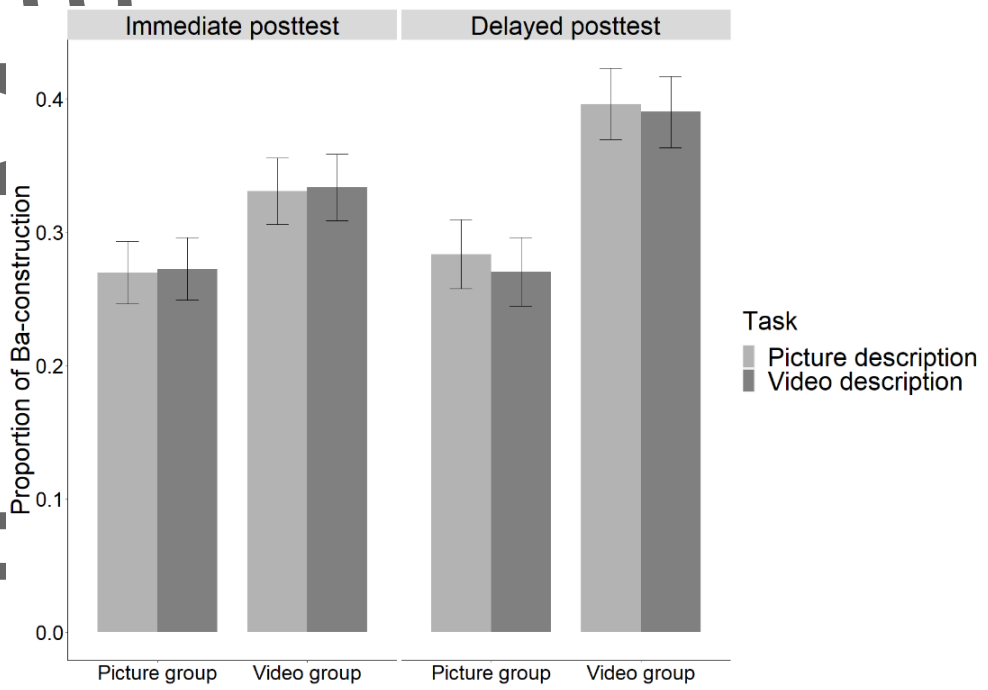
RQ3 concerned whether the priming effects for the *ba* construction depend upon experiencing the same type of visual context during the exposure phase and the subsequent production tasks. As mentioned in the Methods section, for the picture group, the picture description task constituted a context-type-match condition whereas the video description

task was a context-type-mismatch condition, and vice versa for the video group. Since no visual context was involved in the input for the text group, it was excluded from this analysis. As illustrated in Figure 6, in the immediate and the delayed posttests, both the picture and the video groups produced roughly the same amount of *ba* constructions in the context-type-match and -mismatch conditions.

<INSERT FIGURE 6 ABOUT HERE>

FIGURE 6

Production of the *Ba* Construction in the Context-Type-Match and -Mismatch Conditions as a Function of Phase × Group



Note. Error bars indicate standard errors.

Models 7 and 8 were fit using the data from the picture group and the video group in the immediate posttest (Model 7) and the delayed posttest (Model 8), respectively. Task (picture description vs. video description), group (picture vs. video), and Task × Group interaction were entered as the fixed effects. The final model of Models 7 and 8 included random intercepts for participants and items:

Model <- glmer(Response~Group*Task + (1|Item) + (1|Participant), data=dataset, family=binomial, control=glmerControl(optimizer="bobyqa"))

Contrary to our prediction, there was no hint of a task effect or interaction between task and group in either of the models, suggesting that participants show approximately an equal tendency to produce the *ba* construction in the context-type-match and -mismatch conditions. In other words, the cumulative structural priming remained the same whether or not the type of visual contexts of the subsequent production varied from the exposure phase.

<INSERT TABLE 6 ABOUT HERE>

TABLE 6

Immediate (Model 7) and Long-Term (Model 8) Priming Effects of the Picture and Video Groups in Context-Type-Match and -Mismatch Conditions

	Estimate	*SE*	*p*
Immediate posttest (Model 7)			
(Intercept)	–1.94	0.44	0.00
Group	0.78	0.74	0.29
Task	–0.02	0.47	0.96
Group × Task	–0.01	0.32	0.99
Delayed posttest (Model 8)			
(Intercept)	–2.01	0.52	0.00
Group	1.70	0.96	0.08
Task	–0.13	0.42	0.75
Group × Task	0.14	0.37	0.72

<A>DISCUSSION

The current study examined the effects of different types of visual contexts on immediate and long-term L2 cumulative structural priming. After first confirming that immediate and long-term cumulative priming were observed in our dataset, we addressed three RQs.

First, does the type of visual context accompanying prime sentences affect the strength of L2 cumulative structural priming? Consistent with our prediction, the answer to this question is affirmative. Regardless of the type of visual context, participants' exposure to the *ba* construction in the experiment increased their production of the structure from the baseline to the immediate posttest more so when compared with the no-exposure control group. Crucially, compared with the text context, both the picture and video contexts elicited more target structures from the baseline to the immediate posttest. Whereas the immediate priming did not differ between the picture and video contexts, only the video context resulted in statistically significant long-term cumulative priming compared with the baseline. These findings suggest that nonlinguistic visual contexts can boost L2 cumulative structural priming, with continuous visual context (and continuity of indexes within the prime sentences themselves) providing a greater boost for long-term retention of the priming effects.

Second, if we find immediate or long-term cumulative priming, does it generalize beyond the verbs used in the exposure phase? There was no difference in the strength of

immediate cumulative priming for verbs that were in the exposure set versus the novel verbs, irrespective of context type. However, the impact of the verb-overlap condition on the long-term priming was unbalanced: It made significant differences in the picture context but not in the text or video context. For the picture context, the verb stimuli in the exposure set elicited stronger long-term priming than the new verbs.

Third, can L2 structural priming obtained from one type of visual context be transferred to another type of context? The answer is affirmative but runs counter to our prediction. The magnitude of the structural priming effects obtained from the picture context or the video context remained unchanged whether the type of context of the posttests was identical to or different from that in the exposure phase. Moreover, the contextual transfer occurred even though the exposure phase and the delayed posttest were separated by a 3-day lag.

Taken together, the current study adds to the growing body of research indicating that L2 structural priming is a form of implicit learning that contributes to L2 syntactic development (e.g. Jackson & Ruf, 2017; Jaeger & Snider, 2008; Kaan & Chun, 2018; Shin & Christianson, 2012). It should be noted that the findings of the present study might pertain to the L2 proficiency of the participants, who were intermediate learners of Chinese. They had learned the *ba* construction in class and most of them produced the construction in the baseline phase, though the proportion was rather low. This suggests that they had the abstract

representation of the *ba* construction required by the occurrence and persistence of structural priming as indicated by McDonough (2006). At the same time, the priming effects obtained from our study are less robust than those from Hsu (2018), who investigated the cumulative priming effects of the *ba* construction among 3-, 4-, and 6-year-old Chinese-speaking children. In Hsu's study, the priming effects after a 1-day lag were between 60% and 70% in all three age groups. In our study, however, even the priming effects in the video context were just about 40%, indicating that the structural priming among L1 children is much stronger than that among L2 learners. The discrepancies between our study and Hsu (2018) in the strength of structural priming point to the assumption that the magnitude of long-term L2 structural priming might be somewhat related to L2 status of the learners.

More importantly, the present findings bring to the fore that visual context enhances cumulativity and persistence of structural priming. While our participants in the three experimental groups received the same number of *ba* constructions during the exposure phase, their performance in subsequent production varied as a function of the type of visual context. In light of IAM (Pickering & Garrod, 2004), the boost effect of visual contexts could be attributed to the interconnections between the representations at the situation-model and linguistic levels. Rich contextual cues afforded by visual contexts may facilitate the construction of a situation model, thereby making it easier for L2 learners to comprehend the input.

The potential relationship between structural priming and contextually facilitated comprehension of the prime sentences observed in this study is corroborated by the findings from McDonough and Fulga (2015), who investigated structural priming effects on learning the word order of the Esperanto transitive construction, which allows both SVO and OVS orders. Interestingly, they found that comprehension accuracy was correlated with the degree of structural priming. In particular, participants who failed to interpret SVO and OVS items in the input correctly could not be primed to produce Esperanto transitives in either word order. Those who were able to interpret SVO items correctly were primed to produce SVO sentences only and vice versa.

Another possible reason for the greater priming effects in the video context may have to do with the advantages of the video context in exhibiting the semantic constraints of the *ba* construction. As shown in analyzing the target structure, the predicates in the *ba* construction possess intrinsic properties of transitivity and telicity to convey result, change, or completion imposed on the *ba* NP (Huang & Yang, 2004). Compared with static pictures, dynamic video clips are more capable of demonstrating the transitivity of an object—namely, the change of a situation and the completion of an action. In other words, the dynamic video context is more compatible with the semantic or aspectual constraint of *ba* construction than static picture context. As a result, it aids L2 learners' understanding of the meaning of the *ba* construction.

The greater priming effects in the video context may also pertain to the context continuity represented by a coherent storyline. Zwaan and Radvansky (1998) argued that continuous contexts are advantageous in integrating the incoming information into the evolving situation model since successive events share with previous events protagonists, object, causality, and other dimensions of the situation model. A more complete situation model can thus be constructed, which might in turn provoke stronger linguistic alignment since alignment on the situation model level can percolate to the linguistic levels (Pickering & Garrod, 2004).

A caveat is that context continuity is intertwined with topic continuity of the prime sentences. The video context was a complete and coherent story and the protagonist Mr. Bean was dominant throughout the story. Consequently, the agents of the actions depicted by the *ba* constructions were mostly Mr. Bean and the topics (subjects) of the prime sentences were in turn continuous. Therefore, the boost effect of the video context might have to do with topic continuity. This is consistent with the interaction between the magnitude of priming and the subject continuity within the discourse obtained in Travis et al. (2017). In light of Hung & Schumacher (2012), topic continuity can ameliorate the load of information processing. Therefore, we have reason to assume that the processing load of the prime sentences might have an impact on the magnitude of priming effects.

Admittedly, whereas Hung & Schumacher (2012) involved discourse processing, the present study involves sentence-level processing. However, the coherent story line of the video context makes it possible for the prime sentences to be connected with each other in terms of topic. Thus, processing of the prime sentences in the video context of our study is, to a certain degree, analogous to sentence processing in discourse. Drawing on centering, a prominent theory of discourse coherence (Grosz, Joshi, & Weinstein, 1995), Reitter et al. (2011) predicted that "sentences between which a topic is continued would be more likely to show short-term priming and lexical boost effects" (p. 624). The more robust long-term effects in the video context of our study indicate that topic continuity might enhance the long-term priming effects as well.

In summary, the impact of continuous linguistic context on language processing bolsters our conclusion that context continuity could be an important factor in modulating structural priming. We further assume that L2 structural priming in real contexts, which normally takes place in discourse involving abundant paralinguistic and nonlinguistic cues, should be different from that provoked by isolated and decontextualized sentences.

In addition, the facilitative effect of the video context corroborates the claim that rich contextual cues lead to stronger alignment by strengthening the interaction between L2 learners and the input (Wang & Wang, 2015). Our video context was a funny TV episode that offered vivid scenarios illustrating the meaning of the *ba* construction. The video provided L2

learners with a richer array of contextual cues than the picture context, thereby aiding the learners' comprehension of the primes on the one hand and engaging the learners more deeply in the interaction with the primes on the other. The boost effect of the video context on linguistic alignment is consistent with the finding from Cai & Wang (2017) that L2 learners exposed to text-plus-video input were more likely to repeat the words and phrases of the input text than those who received video or text input only.

Note that IAM is not a theory of learning; rather, alignment was proposed as a means of successful communication. However, structural priming is argued to be a primary mechanism of linguistic alignment (Pickering & Garrod, 2004), and structural priming has been proven to be facilitative of L1 (Chang et al., 2006) and L2 development (see Jackson, 2018, for a review). Moreover, there is more recent evidence in both L1 (e.g., Jaeger & Snider, 2013) and L2 research (e.g., Kim, Jung, & Skalicky, 2019) that linguistic alignment persists and reflects long-term adaptation of the production mechanism. If so, linguistic alignment results in learning outcomes. Therefore, it is plausible to attribute the more robust long-term effects in the video group to the syntactic alignment enhanced by the visual context.

Another important implication of the present study is that structural priming aids L2 learners in extending a particular structure to new verbs, which is crucial to L2 construction learning. This is consistent with the finding from Shin (2015), who discovered that Korean

learners English can use DO and phrasal-verb constructions with a wider range of verbs after structural priming. We further revealed that the video context is more favorable to the generalization of the target construction in the long run compared with the picture context. As discussed previously, the video context aids L2 learners' comprehending the meaning of the *ba* construction, which is crucial to the generalization of the construction. L1 acquisition studies have shown that children's mastery of a construction meaning enables them to use new lexical items in the construction with increasing ease (Goldberg, 2006; Goldberg, Casenhiser, & Sethuraman, 2004; Ninio, 2011). Given that better comprehension leads to stronger priming, this result as well indicates that the degree to which structural priming helps L2 learners expand their representations of the target construction is correlated with the magnitude of long-term priming effects.

It also merits attention that our study found that cumulative priming effects can transfer across visual contexts, which suggests that implicit learning by means of L2 structural priming is at least partially flexible and it is not always context-bound as shown in sequence learning (e.g., Sanchez, Yarnik, & Reber, 2015). This finding runs counter to our prediction and contradicts the finding of Kaschak et al. (2014). They found that cumulative structural priming in English native speakers lasted for 1 week but they observed no cumulative priming effects when tasks were changed (written stem-completion task in the exposure phase but the picture-description task in the posttest), which led them to conclude that adults were capable of adjusting their usage of language within a specific context (e.g., a

conversation or an experiment). In contrast, we found that the priming effect exhibited in the video context persisted over 3 days, even when the visual context of the subsequent production task shifted to isolated pictures.

The divergence between the two studies might have to do with how the context was operationalized. Context was operationalized in our study as nonlinguistic visual context that facilitates the comprehension of the prime sentences but in Kashack et al. (2014) as the modality of the production task extrinsic to the linguistic structures to be primed. Hence, the context in Kashack et al.'s study has little impact on the processing of the primes, and the cumulative effects they observed might largely rely on explicit memory, which is tightly bound with and restricted to the task context. However, we should be cautious about our interpretation since the present study is also different from Kaschak et al. (2014) in that participants were exposed to both the picture and the video description tasks, leading them to think that both are part of the 'same' test. As a result, the distinction between the tasks in terms of visual context might be somewhat blurred.

In summary, by demonstrating the boost effect of visual context on structural priming and its long-term impact on L2 syntactic development, the present study confirms the critical role of nonlinguistic context in L2 learning, supporting the usage-based accounts of L2 acquisition that view L2 learning as semiotic learning wherein learners "draw to register and catalogue their encounters with the various semiotic resources comprising their interaction

with context" (Douglas Fir Group, 2016, p. 28; also see Ellis, 2019). Our results also suggest two mechanisms by which visual context facilitates L2 learning—namely, rich contextual cues and contextual continuity. In addition, the present findings highlight the transferability of the priming effects across visual contexts. Therefore, while we conclude that L2 learning is context-dependent in the sense that L2 learning can be facilitated by the nonlinguistic context, L2 learning is not context-dependent in the sense that the facilitative effects of a rich visual context are restricted to a particular type of context.

<A>PEDAGOGICAL IMPLICATIONS

Our results have important implications for L2 construction teaching. Above all, tasks and activities eliciting primed production should be strongly promoted in the L2 instruction of difficult constructions such as the Chinese *ba* construction. One option might be to provide L2 learners with tasks that tightly couple comprehension and production of the target structure, such as the continuation task developed by Wang & Wang (2015), wherein students are instructed to read a story with the second half removed and then complete the story logically and coherently. Furthermore, enhanced input of the target structure in the story to be completed should be encouraged to provoke stronger priming and learning effects, as suggested by Xin (2017). Likewise, it is sensible of teachers to organize interactive tasks such as face-to-face and synchronous computer-mediated communication wherein a particular grammatical structure is embedded (Kim et al., 2019).

Another important pedagogical implication from the present study is that abstract syntactic constructions could be taught more effectively in rich contexts. Teachers are encouraged to expose students to constructions embedded in multimodal contexts that help students schematize and generalize abstract constructions from exemplars (Douglas Fir Group, 2016). As is suggested by the present study, a multimodal context such as a video clip might be more favorable than a discontinuous and static context.

In addition, efforts should be made to strengthen students' interaction with the input so as to enhance linguistic alignment. Along with extant research like McDonough & Fulga (2015), the current study indicates that input characteristics beneficial to the construction of a situation model can trigger stronger linguistic alignment. It follows that input processing strategies like explaining the main ideas of the text, reducing the complexity of the input, and making the target structures more salient should be adopted to engage students in the input more actively.

<A>LIMITATIONS AND FUTURE DIRECTIONS

Despite its contributions and implications, this study has limitations that point to several promising avenues for future research. To start with, it is worthwhile for future studies to disentangle the effects of context continuity and the degree of context engagement. In the present study, the video context elicited more robust long-term structural priming effect than the picture context. However, it varied from the picture context in two important

ways: On the one hand, it was engaging and therefore held more learner interest than the picture context; on the other, it had a continuous story line. Presumably, both differences contribute to the stronger priming effects in the video context, making it difficult to determine the locus of the contextual boost effect. Future studies can parse out contextual continuity and context engagement by comparing the priming effects in two video conditions, one with a continuous story and one without. Another possibility is to compare the priming effects in a video context and a picture context that both have a continuous storyline, for example, a video story versus a comic strip or a series of pictures that depict a continuous event.

Furthermore, more types of contexts should be considered in future studies. The current study merely examined the effect of the visual contexts represented by isolated pictures and a video clip. In order to further illustrate the relationship between context and structural priming, more context types should be investigated—such as scenes of dialogues, scenarios of classroom interaction, settings of interactive tasks, and connected discourse—thereby providing additional insight into L2 learning in the real world.

In addition, future studies would benefit from extending the present study to L2 learners at more proficiency levels and to more target structures. This study elicited data from a relative homogeneous sample (i.e., intermediate L2 Chinese learners). It is an interesting issue to explore how the contextual effect on structural priming is related to the L2 status. At

the same time, the Chinese *ba* construction scrutinized in the present study poses great difficulties for L2 learners of Chinese, so it is taught explicitly in class and learners' noticing of it might be stronger than that of other constructions. Hence, it is recommended to investigate whether the same findings can be obtained when the target structures are novel to or less noticed by L2 learners.

Future studies are also warranted to take into account the overgeneralization of the *ba* construction. As is documented in the literature, L2 learning of the *ba* construction is challenged by both avoidance and overgeneralization (e.g., Zhang, 2010). The present study contributes to enhancing L2 production of the *ba* construction via structural priming, but it leaves unaddressed in what way structural priming is related to overgeneralization—namely, whether boosted production of the *ba* construction increases or ameliorates overgeneralization. Further research is suggested to probe into this issue and explore what type of context may help prohibit overgeneralization of the *ba* construction.

<A>CONCLUSION

The current study is the first empirical investigation into the effect of visual context on cumulativity and persistence of L2 structural priming. We found that visual context facilitated long-term structural priming for the L2 Chinese *ba* construction. More strikingly, the long-term structural priming was not specific to either the verbs or the visual context used in the exposure phase. The current study adds to the growing body of research on L2

long-term structural priming, targeting input features that help to enhance the magnitude of alignment between L2 learners and language input. It also contributes to L2 pedagogy and acquisition research by investigating the underlying mechanism by which context facilitates L2 learning, which is a classical but underexplored issue in the field.

<A>NOTES

[1] HSK (Hanyu Shuiping Kaoshi) is a Chinese proficiency test that tests and rates nonnative Chinese speakers' abilities in using the Chinese language in daily, academic, and professional domains. The HSK test was developed by the Beijing Language Institute at Beijing Language and Culture University (BLCU) in 1984 and now is administered by Hanban. It consists of six levels, with level I for beginners and level VI for very advanced learners. The HSK (Level III) is the counterpart of the Level III of the Chinese Language Proficiency Scales for Speakers of Other Languages and the B1 Level of the Common European Framework of Reference for Languages. More information can be obtained from https://www.chinaeducenter.com/en/hsk/hsklevel3.php.

[2] The native speakers' corpus was the contemporary Chinese subcorpora of CCL (Center for Chinese Linguistics PKU, http://ccl.pku.edu.cn:8080/ccl_corpus/). The Chinese L2 learners' corpus was the HSK dynamic composition corpus in BCC, a collection of Chinese nonnative speakers' compositions in the HSK test (http://bcc.blcu.edu.cn/zh/cid/35).

<A>REFERENCES

Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language, 68*, 255–278.

Barr, D., & Keysar, B. (2004). Is language processing different in dialogue? *Behavioral and Brain Sciences, 27*, 190–191.

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software, 67*, 1–48.

Bock, K. (1986). Syntactic persistence in language production. *Cognitive Psychology, 18*, 355–387.

Bock, K., & Griffin, Z. M. (2000). The persistence of structural priming: Transient activation or implicit learning? *Journal of Experimental Psychology: General, 129*, 177–192.

Branigan, H. P., Pickering, M. J., & Cleland, A. A. (1999). Syntactic priming in written production: Evidence for rapid decay. *Psychonomic Bulletin & Review, 6*, 635–640.

Burmester, J. (2018). Sensitivity to salience: Linguistic vs. visual cues affect sentence processing and pronoun resolution. *Language, Cognition, and Neuroscience, 33*, 784–801.

Cai, N., & Wang, M. (2017). Effects of input modality on L2 oral alignment. *Modern Foreign Languages, 40*, 518–528.

Chang, F., Dell, G. S., & Bock, K. (2006). Becoming syntactic. *Psychological Review, 113*, 234–272.

Chang, F., Dell, G.S., Bock, K., & Griffin, Z. (2000). Structural priming as implicit learning: A comparison of models of sentence production. *Journal of Psycholinguistic Research, 29*, 217–229.

Cheung, H. (1992). *The acquisition of BA in Mandarin.* (Unpublished doctoral dissertation). University of Kansas, Lawrence, KS.

Douglas Fir Group. (2016). A transdisciplinary framework for SLA in a multilingual world. *Modern Language Journal, 100*, 19–47.

Du, H. (2004). *The acquisition of the Chinese ba-construction by adult second language learners*. (Unpublished doctoral dissertation). The University of Arizona, Tucson, AZ.

Du, H. (2006). *The acquisition of the Chinese ba-construction*. Munich: Lincom Europa.

Ellis, N.C. (2019). Essentials of a theory of language cognition. *Modern Language Journal, 103*, 39–60.

Eskildsen, S. W. (2009). Constructing another language: Usage-based linguistics in second language acquisition. *Applied Linguistics, 30*, 335–357.

Ferreira, V. S., & Bock, K. (2006). The function of structural priming. *Language and Cognitive Processes, 21*, 1,011–1,029.

Gámez, P. B., & Vasilyeva, M. (2015). Exploring interactions between semantic and syntactic processes: The role of animacy in syntactic priming. *Journal of Experimental Child Psychology*, *138*, 15–30.

Goldberg, A. E. (2006). *Constructions at work: The nature of generalization in language*. Oxford: Oxford University Press.

Goldberg, A. E., Casenhiser, D. M., & Sethuraman, N. (2004). Learning argument structure generalizations. *Cognitive Linguistics, 15*, 289–316.

Grosz, B., Joshi, A., & Weinstein, S. (1995). Centering: A framework for modeling the local coherence of discourse. *Computational Linguistics, 2*, 203–225.

Hsu, D.–B. (2014). Mandarin-speaking three-year-olds' demonstration of productive knowledge of syntax: Evidence from syntactic productivity and structural priming with the SVO-ba alternation. *Journal of Child Language, 41*, 1,115–1,146.

Hsu, D.–B. (2018) Children's syntactic representation of the transitive constructions in Mandarin Chinese. *PLoS ONE, 13*, e0206788.

Huang, Y., & Yang, S. (2004). The L2 acquisition of the Chinese ba-construction. *Chinese Teaching in the World, 67*, 49–59.

Hung, Y. C. , & Schumacher, P. B. (2012). Topicality matters: Position-specific demands on chinese discourse processing. *Neuroscience Letters, 511*, 59–64.

Hwang, H. & Shin, J. (2019). Cumulative effects of syntactic experience in a between- and a within-language context: Evidence for implicit learning. *Journal of Memory and Language, 109,* 1–14.

Jackson, C. N. (2018). Second language structural priming: A critical review and directions for future research. *Second Language Research, 34*, 539–552.

Jackson, C. N., & Ruf, H. T. (2017). The priming of word order in second language German. *Applied Psycholinguistics, 38*, 315–345.

Jackson, C. N., & Ruf, H. T. (2018). The importance of prime repetition among intermediate-level second language learners. *Studies in Second Language Acquisition, 40*, 677–692.

Jaeger, T. F., & Norcliffe, E. (2009). The cross-linguistic study of sentence production: State of the art and a call for action. *Language and Linguistics Compass, 3*, 866–887.

Jaeger, T. F., & Snider, N. E. (2008). Implicit learning and syntactic persistence: Surprisal and cumulativity. In *Proceedings of the 29th Annual Cognitive Science Society (CogSci09)* (pp. 1,061–1,066). Austin, TX: Cognitive Science Society.

Jaeger, T. F., & Snider, N. E. (2013). Alignment as a consequence of expectation adaptation: Syntactic priming is affected by the prime's prediction error given both prior and recent experience. *Cognition, 127*, 57–83.

Jespon, J. (1989). The ontogenesis of basic word order. *General Linguistics, 29*, 97–111.

Kaan, E., & Chun, E. (2018). Priming and adaptation in native speakers and second-language learners. *Bilingualism: Language and Cognition, 21*, 228–242.

Kaschak, M. P., Kutta, T. J., & Coyle, J. M. (2014). Long and short term cumulative structural priming effects. *Language Cognition & Neuroscience, 29*, 728–743.

Kaschak, M. P., Kutta, T. J., & Schatschneider, C. (2011). Long-term cumulative structural priming persists for (at least) one week. *Memory & Cognition, 39*, 381–388.

Kim, Y., Jung, Y., & Skalicky, S. (2019). Linguistic alignment, learner characteristics, and the production of stranded prepositions in relative clauses: Comparing FTF and SCMC contexts. *Studies in Second Language Acquisition, 41*, 937–969.

Kim, Y. & McDonough, K. (2016). Prime repetition and Korean EFL learners' comprehension and production of passives. *International Review of Applied Linguistics in Language Teaching, 54*, 319–346.

Kim, Y., & McDonough, K. (2008). Learners' production of passives during syntactic priming activities. *Applied Linguistics, 29*, 149–154.

Kress, G. (2010). *Multimodality : A social semiotic approach to contemporary communication*. London: Routledge.

Larsen–Freeman, D. (2020). Complex dynamic systems theory. In B. Van Patten, G. Keating, & S. Wulf (Eds.), *Theories of second language acquisition: An introduction* (3rd ed.). New York: Routledge.

Li, P., & Bowerman, M. (1998). The acquisition of lexical and grammatical aspect in Chinese. *First Language, 18*, 311–350.

Liu, S., Qian, X., & Wang, Y. (2002). Communication strategies and oral testing. *Language Teaching and Linguistic Studies, 60*, 93–101.

McDonough, K. (2006). Interaction and syntactic priming: English L2 speakers' production of dative constructions. *Studies in Second Language Acquisition, 28*, 179–207.

McDonough, K., & De Vleeschauwer, J. (2012). Prompt-type frequency, auditory discrimination, and EFL learners' production of *wh*-questions. *Studies in Second Language Acquisition, 34,* 355–377.

McDonough, K., & Fulga, A. (2015). The detection and primed production of novel constructions. *Language Learning, 65*, 326–357.

McDonough, K., & Mackey, A. (2008). Syntactic priming and ESL question development. *Studies in Second Language Acquisition, 30*, 31–47.

Ninio, A. (2011). *Syntactic development, its input and output*. Oxford: Oxford University Press.

Peng, J., Wang, C., & Lu, X. (2018). Effect of the linguistic complexity of the input text on alignment, writing fluency, and writing accuracy in the continuation task. *Language Teaching Research, 24*, 364–381.

Pickering, M. J., & Branigan, H. P. (1998). The representation of verbs: Evidence from syntactic priming in language production. *Journal of Memory and Language, 39*, 633–651.

Pickering, M. J., & Ferreira, V. S. (2008). Structural priming: A critical review. *Psychology Bulletin, 134*, 427–459.

Pickering, M. J., & Garrod, S. (2004). Toward a mechanistic psychology of dialogue. *Behavioral and Brain Science, 27*, 169–226.

Reitter, D., Keller, F., & Moore, J. D. (2011). A computational cognitive model of syntactic priming. *Cognitive Science, 35*, 587–637.

Sanchez, D., Yarnik, J., & Reber, E. (2015). Quantifying transfer after perceptual-motor sequence learning: How inflexible is implicit learning? *Psychological Research, 79*, 327–343.

Sedivy, J. C., Tanenhaus, M. K, Chambers, C. G., Carlson, G. N. (1999). Achieving incremental interpretation through contextual representation: Evidence from the processing of adjectives. *Cognition, 71*, 109–147.

Shin, J.–A., & Christianson, K. (2012). Structural priming and second language learning. *Language Learning, 62*, 931–964.

Shin, J.–A. (2015). L2 structural generalization through structural priming. *Modern English Education, 16*, 25–43.

Spivey, M. J., Tanenhaus, M. K., Eberhard, K., & Sedivy, J. C. (2002). Eye movements and spoken language comprehension: Effects of visual context on syntactic ambiguity resolution. *Cognitive Psychology, 45*, 447–481.

Sun, C. & Givón, T. (1985). On the so-called SOV word order in Mandarin Chinese: A quantified text study and its implications. *Language, 61*, 329–35l.

Travis, C. E., Torres Cacoullos, R., & Kidd, E. (2017). Cross-language priming: A view from bilingual speech. *Bilingualism: Language and Cognition, 20*, 283–298.

Wang, C. (2010). Interactive alignment and foreign language teaching. *Foreign Language Teaching and Research, 42*, 297–299.

Wang, C., & Wang, M. (2015). Effect of alignment on L2 written production. *Applied Linguistics, 36*, 503–526.

Wei, H.–M. (1989). *Word order in Mandarin Chinese.* (Unpublished doctoral dissertation). Michigan State University, East Lansing, MI.

Wei, H., Boland, J. E., Cai, Z. G., Yuan, F., & Wang, M. (2019). Persistent structural priming during online second-language comprehension. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 45*, 349–359.

Wen, X. (2006). Acquisition sequence of three constructions: An analysis of the interlanguage of learners of Chinese as a foreign language. *Journal of the Chinese Language Teachers Association, 41*, 89–114.

Wen, X. (2010). Acquisition of the displacement ba-construction by English-speaking learners of Chinese. *Journal of Chinese Language Teachers Association, 45,* 73–100.

Woumans, E., Martin, C. D., Bulcke, C. V., Assche, E. V., Costa, A., Hartsuiker, R. J., & Duyck, W. (2015). Can faces prime a language? *Psychological Science, 26*, 1,343–1,352.

Xin, S. (2017). Effects of continuation task condition on L2 grammatical structure acquisition. *Modern Foreign Languages, 40*, 507–517.

Xu, H. (2011). The acquisition of some properties of the *ba* construction by English speaking learners of Chinese. In *Proceedings of the 23rd North American Conference on Chinese Linguistics (NACCL-23)* (pp. 237–249). Oregon, Eugene: University of Oregon.

Zhang, B. (2010). Avoidance and overgeneralization: An investigation of acquisition of the Bă-sentence based on the HSK dynamic composition corpus. *Chinese Teaching in the World, 24*, 263–277.

Zhang, S., Morris, M. W., Cheng, C.–Y., & Yap, A. J. (2013). Heritage-culture images disrupt immigrants' second-language processing through triggering first-language interference. *PNAS, 110*, 11,272–11,277.

Zwaan, R. A., & Radvansky, G. A. (1998). Situation models in language comprehension and memory. *Psychological Bulletin, 123*, 162–185.

APPENDIX A

Prime Sentences and Fillers Sentences

Prime Sentences for the Video Group

1. 豆先生把孩子带走了	10. 豆先生把箭扎在了男人头上
Mr. Bean took the baby away.	Mr. Bean stabbed the man's head with an arrow.
2. 豆先生把车子松开了	11. 豆先生把他赶走了
Mr. Bean unfastened the baby carriage.	Mr. Bean drove the boy away.
3. 豆先生把宝宝推过去	12. 豆先生把钱撞下来
Mr. Bean pushed the baby carriage there.	Mr. Bean hit (the machine) to make the coin fall.
4. 豆先生把绳子解开	13. 男孩把钱拿走了
Mr. Bean unfastened the chain.	The boy took away the money.
5. 豆先生把坏人锁住了	14. 豆先生把硬币塞进去
Mr. Bean locked the bad person.	Mr. Bean put the coin into the machine.

6. 豆先生把宝宝放在车子里	15. 豆先生把宝宝抱走了
Mr. Bean put the baby into the toy bumper car.	Mr. Bean took the baby away.
7. 豆先生把宝宝藏在背后	16. 豆先生把宝宝的裤子脱下来
Mr. Bean hid the baby behind himself.	Mr. Bean took off the baby's trousers.
8. 豆先生把很多钱投进去	17. 豆先生把小熊切开
Mr. Bean put money into the machine.	Mr. Bean cut the toy bear.
9. 豆先生把宝宝留在车子里	18. 男人把裤子扔了
Mr. Bean left the baby in the toy car.	The man threw away the trousers.

Prime Sentences for the Picture Group and the Text Group

1. 妈妈把孩子带走了	10. 警察把坏人扎死了
The mother took the baby away.	The policeman stabbed the criminal with a knife.
2. 男人把领带松开了	11. 女人把男人赶走了
The man unfastened his tie.	The woman drove away the man.

3. 他们把车推上去	12. 司机把车子撞坏了
They pushed the car upward.	The driver hit the car.
4. 男孩把绳子解开	13. 男人把东西拿走了
The boy unfastened the rope.	The man took the stuff away.
5. 警察把坏人锁住了	14. 女孩把书塞进书包
The policeman locked the criminal.	The girl put the book into the schoolbag.
6. 妈妈把宝宝放在车子里	15. 妈妈把宝宝抱走了
The mother put the baby in the baby carriage.	The mother took the baby away.
7. 男人把花藏在背后	16. 男孩把衣服脱下来
The man hid the flowers behind himself.	The boy took off his clothes.
8. 女孩把钱投进存钱罐	17. 厨师把肉切好了
The girl put money into the saving pot.	The cook cut the meat.
9. 男人把钱留在桌子上	18. 男人把气球扔了
The man left the money on the table.	The man threw the balloon.

Filler Sentences for the Video Group

1. 豆先生开车去公园	13. 豆先生去射箭
Mr. Bean drove to the amusement park.	Mr. Bean played the archery.
2. 他的车挂住了宝宝的车子	14. 豆先生玩游戏机
His car caught a stroller.	Mr. Bean played the coin pusher.
3. 豆先生发现了宝宝	15. 有个男孩想玩游戏机
Mr. Bean found the baby.	A boy wanted to play the coin pusher.
4. 豆先生看见几个妈妈	16. 豆先生撞游戏机
Mr. Bean saw several mothers.	Mr. Bean hit the coin pusher.
5. 妈妈们都离开了	17. 很多钱从机器上掉下来
All the mothers left.	Many coins fell from the coin pusher.
6. 豆先生和宝宝去了游乐场	18. 游戏机上还有一个硬币
Mr. Bean and the baby went to the amusement park.	One coin was left on the coin pusher.
7. 宝宝哭了	19. 很多人在排队
The baby cried.	Many people waited in line.

8. 豆先生看见一只狗	20. 宝宝的裤子很臭
Mr. Bean saw a dog.	The trousers were smelly.
9. 豆先生和宝宝玩汽车	21. 女孩有一只玩具小熊
Mr. Bean and the baby played the bumper car.	The little girl had a toy bear.
10. 豆先生找到了宝宝	22. 豆先生给宝宝穿上小熊
Mr. Bean found the baby.	Mr. Bean dressed the baby in the toy bear.
11. 豆先生看见小汽车	23. 裤子飞到男人脸上
Mr. Bean saw a toy car.	The trousers fell on the man's face.
12. 豆先生自己去玩了	
Mr. Bean went to play by himself.	

Filler Sentences for the Picture Group and the Text Group

1. 男人开车去上班	13. 男孩在射箭
The man drove to workplace.	The boy played the archery.
2. 卡车挂住了汽车	14. 男孩在玩电脑游戏

The truck caught a car.	The boy played computer games.
3. 男人发现了金子	15. 他们想玩篮球
The man found the gold.	They wanted to play basketball.
4. 狗看见一只老鼠	16. 汽车撞到了树上
The dog saw a mouse.	The car hit the tree.
5. 男人离开了	17. 很多树叶从树上掉下来
The man left.	Many leaves fell from the tree
6. 爸爸妈妈和孩子去公园	18. 男人有很多硬币
The parents and the child went to the park.	The man had many coins.
7. 宝宝哭了	19. 大家在排队
The baby cried.	People waited in line.
8. 猫看见一只老鼠	20. 这条裤子很臭
The cat saw a mouse.	The trousers were smelly.
9. 爸爸妈妈陪孩子坐摩天轮	21. 草地上有一只狗
The parents rode the sky wheel with their	There was a dog on the lawn.

kids.	
10. 狗找到了骨头	22. 妈妈给宝宝穿上衣服
The dog found a bone.	The mother dressed the baby.
11. 猫看见一条鱼	23. 气球飞到天上了
The cat saw a fish.	The balloon floated around in the air.
12. 男孩在玩玩具	
The boy was playing with a toy.	

APPENDIX B

Target Verbs in Production Tasks

Overlapping Verbs

放	扔	推	拿走	藏	脱
put	throw	push	take away	hide	take off

Nonoverlapping Verbs

倒	挂	给	关	送	打开

pour	hang	give	close	send	open

APPENDIX C

Results of Baseline Comparison

TABLE C1

GLME Results for *Ba*-Construction Production in the Baseline Phase

Group contrast	Estimate	*SE*	*p*
Control vs. Text[a]	0.32	0.69	0.65
Control vs. Picture[a]	–0.15	0.70	0.83
Control vs. Video[a]	0.41	0.69	0.55
Text vs. Picture[b]	–0.47	0.69	0.50
Text vs. Video[b]	0.10	0.68	0.89
Picture vs. Video[c]	0.56	0.69	0.42

[a]The control group as reference, Intercept: Estimate = –2.85, $SE = 0.56$, $p < .001$.

[b]Text group as reference, Intercept: Estimate = –2.53, $SE = 0.55$, $p < .001$.

[c]Picture group as reference, Intercept: Estimate = –3.00, $SE = 0.57$, $p < .001$.

APPENDIX D

TABLE D1

Summaries of GLME Models Testing Verb Overlap Effects for the Three Experimental Groups

	Estimate	*SE*	*p*
Text Group			
(Intercept)	–2.578	0.522	.000
Immediate posttest vs. baseline (immediate)	–0.033	0.213	.878
Delayed posttest vs. baseline (long term)	–0.466	0.213	.029*
Verb overlap	–0.283	0.527	.591
P × V: Immediate × Verb overlap	–0.349	0.426	.412
P × V: Long term × Verb overlap	–0.147	0.425	.729
Picture Group			
(Intercept)	–2.853	0.605	.000
Immediate vs. baseline (immediate)	0.672	0.221	.002**

Delayed vs. baseline (long term)	–0.344	0.228	.132
Verb overlap	–0.009	0.363	.981
P × V: Immediate × Verb overlap	–0.264	0.436	.545
P × V: Long term × Verb overlap	0.885	0.449	.049*
Video Group			
(Intercept)	–1.692	0.504	.001
Immediate vs. baseline (immediate)	0.300	0.198	.130
Delayed vs. baseline (long term)	–1.455	0.207	.000***
Verb overlap	0.151	0.455	.739
P × V: Immediate × Verb overlap	–0.668	0.395	.091
P × V: Long term × Verb overlap	–0.220	0.404	.586

Note. P = phase; V = verb.

* $p < .05$. ** $p < .01$. *** $p < .001$.