Exploring the Interface:

Explicit Focus-on-Form Instruction and Learned Attentional Biases in L2 Latin

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Abstract

Eye-tracking was used to investigate the attentional processes whereby different types of Focus on Form (FonF) instruction overcome learned attention and blocking effects in learners' online processing of L2 input. English native speakers viewed Latin utterances combining lexical and morphological cues to temporality under control conditions (CC) and three types of explicit FonF: verb grammar instruction (VG), verb salience with textual enhancement (VS), and verb pretraining (VP). Chinese native speakers were also tested on CC and VG conditions. All groups participated in three phases: exposure, comprehension test, and production test. VG participants viewed a short lesson on Latin tense morphology prior to exposure. VS participants saw the verb inflections highlighted in bold and red during exposure. VP participants had an additional introductory phase where they were presented with solitary verb forms and trained on their English translations. Instructed participants showed greater sensitivity to morphological cues in comprehension and production. Eye-tracking revealed how FonF affects learners' attention during online processing and thus modulates long-term blocking of verb morphology.

Keywords: second language acquisition, morphology, tense, learned attention, focus on form, grammar instruction, explicit-implicit interface

Exploring the Interface:

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Naturalistic second language (L2) learners tend to focus more in their language processing upon open-class words (nouns, verbs, adjectives and adverbs) than on grammatical cues. Grammatical morphemes and closed-class words tend not to be put to full use (e.g., Bardovi-Harlig, 1992; Clahsen & Felser, 2006; Schmidt, 1984; Van Patten, 1996, 2006). So L2 learners initially make temporal references mostly by use of temporal adverbs, prepositional phrases, serialization, and calendric reference, with the grammatical expression of tense and aspect emerging only slowly thereafter, if at all (Bardovi-Harlig, 1992, 2000; Lee, 2002; Meisel, 1987; Noyau, Klein, & Dietrich, 1995).

One might ask whether this failure to learn L2 morphology, which can be the case after many years of rich L2 experience (Klein, 1998; Schmidt, 1984), reflects a failure of explicit learning, or a failure of implicit learning. The answer must be both. In these non-learners, neither implicit learning nor explicit learning has produced observable gains in acquisition over thousands of experiences of tense morphology from untutored naturalistic usage. The questions that follow are how to promote the learning of these constructions, whether by exploiting explicit learning, or implicit learning, or both, and whether these two forms of knowledge can influence each other. Issues of the interface of explicit and implicit knowledge are central to SLA research and practice (Ellis, 2005).

Salience and Learned Attention

One factor determining cue selection is salience: Prepositional phrases, temporal adverbs, and other lexical cues to time are salient and stressed in the speech stream. Verb inflections are

not (consider *yesterday I walked*). The low salience and low reliability of grammatical cues tends to make them less learnable (Ellis, 2006b; Goldschneider & DeKeyser, 2001). Ellis (2006a, 2006b) attributes L2 difficulties in acquiring inflectional morphology to an effect of *learned attention* known as *blocking* (Kamin, 1969; Kruschke, June 2006; Kruschke & Blair, 2000; Mackintosh, 1975). Blocking is an associative learning phenomenon, occurring in animals and humans alike, that shifts learners' attention to input as a result of prior experience (Rescorla & Wagner, 1972; Shanks, 1995; Wills, 2005). Knowing that a particular stimulus is associated with a particular outcome makes it harder to learn that another cue, subsequently paired with that same outcome, is also a good predictor of it. The prior association "blocks" further associations.

There are many situations in L2A where cues are redundant (Schmidt, 2001; Terrell, 1991; Van Patten, 1996) and thus, as a consequence of blocking, might be less readily learned. Where a learners' L1 experience has led them to look elsewhere for cues to interpretation, they might use these types of cue where available in the L2. For example, L1-derived knowledge that there are reliable lexical cues to temporal reference (words like German *gestern,* French *hier,* Spanish *ayer,* English *yesterday*) might block the acquisition of verb tense morphology from analysis of utterances such as *Yesterday I walked*.

A number of theories of second language acquisition (SLA) incorporate related notions of transfer and learned attention. The Competition Model (MacWhinney, 2001; MacWhinney & Bates, 1989; MacWhinney, Bates, & Kliegl, 1984) was explicitly formulated to deal with competition between multiple linguistic cues to interpretation. Input Processing (IP) theory (Van Patten, 1996) includes a *Lexical Preference Principle*: "Learners will process lexical items for meaning before grammatical forms when both encode the same semantic information" (Van Patten, 2006, p. 118), and a *Preference for Nonredundancy Principle*: "Learners are more likely to process nonredundant meaningful grammatical markers before they process redundant

meaningful markers" (Van Patten, 2006, p. 119). Benati (2013) reviews a series of studies showing learners are better able to identify temporal reference when presented with temporal adverbs rather than verbal morphological cues.

Prior Experiments on Learned Attention and Blocking

Ellis and Sagarra (Ellis et al., 2014; 2010a, 2011) report a series of experimental investigations of learned attention L2A involving the learning of a small number of Latin expressions and their English translations. We sketch them in some detail here because they introduce key concepts and because we build on their design in the present study.

In Ellis & Sagarra (2011a) there were three groups: Adverb Pretraining, Verb Pretraining, and Control. In Phase 1, Adverb Pretraining participants learned two adverbs and their temporal reference - *hodie* today and *heri* yesterday; Verb Pretraining participants learned verbs (shown in either first, second, or third person) and their temporal reference – e.g., *cogito* present or *cogitavisti* past; the Control group had no such pretraining. In Phase 2, all participants were shown sentences which appropriately combined an adverb and a verb (e.g. *heri cogitavi, hodie cogitas, cras cogitabis*) and learned whether these sentences referred to the past, the present, or the future. In Phase 3, the Reception test, all combinations of adverb and verb tense marking were presented individually and participants were asked to judge whether each sentence referred to the past, present, or future. The logic of the design was that in Phase 2 every utterance contained two temporal references – an adverb and a verb inflection. If participants paid equal attention to these two cues, then in Phase 3 their judgments should be equally affected by them. If, however, they paid more attention to adverb (/verb) cues, then their judgments would be swayed towards them in Phase 3.

The results showed that the three groups reacted to the cues in very different ways - the Adverb pretraining group followed the adverb cue, the Verb pretraining group tended to follow the verb cue, and the Control group lay in between. For example, Ellis and Sagarra (2011a) report multiple regression analyses, one for each group, where the dependent variable was the group mean temporal interpretation for each of the Phase 3 strings and the independent variables were the information conveyed by the adverbial and verbal inflection cues: in standardized ß coefficients, Adverb Group Time = 0.99Adverb - 0.01Verb; Verb Group Time = 0.76Adverb + 0.60Verb; Control Group Time = 0.93Adverb + 0.17Verb.

Ellis and Sagarra (2010a) Experiment 2 and Ellis & Sagarra (2011) Experiments 2 and 3 also illustrated long-term language transfer effects whereby the nature of learners' first language (+/- verb tense morphology) biased the acquisition of morphological vs. lexical cues to temporal reference in the same subset of Latin. First language speakers of Chinese (no tense morphology) were less able than first language speakers of Spanish or Russian (rich morphology) to acquire inflectional cues from the same language experience where adverbial and verbal cues were equally available, with learned attention to tense morphology being in standardized ß coefficients: Chinese (-0.02) < English (0.17) < Russian (0.22) < Spanish (0.41) (Ellis & Sagarra, 2011, Table 4). These findings suggest that there is a long-term attention to language, a processing bias affecting subsequent cue learning that comes from a lifetime of prior L1 usage.

Such experiments demonstrate both short-term and long-term effects where sensitivity to lexical cues blocks subsequent acquisition of inflectional morphology. These learned attention effects have elements of both positive and negative transfer. Prior use of adverbial cues causes participants to pay more attention to adverbs - positive effects of entrenchment of the practised cue (see Ellis, 2002 review of frequency effects). Additionally, increased sensitivity to adverb cues is accompanied by a reduced sensitivity to morphological cues - blocking. A meta-analysis

of the combined results of Ellis and Sagarra (2010a, 2011) demonstrated that the average effect size of entrenchment was large (+1.23) and that of blocking was moderate (-0.52).

Explicit Instruction: Refocusing Attention and the Explicit/Implicit Interface

Can learned attentional biases be overcome by interventions that retune attention? FonF instruction attempts to do this (Doughty & Williams, 1998; Long, 1991). For example, *Processing Instruction* (VanPatten, 1996) aims to alter learners' default processing strategies, to change the ways in which they attend to input data, and thus to maximize the amount of intake of data in L2 acquisition. FonF can first help the learner to recognize relevant cues to interpretation that otherwise they would ignore. Conscious awareness is important in the initial consolidation of a new pattern recognition unit as an explicit, episodic memory (Ellis, 2005). These are mechanisms of Schmidt's (1990, 1993) noticing hypothesis: "since many features of L2 input are likely to be infrequent, non-salient, and communicatively redundant, intentionally focused attention may be a practical (though not theoretical) necessity for successful language learning." Schmidt (2001, p. 23).

But "knowing" a cue does not necessarily entail that it will be used. Explicit knowledge and implicit knowledge are distinct and dissociated; they involve different types of representation and are substantiated in separate parts of the brain (Andringa & Rebuschat, this volume; Ellis, 1994; Rebuschat, in press). There are always possibilities of non-interface, where learners who can explain a grammatical rule nevertheless fail to put it to everyday use (Ellis, 1993; Krashen, 1985). Likewise, one can have relevant knowledge but fail to recall it because the processes engaged in during encoding do not match those engaged in during retrieval. Lightbown (2008) calls this as a lack of "transfer appropriate processing". The new cue must be integrated into routine processing.

Terrell (1991) characterized explicit grammar instruction (EGI) as "the use of instructional strategies to draw the students' attention to, or focus on, form and/or structure" (p. 53), with instruction targeted at increasing the salience of inflections and other commonly ignored features by firstly pointing them out and explaining their structure, and secondly by providing meaningful input that contains many instances of the same grammatical meaning-form relationship. Terrell had worked with Krashen, reacting against the worst of traditional grammar instruction, and developing the best of an instruction-free Natural Approach (Krashen & Terrell, 1983). Nevertheless, after sufficient experience of the latter, he proposed three ways in which EGI might affect acquisition: 1) "as an advance organizer to help the learner make sense of input"; 2) "as a meaning-form focus in communication activities in which there are many examples of a single meaning-form relationship", and 3) "monitoring itself might directly affect acquisition if it is possible for learners to acquire their own output." (Terrell, 1991, p. 62). He closed his article "Naturally, the proposals in this paper are only hypotheses which will need to be confirmed or rejected in two ways: by teachers in the classroom, who will find them useful or not, and by researchers, who will look at learners with and without such instruction to see if there are predictable differences." The latter is our intention here.

There are several options for FonF instruction (see for example the classifications in Norris & Ortega, 2000). Attention can be redirected in various ways: Grammar Instruction tries to make learners explicitly aware of how cues work, and hopes that this will be memorable enough to encourage subsequent use of this knowledge. Textual enhancement aims to draw learners' attention to the relevant cues during processing. Cue Pretraining in isolation in task-essential rather than redundant contexts is another method again. The present research aims to contrast and illuminate the processes by which these different methods of FonF act in usage to counteract learned attentional biases.

Verb Grammar Instruction (VG)

Grammar instruction has been broadly defined as "any instructional technique that draws learners' attention to some specific grammatical form in such a way that it helps them either to understand it metalinguistically and/or process it in comprehension and/or production so that they can internalize it" (Ellis, 2006c, p. 84). Such Form-Focused Instruction (FFI, Spada, 1997) can be either implicit or explicit. In implicit FFI, learners are expected to infer rules without awareness, whereas explicit FFI involves either the presentation of rules or a means for the learners to inductively resolve the rule (Ellis, 2008). The meta-analysis of effects of grammar instruction by Norris and Ortega (2000) showed that explicit types of L2 instruction outperformed implicit types. Likewise the more recent meta-analysis by Spada and Tomita (2010), where at least half the studies included free constructed response outcome measures, found a larger advantage of explicit instruction in the acquisition of both complex and simple language forms. Nevertheless, as R. Ellis (2012, chapter 9) makes clear in his yet more recent review of FFI, it is often difficult to compare and collate studies, since explicit treatments tend to be combined with other methods, such as negative feedback and rule review, whereas implicit groups typically include only one source of exposure.

Weighing these considerations, the operationalization of VG we adopted here was a short, hopefully clear and memorable, metalinguistic description of simple regular tense morphology in Latin. The four slides we used under computer administration are shown in Figure 1.

These meta-analyses also discuss the difficulties of comparing studies with quite different outcome measures, some much more explicit than others (as first made clear in Norris & Ortega,

2000). In this experiment, therefore, we used the same variety of comprehension and production measures for all of our treatments.

Figure 1 about here

Verb Salience (VS)

Input enhancement involves relatively unobtrusive methods to direct learners' attention to non-salient forms in the input (Doughty & Williams, 1998; Sharwood-Smith, 1993). In Textual Enhancement (TE), visual manipulations such as color-coding, boldfacing and underlining are typically used to enhance forms in written input, thus to prompt learners' further processing of these cues (Sharwood-Smith, 1993). Research has yielded conflicting findings regarding its effectiveness. Some studies demonstrate that TE is successful in drawing learners' attention to the target forms (Alanen, 1995; Cho, 2010; Izumi, 2002; Jourdenais, Ota, Stauffer, Boyson, & Doughty, 1995; Lee, 2007; Winke, 2013) and in enhancing their subsequent knowledge of these forms (Jourdenais et al., 1995; Lee, 2007; Shook, 1994) as measured by a variety of recognition, recall, and grammaticality judgment tasks. Others have found no effect of TE on learning (Izumi, 2002; Leow, 1997, 2001; Leow, Egi, Nuevo, & Tsai, 2003; Overstreet, 1998; Wong, 2003). These discrepancies are likely the result of study differences variously in learners' target and native languages, target type, complexity, and task-communicative essentialness, density of target exposure, learner proficiency, treatment intensity, and the measures used to assess the noticing and learning of these forms.

Many TE studies have simply evaluated how well learners acquire the target forms, leaving to speculation learners' degree of attention to these forms (Han, Park, & Combs, 2008; Leow et al., 2003). However, some studies have adopted methods such as retrospective verbal report, note-taking (Izumi, 2002) or think-alouds (Alanen, 1995; Jourdenais et al., 1995; Leow,

2001; Leow et al., 2003; Overstreet, 1998) to try to measure the amount of noticing of the target forms. Retrospective verbal reports are problematic because the probability of forgetting restricts the claims that can be made regarding learners' attention or awareness of the forms (Leow, 2007; Winke, 2013). Even online measures, such as note-taking and concurrent think-alouds, can be troublesome because one cannot be certain that failing to capture noticing in these types of tasks necessarily means that the learners did not notice the forms: "at a lower level of processing, individuals may register the form but not be able to self-report noticing" (Winke, 2013, p. 329). An important recent advance, therefore, is the inclusion of eye movement recordings as a measure of attention with TE (Winke, 2013). In Winke's (2013) study, although enhancement of English passive forms did neither significantly improve nor detract learners' performance in subsequent form correction and comprehension tasks, those exposed to the enhanced forms revisited these forms more often, and fixated on them longer than those exposed to the unenhanced text. This provided evidence for the positive impact of enhancement at least in drawing learners' attention to non-salient forms.

In the present study, we operationalize TE by means of bolding and colour to make verbal inflectional cues more salient. This condition is therefore called VS (for Verbal Salience). Following Winke (2013), we use eye-tracking to measure the visual attention to form that results from this condition and all other conditions of language exposure.

Verb Pretraining (VP)

Blocking is particularly potent whenever the to-be-learned cue is met in conjunction with other cues to the same interpretation which have been prior-learned or are more salient. One counter, therefore, is to ensure that early in L2 experience, the cue is experienced on its own in

situations where it must be processed for successful interpretation. Ellis & Sagarra's Verb Pretraining conditions tested the effects of this and demonstrated that once the cue has been consolidated into the processing system, it continues to contribute to processing in subsequent situations of potential cue competition. For sake of continuity, replication, and comparison, therefore, we include the VP condition of Ellis and Sagarra (2012) here, in order to investigate its mechanisms with eye-tracking and to compare its efficiency and operation with VG and VS conditions.

Eye-tracking as a measure of attention

L2A research is increasingly recognizing eye tracking as a research tool (Roberts & Siyanova-Chanturia, 2013; Winke, Godfroid, & Gass, 2013). Eye-movement recordings provide a means toward capturing language learning attentional processes, allowing a direct, objective study of moment-by-moment processing decisions during natural, uninterrupted comprehension, without the need to rely on participants' strategic or metalinguistic responses (Roberts & Siyanocha-Chanturia, 2013, p.214).

Kruschke, Kappenman and Hetrick (2005) demonstrated that eye-tracking could be used to inform the processes of blocking in associative learning. They showed that participants' eye-gaze in the training phase of a blocking experiment (the equivalent of our Phase 2) was greater for the blocking cue than the blocked cue, and that individual differences in this ratio covaried with covert indices of blocking in a subsequent testing phase (r = .48): Individuals who showed stronger overt gaze preferences in the learning phase tended to show stronger blocking.

Ellis et al. (2014) adopted eye tracking to investigate the locus of learned attention effects in L2A for Verb and Adverb Pretraining. Eye-tracking measures showed that prior experience of particular cue dimensions affected what participants overtly focused upon during subsequent

language processing, and how, in turn, this overt study resulted in covert attentional biases in comprehension and in productive knowledge. A structural equation model showed the higher the overt attention to verbs in Phase 2, the greater (0.49) the covert attention to verb cues and the less (-0.32) to adverb cues in comprehension and the greater (0.40) the knowledge of verb cues and the less (-0.06) of adverb cues in production (Ellis et. al, 2014, Figure 10).

Aims

The current research therefore aimed to explore and compare the degree to which, and the processes by which, VG, VS and VP methods of FonF might counteract learned attention effects where the learning of verb inflections is blocked by L2 learners' learned attention to adverbial cues.

In Experiment 1 we compared the behavioral effects of Control Condition (CC) learners with those in VG, VS and VP conditions in first-language English speakers. CC and VP conditions allowed us to replicate Ellis and Sagarra (2012) with larger samples. VG and VS conditions allowed us to compare the effects of these two FonF manipulations with VP.

In Experiment 2, we investigated the attentional processes of a subset of learners from Experiment 1. Eyetracking data showed us the effects of these FonF manipulations upon overt attention to the lexical and morphological cues during language processing, and we assessed in turn the effects of this attention to input upon subsequent knowledge.

In Experiment 3, we investigated (1) the degree to which first language speakers of Chinese (no verb tense morphology) are less or equally able than first language speakers of English (light morphology) to acquire inflectional cues from the same language experience where adverb and verb cues were equally available, and (2) whether VG was equally effective in overcoming

learned attentional biases. Again, in a subset of these learners, we investigated their attentional processes during processing to see how these determine later knowledge.

Experiment 1

Experiment 1 involved the L2 learning of a small number of Latin expressions and their translations by native English speakers. It investigated the learning of different types of cue for temporal reference, adverbs (*hodie*, today; *heri*, yesterday; *cras*; tomorrow) and verb inflections in three tenses and three persons (*cogito/ cogitas/ cogitat*, I/ you/ he think; *cogitavi/ cogitavisti/ cogitavit*, I/ you/ he thought; *cogitabo/ cogitabis/ cogitabit*, I/ you/ he will think). It determined if the acquisition of verb morphology is blocked in a CC where it is always experienced along with another reliable adverbial indicator of event time. It then compared these levels of performance with those in three different explicit FonF conditions involving, respectively, Verb Grammar instruction (VG), Verb morphological Salience with textual enhancement (VS), and Verb Pretraining (VP).

Participants

Participants consisted of 320 individuals recruited from a major university in the United States (n=308) or the local community (n=12). They were volunteers and either participated as part of an undergraduate Psychology course requirement or they were compensated with 10 dollars for their time. Inclusion criteria required participants to be native English speakers who had not learned Latin or Italian previously. Participants could know Spanish, but could not have been raised bilingually before the age of 6 years old. Approximately two-thirds of the participants

had studied Spanish for more than 3 years, with a range from 1 to 15 years. They were randomly assigned to one of four conditions: CC: n=72 (37 females and 35 males), age range 18-56 (mean: 20.47; median: 19; although this age range appears to be large, there was only one participant of age 56); VG: n= 101 (67 females and 34 males), age range 17-49 (mean: 20.23; median: 20); VS: n=74 (49 females and 25 males), age range 17-54 (mean: 19.59; median 19, again only one participant was responsible for the large age range); VP: n=73 (42 females and 31 males), age range 18-24 (mean: 19.22; median: 19).

Procedure

The experiment was programmed in E-Prime (Schneider, Eschman, & Zuccolotto, 2002). It took less than one hour to complete. There were four phases: Phase 1 – Pretraining, Phase 2 – Sentence decoding, Phase 3 – Reception testing, Phase 4 – Production testing. The procedure of the first 3 phases is schematized in Table 1. The procedure for the VP and CC groups replicated Ellis and Sagarra (2011).

Table 1 about here

Phase 1.

VP participants engaged in a Phase 1 which involved training on verb inflections alone. On each trial they saw one of the past (*cogitavi*, *cogitavisti, cogitavit)* or present (*cogito*, *cogitas, cogitat*) inflected verbs and learned that each corresponded to the appropriate one of the two translations *X think(s)* or *X thought,* by clicking the appropriate alternative with the mouse. A correct choice returned the feedback 'Correct', an incorrect one 'Incorrect – the meaning of [Latin] is [English]'. The 36 trials thus involved each of the three persons of present and past tense being presented 6 times in random order. Since the future tense adverb and verb forms were

only presented from Phase 2 onwards, this allowed determination of whether training affected attention to cue dimensions rather than specific words.

Phase 1 for the VG participants involved a brief lesson on Latin verb-tense morphology using the four slides shown in Figure 1. Although they could view each of the slides for an undetermined amount of time, they were not allowed to take notes, and could not regress to previous slides. The mean (SD) time in seconds spent looking at these slides were slide 1 22.8 (11.6), slide 2 24.4 (10.6), slide 3 16.8 (6.2), slide 4 33.8 (24.1), giving a mean total instruction time of 1 minute 38 sec (34.4).

There was no Phase 1 for CC or VS participants.

Phase 2. In Phase 2, participants were exposed to 18 sentences (*hodie cogito/as/at, cogito/as/at hodie, heri cogitavi/visti/vit, cogitavi/visti/vit heri, cras cogitabo/bis/bit, cogitabo/bis/bit cras*) which appropriately combined the adverb with a verb, half in adverb-verb word order and half in verb-adverb, and had to choose whether these sentences referred to the present, the past, or the future. Both word orders were used in order to counterbalance which cue was experienced first across sentences. Each of the 18 sentences was presented twice during this Phase of the experiment. Feedback was given for both correct and incorrect choices. For correct answers, the word "correct" would appear on the screen, while for incorrect answers, participants would see the word "incorrect" accompanied by the correct answer (e.g. 'Incorrect – [cogitavisti] is [past]'.

The Phase 2 procedure was identical for the CC, VG and VP groups. For VS participants alone, the stimuli were textually enhanced so that the verbal inflections were highlighted in bold and red in order to increase the salience of these items. Participants were not made aware of this beforehand, and were given the same instructions for this task as the other groups.

Phase 3. In this phase, participants were presented with all single-word items (verbs and adverbs) and all possible combinations of adverbs and verb tenses, for a total 12 single-word items, and 54 two-word items, comprised of 27 unique combinations (a grand total of 66 trials – see Table 1). The two-word items were presented in two different word orders, counterbalancing which cue participants would experience first. The presentation of all possible combinations meant that participants experienced sentences that were familiar to them from the previous task, but also combinations where the verb and adverb were incongruent in their time reference. Before the start of the task participants told that there would be both congruent and incongruent sentences. They were asked to judge their temporal reference on a 5-point scale by using their mouse to select the appropriate answer. The possible scale points were labeled 1-past, 2- both past and present, 3-present, 4-both present and future, and 5-future. Participants were told they could also choose 3 if they encountered an incongruent sentence with both past and future cues. For example, the participant could be presented with an incongruent sentence such as *heri cogitabo* "Yesterday I will think", for which the correct answer was 3 and understood as the average of the items' tenses (past [1] + future [5]/2 = 3). The correct answer for each trail, which Ellis and Sagarra (2011) referred to as the *semidiem*, is shown in Table 1. This task separately assessed the degree to which they learned the adverb and verbal cues, by determining the relative weight that learners put on adverbial and inflectional cues to time reference. For this reason, feedback was not provided.

Phase 4. Here participants were asked to translate from English to Latin by typing in the Latin equivalents of several of the elements they had been exposed to. Nine unique items were given twice for a total of 18 items. Three adverbs were given in isolation (*yesterday*, *today*, *tomorrow*), three verbs were given in isolation (*X thought*, *X think(s)*, *X will think*), and three

sentences were given with the tense of the verb and the temporal adverb matching (*yesterday X thought*, *today X think(s)*, *tomorrow X will think*). All the target productions in this portion had been experienced in Phase 2 of the experiment. This phase did not include feedback.

The logic behind the experiment follows that of previous studies of learned attention and blocking (Ellis et al., 2014; Ellis & Sagarra, 2010a, 2010b, 2011). During Phase 2, regardless of condition, all participants experience both the adverb and verbal cue together. If they pay equal attention to both cues during this phase, then their judgment during Phase 3 should be equally affected by them, and in Phase 4, they should do equally well in producing the adverbs and verbs, with corresponding inflections. However, if they are biased toward one cue or the other, it is expected that their judgment in Phase 3, will be swayed toward the corresponding cue, and that their productions in Phase 4 will also display this bias. Because CC only saw the two cues together, their performance was expected to mirror how native speakers of English typically weigh these cues, which in Ellis and Sagarra (2010, 2011, 2012) was characterized by the overshadowing of morphological cues by the more salient and reliable adverbial cues.

Results

Phase 2 The pretraining for VP gave them an accuracy advantage at the beginning of Phase 2 training: mean performance in the first quarter of Phase 2 was 56% for CC, 61% VG, 62% VS, and 79% for VP. By the end of Phase 2, however, group performance levels had become more even: mean performance in the final quarter of Phase 2 was 82% for CC, 81% VG, 83% VS, and 89% for VP. A oneway ANOVA on these final-quarter scores showed a marginally significant effect of Group (F [3,301] = 2.88, $p < .05$), post-hoc Tukey HSD tests demonstrating just one significant pairwise group difference, that between VP and VG, p = .03).

Perception data Phase 3 Participants in these four groups differed in their cue use in Phase 3. Figure 2 illustrates the average group understanding of the temporal reference of each of the constructions of Phase 3 in terms of deviations from their semidiem average shown in the right column of Phase 3 Table 1. The strings are ordered from past on the left to future on the right. For each string where the two cues are in conflict, the large solid diamond shows the temporal information provided by the verb, the large solid circle the temporal information provided by the adverb. In the sentence *cogito heri* "I think yesterday," for example, with a verb reference of 3 and an adverb reference of 1, the respective deviations from the semidiem (2) are +1 and -1; for *cogitabo heri* "I will think yesterday," the verb reference is 5, the adverb reference is 1, and thus the relative deviations from the semidiem (3) are +2 and -2.

Subject ratings are similarly plotted as deviations from the semidiem. Consider, for example, a participant rating *heri cogitavi* "Yesterday I thought." The semidiem in this case is (1 [Yesterday]+ 1 [I thought])/2 = 1. So a rating of 2 would be plotted (2 [rating] -1 [semidiem]) = +1 [a unit deviation to the future], a rating of 1 would be plotted (1 [rating] -1 [semidiem]) = 0 [zero deviation], etc. As a second example consider a participant rating *cras cogito* "Tomorrow I think." The semidiem in this case is (5 [Tomorrow]+ 3 [I think])/2 = 4. So a rating of 3 would be plotted (3 [rating] - 4 [semidiem]) = -1 [a unit deviation to the past – this is the score that someone who just interpreted the *cogito* would get], a rating of 4 would be plotted (4 [rating] - 4 [semidiem]) = 0 [a zero deviation indicating that the participant was balancing the information from both cues], and a rating of 5 would be plotted (5 [rating] - 4 [semidiem]) = 1 [a unit deviation to the future – this is the score that someone who just interpreted the *cras* would get], etc.

Figure 2 shows that in two word strings of Phase 3 where there is temporal information

cued by both an adverb and a verb inflection, when these cues deviate, as in Ellis and Sagarra (2010b, 2011), CC learners tend to be more influenced by the adverb than the verb. However, the other groups are more sensitive to verb inflection, with VP showing a balance between the two cues, and VS and VG participants more swayed by the verb.

Figure 2 about here

These impressions are confirmed by four multiple regression analyses, one for each group, where the dependent variable is group mean temporal interpretation for each of the 54 two-word strings and the independent variables are the interpretation cued by the adverb cue and that by the verb inflection. The differential cue use by each of the three groups, in standardized β coefficients, are shown in Table 2.

Table 2 about here

Participants in CC, who had not been pretrained on either cue, were more reliant upon the adverb cue (β = 0.97) than the verb cue (β = 0.17). The confidence intervals of the two coefficients are non-overlapping. This performance might reflect the relative salience, simplicity and reliability of the adverb cues compared to the verb inflections.

Against this baseline there are the effects of different types of explicit instruction. VG participants were more reliant on the verb cue (β = 0.95) than the adverb (β = 0.21). Likewise were VS: verb cue (β = 0.98), adverb (β = 0.14). VP participants were reliant upon both the verb (β = 0.79) and adverb (β = 0.58) cues. Comparing the 95% CIs for these coefficients across groups, relative adverb cue sensitivity is CC > VP > VG > VS; verb cue sensitivity is the reverse: VS ≈ VG > VP > CC .

In order to determine whether these patterns are reliable across individual group members, we calculated the degree to which each individual's Phase 3 temporal rating on each construction

correlated with the information provided by the verb cue and that separately provided by the adverb cue. These Pearson correlations thus show the degree to which each participant is biased by each cue. Figure 3, which plots each individual in the space defined in this way, shows that most CC individuals were predominantly influenced by the adverb cue, whereas most VS and VG participants were more influenced by the verb cue. VP were more scattered: most show greater sensitivity to the verb, though there are some who lie close to the 45 degree diagonal, more evenly affected by these two cues.

Figure 3 about here

The group means of these correlations are shown in Figure 4, where error bars represent 2 standard errors, and the top panel of Table 3. Following Corey, Dunlap, and Burke (1998), when averaging or performing inferential statistics upon the correlation coefficients, we first transformed the r values to z values, then performed the statistics, and then reverse transformed to report the values. These group means of the individual correlations within each group are slightly different, because of the different orders of steps of calculation, from the correlations of the group mean scores over the individuals, but the patterns are substantially the same. CC participants are more influenced by the adverb (M = 0.73, 95% CI [0.62, 0.83]) than the verb (M = 0.21, [0.14, 0.28]). VG participants are influenced more by the verb (M = 0.80, [0.71, 0.89]) than the adverb (M = 0.16, [0.10, 0.22]), as are VS verb (M = 0.70, [0.60, 0.80]), adverb (M = 0.13, [0.08, 0.19]). VP participants are influenced by both verb (M = 0.61, [0.52, 0.70]) and adverb (M = 0.45, [0.37, 0.53]).

Analysis of Variance (4 Groups x 2 Cues with subjects nested within Groups) showed this to be a large and significant interaction of group by cue (F [3,325] = 32.93, $p < .001$, $\eta^2 = 0.132$). To check that each of the FonF groups showed greater sensitivity to the verbal cue over the

adverbial cue than did the controls, we performed individual ANOVAs (2 Groups x 2 Cues) of each FonF group against CC. The group x cue interaction was significant for VG vs. CC (F [1, 171] = 77.07, $p < .001$, $\eta^2 = 0.181$), as it was for VS vs. CC (F [1,146] = 66.31, $p < .001$, $\eta^2 = 0.175$). For VP vs. CC there was a main effect of cue (F [1,150] = 5.37, $p < .05$, $\eta^2 = 0.018$), and a significant interaction of group and cue (F [1,150] = 24.94, $p < .001$, $\eta^2 = 0.078$). All three FonF treatments therefore increased sensitivity to the verb cue; VP participants additionally maintained sensitivity to the adverb.

Table 2 and Figure 4 about here

Production data – Phase 4. Each participant translated 18 items of which 12 required adverb production and 12 verb production. The production data were scored following the procedure of Ellis and Sagarra (2011, pp. 602-603) and expressed as proportion correct production for the adverb and verb separately.

The group means of these production scores are shown in Figure 5 and the bottom panel of Table 3. CC participants produced the adverb (M = 0.50, 95% CI [0.43, 0.57]) more reliably than the verb (M = 0.28, [0.22, 0.35]). VG participants produced the verb (M = 0.36, [0.30, 0.42]) marginally more reliably than the adverb (M = 0.29, [0.24, 0.34]), as did VS: verb (M = 0.39, [0.33, 0.46]), adverb (M = 0.31, [0.25, 0.38]). VP accurately produced both verb (M = 0.52, [0.46, 0.58]) and adverb (M = 0.47, [0.40, 0.55]).

Analysis of Variance (4 Groups x 2 Cues with subjects nested within Groups) showed this to be a significant interaction of group by cue (F [3,325] = 12.08, $p < .001$, $\eta^2 = 0.041$). Within-group comparison of cue use using Fisher's LSD shows CC adverb > verb ($p < .05$), VG verb > adverb ($p < .05$), VS verb > adverb ($p < .05$), VP verb ≈ adverb.

Figure 5 about here

Discussion

The results of Experiment 1 demonstrate that under control conditions (CC), adverbs were better learned than verb inflections. This was evidenced in both comprehension and production testing and replicates Ellis and Sagarra (2010a, 2011a). We interpret these findings in terms of learner attention. Firstly, the relative salience, simplicity and reliability of adverb cues compared to verb inflections makes them intrinsically more learnable. Secondly, adult language learners' prior knowledge of the use of adverb temporal references from their L1 results in long-term blocking.

Pretraining on isolated verb cues (VP) reverses this bias. VP participants use verbs more than adverbs in comprehension and are more able to produce them than are CC participants. Again, this replicates Ellis and Sagarra (2010a, 2011a) and demonstrates learned attention effects in the short-term of an experiment manipulating instructional sequence - prior learning of one cue affects learner attention so that subsequently they attend more to that cue.

The two novel conditions in this experiment were VG and VS. Early focusing of attention upon verbal morphology by means of less than two minutes of VG, a FonF which explained how tense and person were encoded, resulted in better verb comprehension and production than both CC and VP groups. Making the verbal morphology salient by means of TE during exposure to both cues in the sentences of Phase 2 improved later verb comprehension and production to the similar levels as VG, again superior to both CC and VP.

Thus all three FonF manipulations resulted in superior acquisition of verbal morphology. Of the three treatments, VP resulted in more balanced acquisition of both verbal and adverbial cues.

Experiment 2

In order to investigate how these different FonF manipulations affected attention to input during language processing, we used eye-tracking to record learners' overt attention to adverbs and verb inflections during Phase 2 in a subset of the above participants. We have in the introduction described the use of this tool in L2A research more generally (Winke et al., 2013), in studying the processes of blocking in associative learning (Kruschke et al., 2005), and, more specifically still, in investigating the locus of learned attention effects in L2A under control conditions and following Verb and Adverb Pretraining (Ellis et al., 2014).

Participants

Eye-tracking data was collected for a subset (n=66) of the Experiment 1 participants:18 in CC (7 females and 11 males), age range 18-22 (mean: 19.28; median: 19); 17 in VS (9 females and 8 males), age range 18-21 (mean: 19; median: 19); 17 in VG (10 females and 7 males), age range 20-22 (mean: 19.88; median: 20); and 18 in VP (12 females and 6 males), age range 18-21 (mean: 18.94; median: 19).

Procedure

Eye-movement recordings were gathered using an ISCAN-ETL 400 Eye-Imaging System with a sampling rate of 60 Hz. The eye-tracking cameras were mounted on headgear. Before the start of Phase 1 (or Phase 2 for CC or VS), participants' gaze was calibrated using a 6-point calibration sequence. This sequence was again repeated for all participants before starting Phase 3. Eye-tracking equipment was not used to collect data during Phase 4. In E-Prime, stimuli were positioned within a screen area of 640x480 pixels, where in Phase 2, the Left Stimulus (STIML) was centred at coordinates (x,y) 94, 99, and the Right Stimulus (STIMR) was positioned at 454,

99 coordinates. For Phase 3, STIML and STIMR were positioned at 109, 108, and 505, 108 respectively. Participants' fixations were analysed using ILAB version 3.6.4, an open-source program developed for the analysis of eye-movement recordings (Gitelman, 2002) through the MATLAB (Mathworks, Natick, MA) software platform. For each condition, fixations were analyzed from 600ms after the start of Phase 2 and Phase 3 trials (coincident with end of presentation of a fixation cross at the centre of the screen) until trail end (coincident with participant response). Region of interest (ROI) analyses were calculated using two positions (Left and Right) at the uppermost part of the screen. Both ROIs had a height of 200, and a width of 250; the ROI for STIML was centralized at 175, 103, and STIMR at 465, 103. These relatively large ROIs reflect our simple set-up with merely a chin-rest and forehead bar to stabilise the participant's head position. In occasional cases, for individual subjects it was necessary to edit coordinates for both ROIs in order to adjust for drift. Fixation analyses were run using the default ILAB fixation velocity/distance calculation parameters, with fixations determined according to degree of movement (horizontal 1.02 degrees; vertical 1.09 degrees) and minimum duration 100 ms. Eye movement analysis was done blind to stimulus content: Random order of stimulus presentation for each participant entailed that right and left fixation durations were assigned as verb and adverb fixation durations only in subsequent statistical analysis on the basis of trial number.

Results

Behavioral Data Figure 6 confirms that the behavioural data of this subset of participants reflects the overall Experiment 1 patterns of comprehension in Phase 3 (left panel) and production in Phase 4 (right panel). This is clear for Phase 3 and generally the case for Phase 4,

with the exception of the VS group here producing adverbs somewhat more reliably than in Experiment 1; we know not why.

Figure 6 about here

Phase 2 Eye-tracking data Figure 7 and Table 3 show the group mean fixation duration of these participants as they were studying the adverb and verb cues during exposure to the Latin sentences in Phase 2. It was this usage that led to the knowledge expressed in Figure 6. The left hand panel shows the total fixation duration on these cues. The right panel shows these data as the proportion of the total fixations on each trial, i.e. the relative amount of attention given to the verb or adverb. The pattern is quite clear. All groups look at the verb more than the adverb, but the three explicit FonF groups do so much more than CC. Note that the verb stem plus inflections were overall more salient in terms of number of letters that were the shorter adverbs.

Analysis of Variance on the proportion fixations (4 Groups x 2 Cues with subjects nested within Groups) showed a significant effect of cue (F [1,60] = 128.5, $p < .001$, $\eta^2 = 0.681$), and a significant group x cue interaction (F [3,60] = 4.59 $p < .001$, $\eta^2 = 0.187$). To check that each of the FonF groups gave greater attention to the verbal cue over the adverbial cue than did the controls, we performed individual ANOVAs (2 Groups x 2 Cues) for each FonF group against CC. The group x cue interaction was significant for VG vs. CC (F [1, 31] = 9.11, $p < .005$, $\eta^2 = 0.227$), as it was for VS vs. CC (F [1,32] = 11.16, $p < .005$, $\eta^2 = 0.258$), and for VP vs. CC (F [1,31] = 6.31, $p < .05$, $\eta^2 = 0.169$). All three FonF treatments therefore paid more attention than the CC group to the verb cue while processing these two-part stimuli.

Figure 7 and Table 3 about here

Correlations Phase 2 Attention, Phase 3 Comprehension, and Phase 4 Production

Pearson correlations investigating these relations from Phase 2 attention to comprehension ability in Phase 3 and production ability in Phase 4 across all the participants and groups of Experiment 2 show that proportion of fixation time spent on the adverb in Phase 2 correlates significantly with later adverbial bias in Phase 3 ($r = 0.55$, $p < .01$) and with correct adverbial production in Phase 4 ($r = 0.26$, $p < .05$). Proportion of fixation time spent on the verb in Phase 2 correlates significantly with later verb bias in Phase 3 ($r = 0.34$, $p < .01$) and with correct verb production in Phase 4 ($r = 0.32$, $p < .05$).

Phase 2 Eye-tracking over trials So how do these attentional biases change over experience of usage in Phase 2? Although the random order of stimuli was different for each participant, we can determine the degree to which the participants attended the verb and adverb cues over trials. Figure 8 shows the total fixation duration on each cue by trial of experience in the three groups. It can be seen that CC participants initially spend more time looking at the verb, but interest in this cue wanes over trials and more attention is paid to the adverbial cue. Participants in the three FonF conditions, however, maintain a steady attentional preference for the verb cue. These patterns are clearer in Figure 9 which plots the proportion of fixation time on each trial spent on the adverb and verb cues respectively.

Figures 8 and 9 about here

Discussion

The eye-tracking data showed how FonF treatments affected attention to cues in the input processing in Phase 2. Over the whole session, all participants looked relatively more at the verbs (verb stem + inflection) than they did at the shorter adverb. However, all FonF treatments (VG,

VS and VP) led to significantly more scrutiny of the verbs during Phase 2 processing than in CC. The correlational analyses suggests that it is the relative amount of time spent processing the verb/adverb cues in Phase 2 which determined cue usage in later comprehension and production. The trial-by-trial analyses showed how in early exposure, CC participants fixated both cues, but fairly soon came to attend relatively more to the adverbs. Whether they could not fathom the verbal inflections, or whether they simply came to rely more on the more reliable and salient adverbial cue, we cannot tell. But it is clear that within about twenty trials of exposure, CC learners were preferentially attending to adverbial cues. However, as seen in Figures 8 and 9, if learners had already been made aware of verbal cues (VP), or if their functions had already been explained (VG), then learners attended to them more from the outset, and they continued to focus more upon these cues. From Figure 9, if anything the bias increased over exposure in the VG group. Preferential attention to the verbs was also achieved in VS by making the verbal inflections more salient with TE during exposure to the language input.

Experiment 3

Blocking as a long-term attentional bias in language processing results from a lifetime of prior language usage. Ellis and Sagarra (2011) illustrated differential long-term language transfer effects whereby the nature of learners' first language (+/- verb tense morphology) prejudiced the acquisition of morphological vs. lexical cues to temporal reference using the same experimental paradigm as used here. First language speakers of Chinese (no tense morphology) were less able than first language speakers of Spanish or Russian (rich morphology) to acquire inflectional cues from the same language experience where adverbial and verbal cues were equally available, with learned attention to tense morphology being in standardized ß coefficients: Chinese (-0.02) < English (0.17) < Russian (0.22) < Spanish (0.41) (Ellis & Sagarra, 2011, Table 4). However, it

remains to be shown that these effects likewise show themselves in differential overt attention to cues during Phase 2 processing. Furthermore, it remains to be seen that FonF can be equally effective in promoting the processing of L2 verbal inflections in native speakers of Chinese, whose L1 does not exhibit verb tense morphology, either free or bound, that corresponds to tense, and where "gender, plurality and tense are either indicated by lexical choice or not indicated at all" (Li & Thompson, 1987, p. 825).

Experiment 3 therefore compares the learning of Chinese L1 learners for their learning of verb morphology under CC and VG conditions.

Participants

Chinese Native speakers who had not learned Latin or Italian previously were recruited from a major university in the United States (n=70) or the local community (n=6). They were volunteers and either participated as part of an undergraduate Psychology course requirement or they were compensated with 10 dollars for their time. Note that all were bilingual, with high-level English language proficiency sufficient to admit them to study in English. However, all had learned English as a second language, after the age of five years old A subset of the participants had previously studied Spanish (CC= 3; VG= 2), but reported less than three years of instruction. Participants were randomly assigned to one of two conditions: CC: n= 44 (30 females and 14 males), age range 18-35 (mean: 23.09; median: 22); VG: n= 32 (25 females and 7 males), age range 19-39 (mean: 22.84; median: 21).

As in experiment 2, eye-tracking data was collected for a small subset of this sample (n=31). There were 15 participants in CC (8 females and 7 males), age range 18-35 (mean: 23.82; median: 23); and 16 in VG (11 females and 5 males), age range 20-26 (mean: 22.83; median: 21.00).

Procedure

The procedure was an exact replication of the CC and VG conditions of Experiment 1.

Results

Behavioral data from the larger sample

Perception data Phase 3 From the multiple regression analyses of group mean temporal interpretation against the interpretation cued by adverb cue and by verb inflection, Chinese CC participants were more reliant upon the adverb cue ($\beta = 0.95$, $p < .001$, 95% CI [0.87, 1.03]) than verb cue ($\beta = 0.09$, $p < .05$, 95% CI [0.00, 0.17]). Comparing these figures with the Experiment 1 English CC participants (adverb cue ($\beta = 0.97$, $p < .001$), verb cue ($\beta = 0.17$, $p < .001$)), they seem to be marginally less sensitive to the verbal cues, with the English β lying at the very top of the 95% CI for the same Chinese coefficient. Chinese participants were more reliant on the verb cue ($\beta = 0.93$, $p < .001$, 95% CI [0.84, 1.02]) than the adverb ($\beta = 0.21$, $p < .001$, 95% CI [0.12, 0.30]). Compared to the Chinese CC group, VG has thus changed their relative attention to cues, very much as it did for the Experiment 1 English VG participants (verb cue ($\beta = 0.95$, $p < .001$), adverb cue ($\beta = 0.21$, $p < .001$)).

As in Experiment 1, each participant's temporal rating responses for the strings in Phase 3 were correlated with the information provided by the verb cue and that separately provided by the adverb cue to determine the degree to which each participant was biased by each. Chinese CC participants were more influenced by the adverb (M = 0.67, 95% CI [0.55, 0.78]) than the verb (M = 0.05, [0.00, 0.11]) (compare English CC adverb M = 0.73, 95% CI [0.62, 0.83], verb M = 0.21, [0.14, 0.28]). In contrast, Chinese VG participants were more influenced by the verb (M = 0.59, 95% CI [0.45, 0.72]) than the adverb (M = 0.15, [-0.03, 0.26]) (compare English VG

participants verb (M = 0.80, [0.71, 0.89]) , adverb (M = 0.16, [0.10, 0.22]). A two factor ANOVA comparing Chinese CC vs. VG showed no overall effect of group (F [1,75] = 0.03, *ns*, $\eta^2 = 0.000$), a main effect of cue (F [1,75] = 5.14, $p < .05$, $\eta^2 = 0.038$), and a significant interaction of group and cue (F [1,75] = 41.88, $p < .001$, $\eta^2 = 0.244$), again showing that VG increased sensitivity to the verb cue in Chinese L1 learners.

Production data – Phase 4. The production data was expressed as proportion correct production for the adverb and verb separately. Chinese CC participants produced the adverb (M = 0.55, 95% CI [0.45, 0.65]) more reliably than the verb (M = 0.23, [0.17, 0.29]) (compare English CC M = 0.50, 95% CI [0.43, 0.57]), verb (M = 0.28, [0.22, 0.35]). Chinese VG participants produced the verb (M = 0.22, 95% CI [0.16, 0.29]) about as much as the adverb (M = 0.23, [0.13, 0.33]) (compare English VG verb M = 0.36, [0.30, 0.42]), adverb M = 0.29, [0.24, 0.34]). A two factor ANOVA comparing Chinese CC vs. VG showed a significant effect of group (F [1,75] = 11.62, $p < .01$, $\eta^2 = 0.09$), a main effect of cue (F [1,75] = 28.16, $p < .001$, $\eta^2 = 0.12$), and a significant interaction of group and cue (F [1,75] = 18.53, $p < .001$, $\eta^2 = 0.08$), showing that VG increased Chinese L1 learners ability to produce verbal inflections, although perhaps to a lesser degree than in English L1 learners – the Chinese and English VG verb production CIs do not overlap.

Eye-tracking data from the subset

Phase 2 Eye-tracking data Figure 10 shows the group mean fixation duration of the Chinese CC and VG participants as they were studying the adverb and verb cues during exposure to the Latin sentences in Phase 2. The data for English CC and VG participants from Experiment 2 are shown alongside for comparison. VG increases attention to the verb in both L1 groups.

Analysis of Variance (2 Groups [Chinese CC, Chinese VG] x 2 Cues with subjects nested within Groups) showed a significant effect of cue (F [1,29] = 27.01, $p < .001$, $\eta^2 = 0.133$), and a significant group x cue interaction (F [1,29] = 6.86 $p < .05$, $\eta^2 = 0.038$).

Figure 10 about here

Phase 2 Eye-tracking over trials Figure 11 shows the proportion fixation duration on each cue by trial of experience in the Chinese CC and Chinese VG groups under the English equivalent data from Experiment 2 for comparison. It can be seen that CC participants initially spend more time looking at the verb, but interest in this cue quickly wanes over trials, and this happens earlier than it does in the English CC participants. However, VG results in a clear and steady attention to the verb cue across trials in the Chinese L1 participants just as in the English L1 participants.

Figure 11 about here

Discussion

The behavioural data patterns for the Chinese L1 participants broadly follow those for the English ones. Chinese CC participants focus more upon the adverbial cue than the verbal cue in comprehension and production. They are marginally less sensitive to the verbal cues than are the English L1 group. Remember that all of these participants had since learned English as an L2 to a high level, yet still their L1 experience has marked enough effect to discriminate them for the English group in terms of sensitivity to verb morphology. VG increased Chinese L1 learners' ability to comprehend and to produce verbal inflections, although in absolute terms, perhaps to a lesser degree than in English L1 learners. The eye-tracking data showed that Chinese CC learners rapidly lose interest in the verb cue across trials, more so than do the English CC learners. VG FonF produces a clear and steady attention to the verb cue across trials in the Chinese L1

participants just as in the English L1 participants. Although VG prompts the Chinese L1 participants to attend the verb more during input processing, they do not acquire as much from this experience as do the English L1 participants.

Conclusions

These experiments lend further support to the idea that the limited attainment of adult second and foreign language learning follows general principles of associative learning and cognition. All three experiments demonstrated that under normal conditions (CC), adverbs were better learned than verb inflections. Replicating Ellis and Sagarra (2010a, 2011a), this effect was evidenced in both comprehension and production testing. We interpret it in terms of learner attention: (i) the relative salience, simplicity and reliability of adverb cues compared to verb inflections makes them intrinsically more learnable; (ii) adult language learners' prior knowledge of the use of adverb temporal references from their L1 results in long-term blocking – a learned attention effect. Pretraining on isolated verb cues (VP) reverses this bias. VP participants use verbal morphology more than adverbs in comprehension and are more able to produce inflections. Again, this replicates Ellis and Sagarra (2010a, 2011a) and demonstrates learned attention effects in the short-term of an experiment manipulating instructional sequence: Prior learning of one cue affects learner attention so that learners subsequently attend more to that cue.

Two other FonF manipulations similarly resulted in superior acquisition of verbal morphology. Early focusing of attention upon verbal morphology by means of a short grammar lesson, which explained how tense and person were encoded, resulted in better verb comprehension and production than both CC and VP groups. Likewise, making the verbal morphology salient by means of TE during exposure to input also improved later verb comprehension and production to the similar levels as VG, again superior to both CC and VP.

Of the three treatments, VP resulted in more balanced acquisition of both verbal and adverbial cues. We believe that this is because having learned to use the morphology, participants were next able to consider the role of adverbs too. This finding parallels others demonstrating that, in the early stages of acquisition from a problem space comprising multiple cues to interpretation, participants typically focus upon one cue at a time, exploring its utility and moving on to others later, one-by-one, as they reduce error of estimation (Cheng & Holyoak, 1995; MacWhinney, 1987; Matessa & Anderson, 2000; McDonald, 1986). VS learners were introduced to the verbal cues during the exposure phase, but still had to sort out how they function. VG learners were first provided with declarative statements about their function, but still had to put this knowledge to effect during phase 2. For these reasons, both VS and VG remained highly focused upon the morphological cues.

In our study here, Chinese L1 learners were especially insensitive to verbal morphology, less so than the English L1 group (as in Ellis and Sagarra, 2011). Nevertheless, VG increased Chinese L1 learners' ability to comprehend and to produce verbal inflections, albeit in absolute terms, to a lesser degree than in English L1 learners. The eye-tracking data showed that Chinese CC learners rapidly lose interest in the verb cue across trials, more so than do the English CC learners. In contrast, VG FonF produces a clear and steady attention to the verb cue across trials in the Chinese L1 participants just as in the English L1 participants. Although VG prompts the Chinese L1 participants to attend the verb more during input processing, they do not acquire as much from this experience as do the English L1 participants. So learned attention firstly makes FonF necessary for successful L2A of low salience, low contingency, or redundant cues, and secondly, it qualifies the rate of acquisition of these forms from subsequent experience of input.

Although in the present experiments, the three different FonF treatments were broadly equally effective in focusing learners' attention in subsequent input processing and in affecting

rate of acquisition from this experience, we do not believe that this will necessarily be true for all linguistic constructions. As the recasts literature shows, different forms will require different levels of explicitness and explanation (Long, 2006; Spada & Tomita, 2010). Additionally, as recent research by Tolentino and Tokowicz (2014) highlights, L1-L2 similarity along with the type of instructional method will also play a role in the learning of L2 morphosyntax. They found that in the case of dissimilar L1-L2 morphosyntactic features, that are common to both languages but differ in the way they are represented (e.g., noun phrase definiteness in English and in Swedish), input enhancement was effective in improving learners' performance in subsequent posttests. However, in the case of unique features to the L2, input enhancement along with a metalinguistic explanation proved to be more beneficial.

Eye-tracking elucidated the attentional processes whereby the different types of FonF instruction affected attention to morphological cues in the input processing in Phase 2. All FonF treatments (VG, VS and VP) led to significantly more scrutiny of the verbs during Phase 2 processing than in CC. The correlational analyses showed that the relative amount of time spent attending the verb/adverb cues during input processing was positively related to cue usage in later comprehension and production. In early trails of experience, CC participants fixated both cues, but soon came to preferentially attend to adverbial cues. However, if the functions of verb inflections have already been explained (VG), or if the verbal inflections were made more salient with TE during exposure (VS), or if participants were pretrained on verbal cues in non-redundant situations (VP), then learners attended to verbal morphology more from the outset, and continued to focus more upon these cues over trials of experience, with if anything this bias increasing over time in the VG group.

Ellis (2005) reviewed aspects of the explicit-implicit interface whereby explicit FonF instruction might encourage subsequent use of a cue in processing: "Once consolidated into the

construction, it is this new cue to interpretation of the input whose strengths are incremented on each subsequent processing episode. The cue does not have to be repeatedly noticed thereafter; once consolidated, mere use in processing for meaning is enough for implicit tallying. A natural corollary is that if explicit knowledge is to be effective, it must be provided before relevant input that exemplifies it" (Ellis, 2005, p. 324). So, FonF instruction attempts to guide attention to cues over repeated episodes of the processing of usage.

In terms of the psychological interface between explicit knowledge and processing, the behavioral data in our experiments demonstrate that FonF indeed causes learning to occur, and the eye-tracking data show that the different FonF treatments achieve this because there is greater overt attention on the verbal morphological cues on each experience of usage. Does this overt attention reflect explicit or implicit learning? While we believe fixations reflect attention, we do not equate them with noticing, nor awareness. Without additional data which taps conscious awareness, we cannot tell. Eye-movements can reflect conscious control, and we suspect that this is what is happening in early trials. On the other hand, eye-movements in fluent reading are unconscious and automatically guided behaviors. The fixation times across trials shown in Figure 8 look very much like classical learning curves, and it is plausible that automatization and proceduralization is happening over usage experience (DeKeyser, 2001, 2007; Segalowitz, 2010). Perhaps by the end of Phase 2, attention to these cues is automatic. Whatever tallying that is taking place is surely implicit. These questions warrant future research with introspective and neuroimaging techniques. At least, the current research demonstrates the effects of FonF on trial-by-trial retuning of attention.

In terms of the educational interface between explicit knowledge and processing, these findings broadly confirm the mechanisms suggested by Terrell (1991) regarding EGI to increase the salience of inflections and other commonly ignored features by firstly pointing them out and

explaining their structure, and secondly by providing meaningful input that contains many instances of the same grammatical meaning-form relationship. In terms of the dynamics of the interface, the new cue must be integrated into the processing of these instances. If successfully achieved, thereafter the new cue has its strengths incremented on each subsequent processing episode.

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Table 1

The design of Phases 1-3 of Experiment 1

Phase 1: Pretraining (+ feedback) 36 randomized trials	Phase 2: Sentence decoding (+ feedback) 36 (18 × 2) randomized trials	Phase 3: Reception testing (- feedback) 66 randomized trials
Control group No pretraining	Present *Hodie cogito* *Hodie cogitas* *Hodie cogitat* *Cogito hodie* *Cogitas hodie* *Cogitat hodie* Past *Heri cogitavi* *Heri cogitavisti* *Heri cogitavit* *Cogitavi heri* *Cogitavisti heri* *Cogitavit heri* Future *Cras cogitabo* *Cras cogitabis* *Cras cogitabit* *Cogitabo cras* *Cogitabis cras* *Cogitabit cras*	Stimulus — Semidiem *Hodie* 3 *Heri* 1 *Cras* 5 *Cogito/as/at* 3 *Cogitavi/visti/vit* 1 *Cogitabo/bis/bit* 5 *Hodie cogito/as/at* 3 *Hodie cogitavi/visti/vit* 2 *Hodie cogitabo/bis/bit* 4 *Heri cogito/as/at* 2 *Heri cogitavi/visti/vit* 1 *Heri cogitabo/bis/bit* 3 *Cras cogito/as/at* 4 *Cras cogitavi/visti/vit* 3 *Cras cogitabo/bis/bit* 5 *Cogito/as/at hodie* 3 *Cogitavi/visti/vit hodie* 2 *Cogitabo/bis/bit hodie* 4 *Cogito/as/at heri* 2 *Cogitavi/visti/vit heri* 1 *Cogitabo/bis/bit heri* 3 *Cogito/as/at cras* 4 *Cogitavi/visti/vit cras* 3 *Cogitabo/bis/bit cras* 5
Verb Grammar group Brief Grammar Lesson see Figure 1.		
Verb Salience group No pretraining		
Verb Pretraining group *Cogito* "I think" *Cogitas* "you think" *Cogitat* "X thinks" *Cogitavi* "I thought" *Cogitavisti* "you thought" *Cogitavit* "X thought"		

Note: The Semidiem is the average time reference of the stimulus items. See Method for details.

Table 2

Regression Analyses Predicting Mean Temporal Interpretation Across the 54 Two-Word Strings in Phase 3 as a Function of Adverbial and Verb Inflectional Cue Information in each of the Four Groups

Group	Cue	β	95% CI	Adjusted R^2	F
Control	Adverb	.97***	[0.91, 1.02]	.96	654***
	Verb	.17***	[0.12, 0.22]		
Verb Grammar	Adverb	.21***	[0.18, 0.23]	.99	2528***
	Verb	.95***	[0.92, 1.00]		
Verb Salience	Adverb	.14***	[0.10, 0.18]	.98	1246***
	Verb	.98***	[0.94, 1.02]		
Verb Pretraining	Adverb	.58***	[0.52, 0.63]	.96	699***
	Verb	.79***	[0.74, 0.84]		

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

Table 3

Mean Participant Performance of the Four Groups of Experiment 1

L1 Group	Cue	Mean	95% CI
Correlations of participant rating with cue across strings of Phase 3			
Control	Adverb	0.73	[0.62, 0.83]
	Verb	0.21	[0.14, 0.29]
Verb Grammar	Adverb	0.16	[0.10, 0.22]
	Verb	0.80	[0.71, 0.89]
Verb Salience	Adverb	0.13	[0.08, 0.19]
	Verb	0.70	[0.60, 0.80]
Verb Pretraining	Adverb	0.45	[0.37, 0.53]
	Verb	0.61	[0.52, 0.70]
Accuracy of production of cue in Phase 4			
Control	Adverb	0.50	[0.43, 0.57]
	Verb	0.28	[0.22, 0.35]
Verb Grammar	Adverb	0.29	[0.24,0.34]
	Verb	0.36	[0.30,0.42]
Verb Salience	Adverb	0.31	[0.25,0.38]
	Verb	0.39	[0.33,0.46]
Verb Pretraining	Adverb	0.47	[0.40,0.55]
	Verb	0.52	[0.46,0.58]

Note: CI = confidence interval

Table 4

Mean Participant Fixations on the Adverb and Verb Cues by the Four Groups of Experiment 2

L1 Group	Cue	Mean	95% CI
		Mean Total Fixation duration (ms.)	
Control	Adverb	680	[347,1012]
	Verb	963	[532,1394]
Verb Grammar	Adverb	741	[300,1182]
	Verb	1579	[793,2365]
Verb Salience	Adverb	403	[56,750]
	Verb	1085	[589,1581]
Verb Pretraining	Adverb	526	[274,778]
	Verb	1116	[797,1437]
		Mean Proportion Fixation time	
Control	Adverb	0.59	[0.52, 0.67]
	Verb	0.41	[0.33, 0.48]
Verb Grammar	Adverb	0.68	[0.59,0.78]
	Verb	0.32	[0.22,0.41]
Verb Salience	Adverb	0.74	[0.58,0.91]
	Verb	0.26	[0.09,0.42]
Verb Pretraining	Adverb	0.68	[0.56,0.80]
	Verb	0.32	[0.20,0.44]

Note: CI = confidence interval

1

In this section, you will be presented a short grammar lesson on Latin verb structure. The information in this lesson will help you answer the questions that will appear later in the experiment. You are encouraged to take as much time as you like to study the lesson, but be aware that once you advance to the next page you will not be able to go back.

2

A Latin verb consists of 3 parts:

1. **The stem**, which tells you what verb it is (for example, "to eat" or "to love")

2. **The tense marker**, which tells you when the action of the verb takes place (past, present, or future)

3. **The agreement marker**, which tells you who performs the action (first, second, or third person)

STEM + TENSE MARKER + AGREEMENT MARKER

3

Breakdown of the three parts of a verb:

STEM + TENSE MARKER + AGREEMENT MARKER

Such a verb might look like this:

verbavi

With the first part telling you **what** the action is, the second part telling you **when**, and the third part telling you **who**.

4

A verb can appear in any combination of past, present, or future, and first, second, or third person.

	Past	Present	Future
First Person	**verbavi**	**verbo**	**verbabo**
I	I verbed	I verb	I will verb
Second Person	**verbavisti**	**verbas**	**verbabis**
You	You verbed	You verb	You will verb
Third Person	**verbavit**	**verbat**	**verbabit**
He/She	He verbed	He verbs	He will verb

While different verbs differ in their stems, these endings apply to all verbs.

Figure 1. Grammar Lesson Slides for Grammar Instruction Condition.

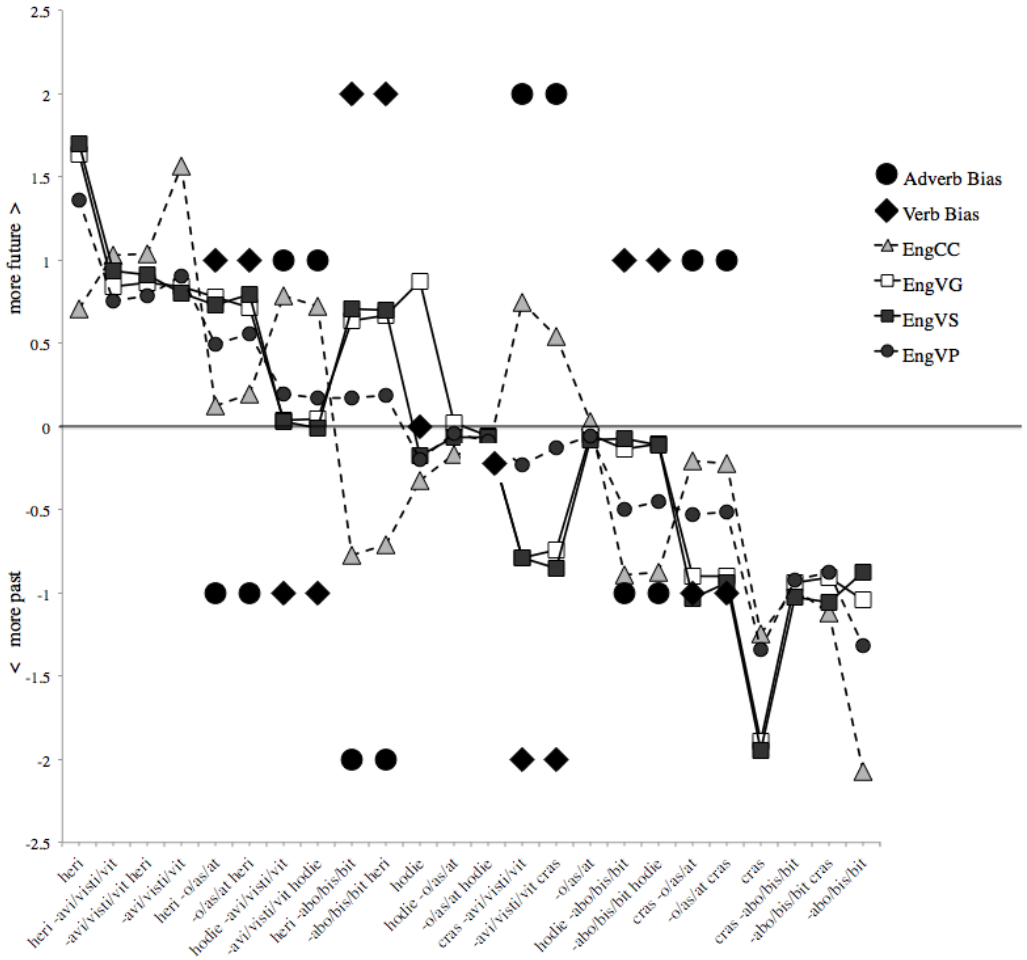


Figure 2. Mean deviations of Phase 3 temporal interpretations from semidiem average. Bias symbols mark the deviation of the adverbial cues (circles) and verb inflection cues (diamonds) when these cues conflict.

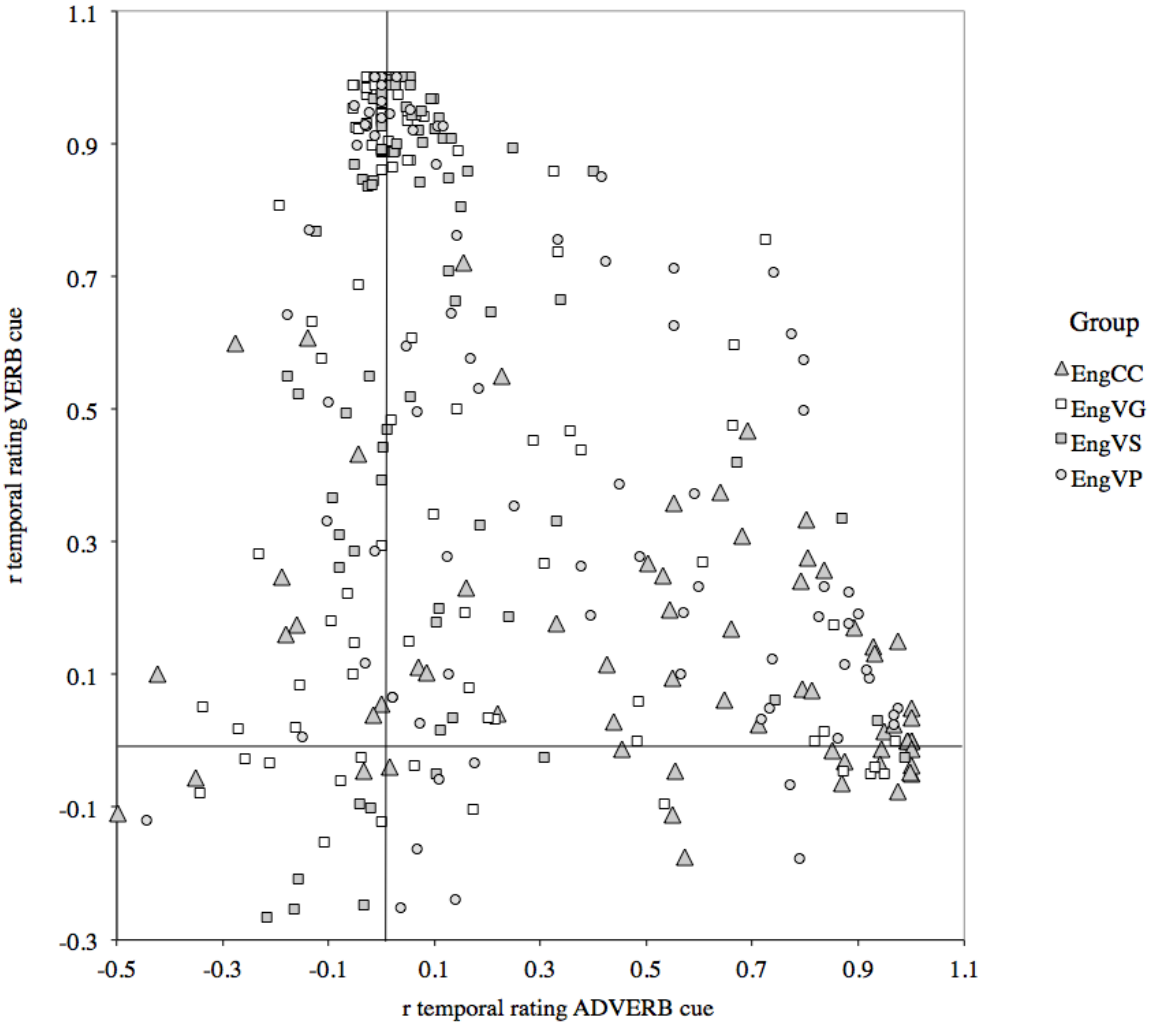


Figure 3. Sensitivity to adverbial and verbal inflectional cues to temporal reference in each participant.

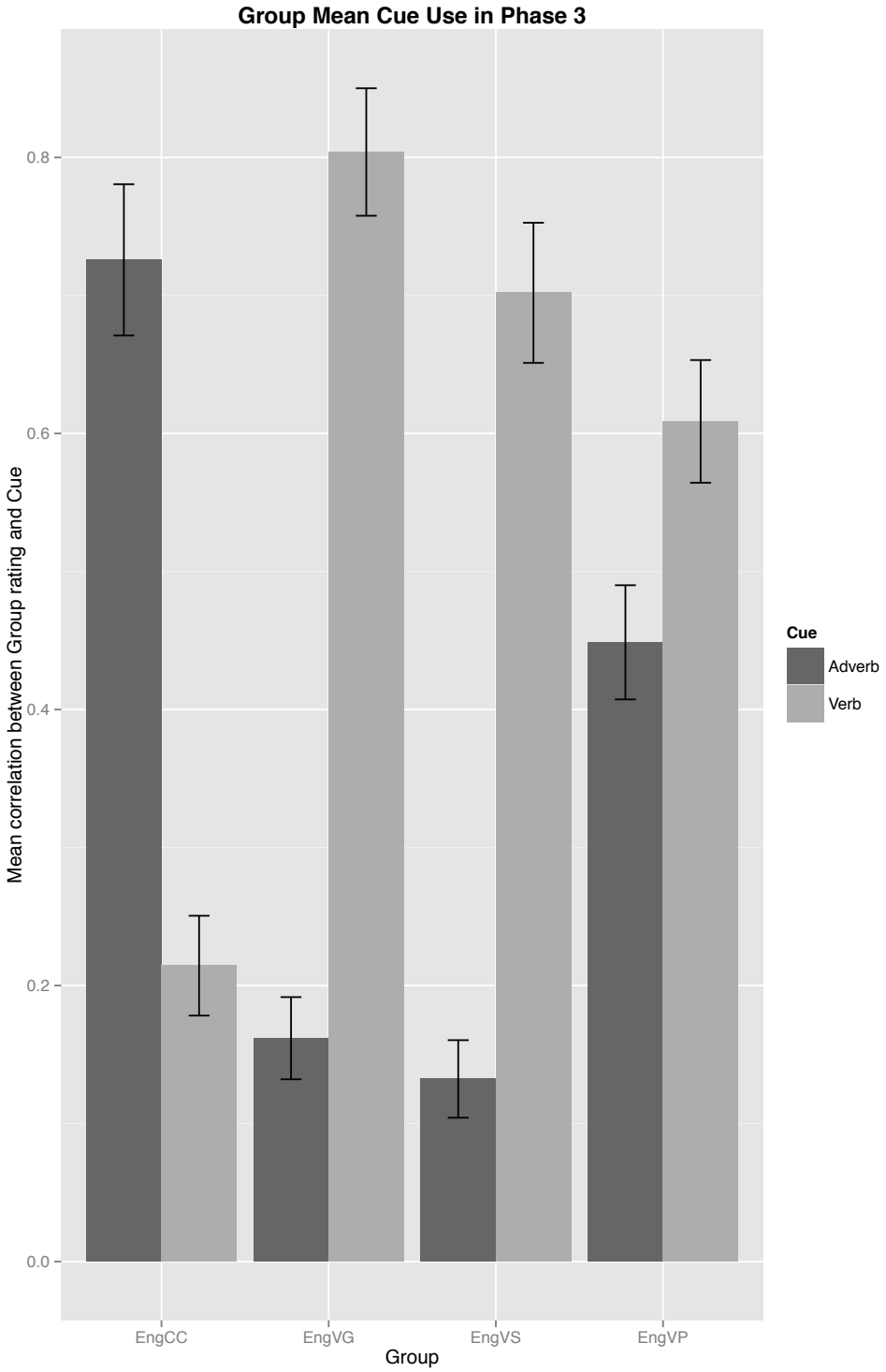


Figure 4. Group mean correlations between individual participants' Phase 3 sentence ratings and the information given by the corresponding adverb and verb cues. Error bars are 2 standard errors long.

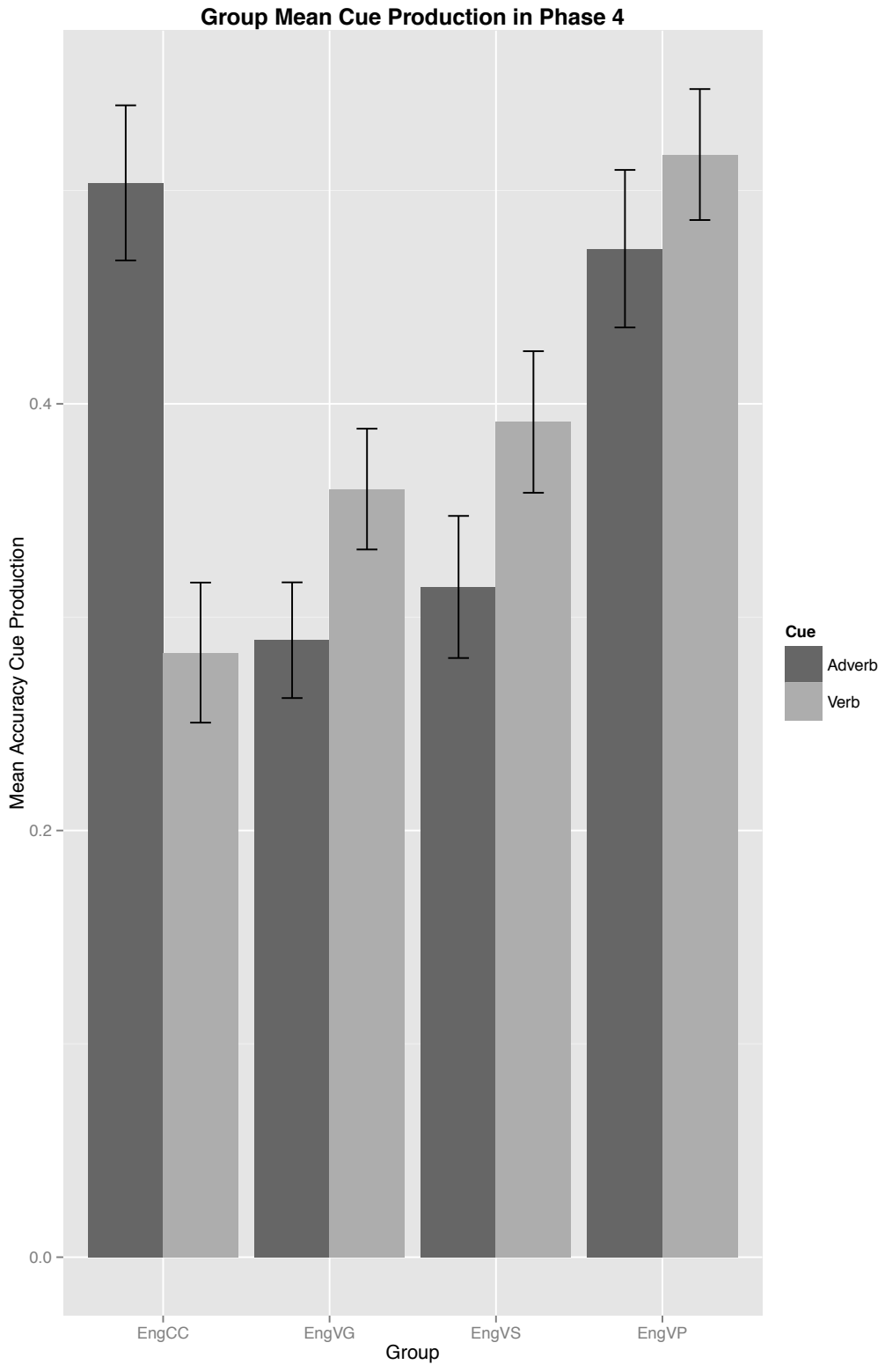


Figure 5. Group mean production scores for adverb and verb cues. Error bars are 2 standard errors long.

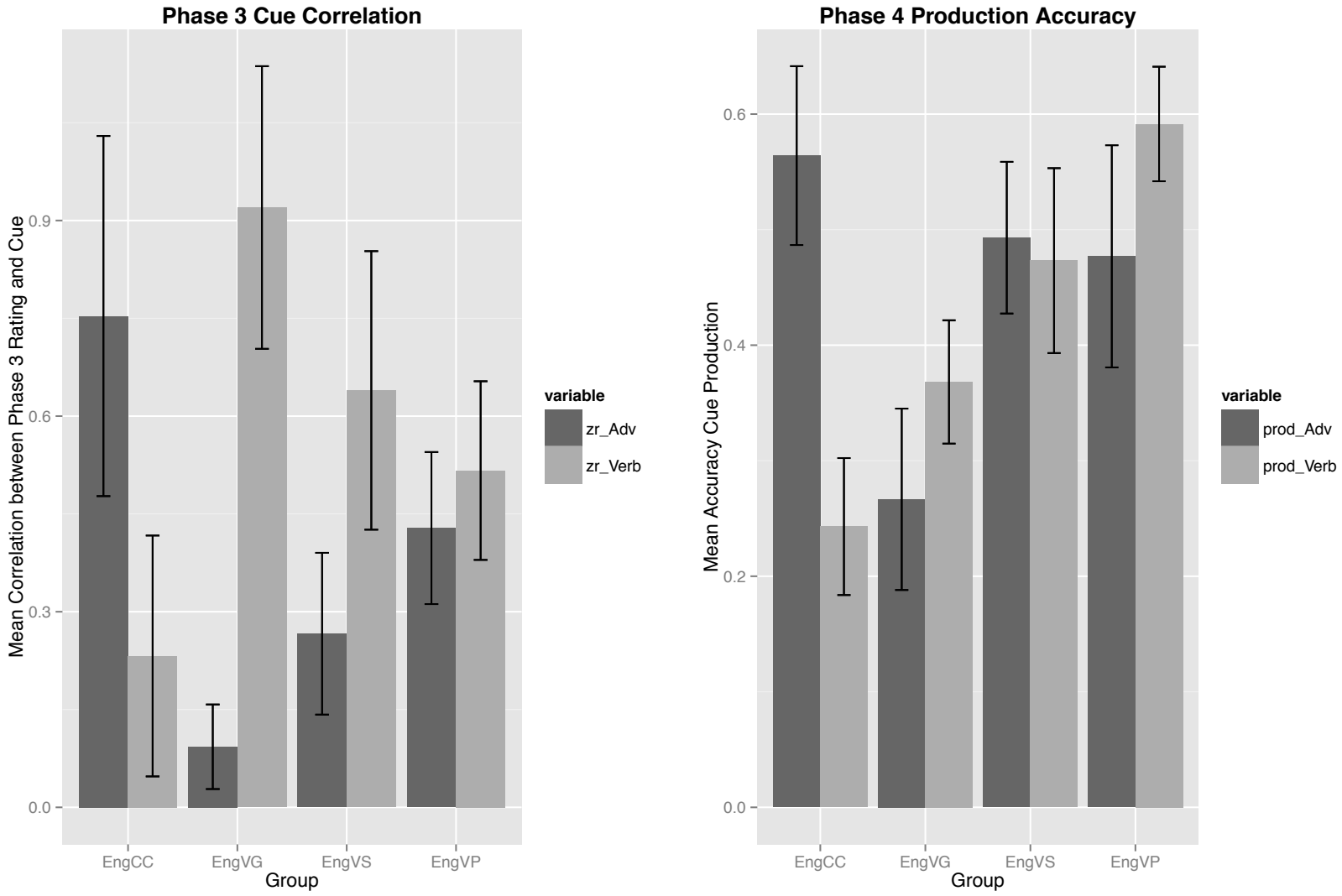


Figure 6. Experiment 2 Group mean correlation and production accuracy for adverb and verb cues. Error bars are 2 standard errors long.

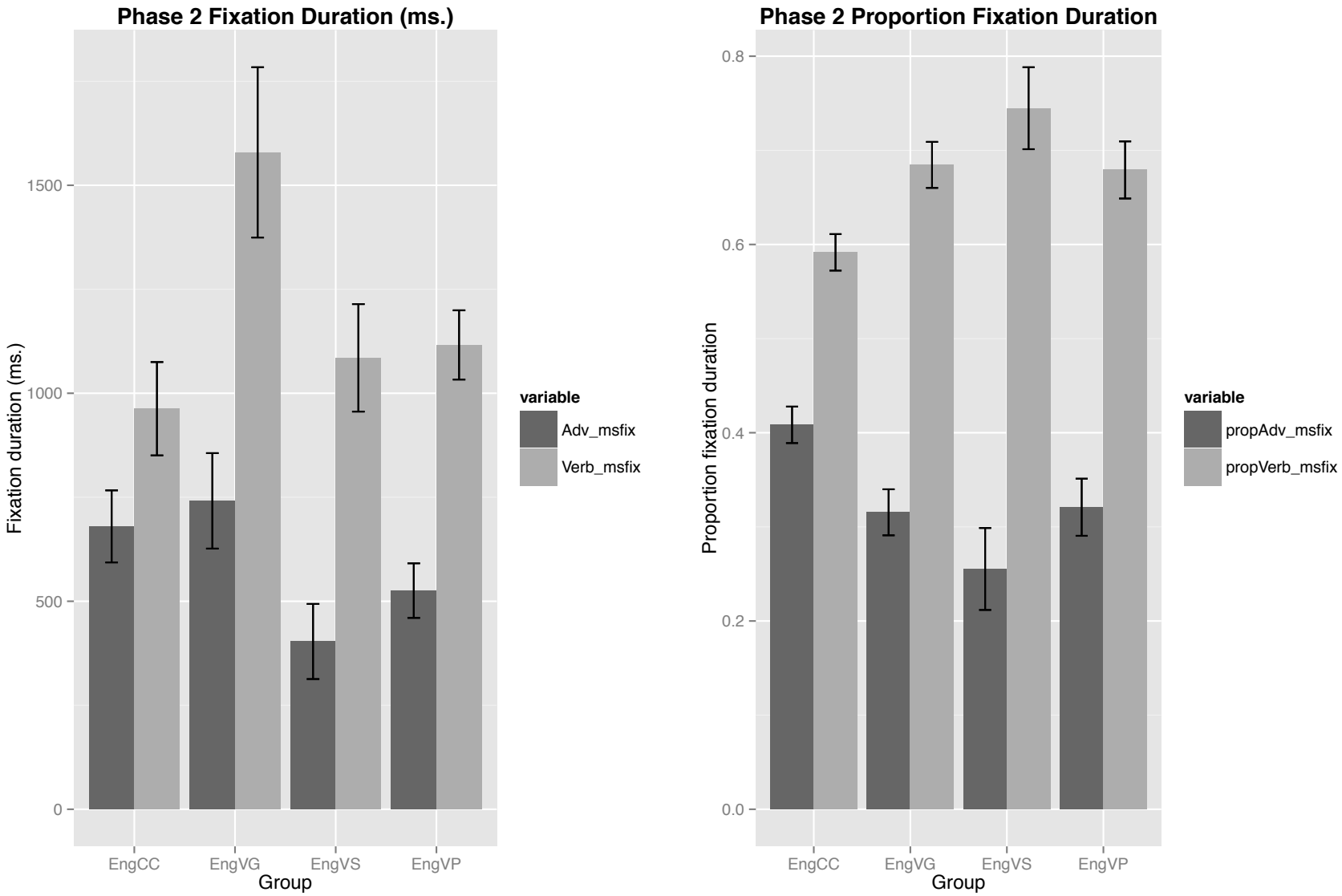


Figure 7. Mean Group Fixation Duration on the Adverb and Verb cues in Exposure Phase 2. Error bars are 2 standard errors long.

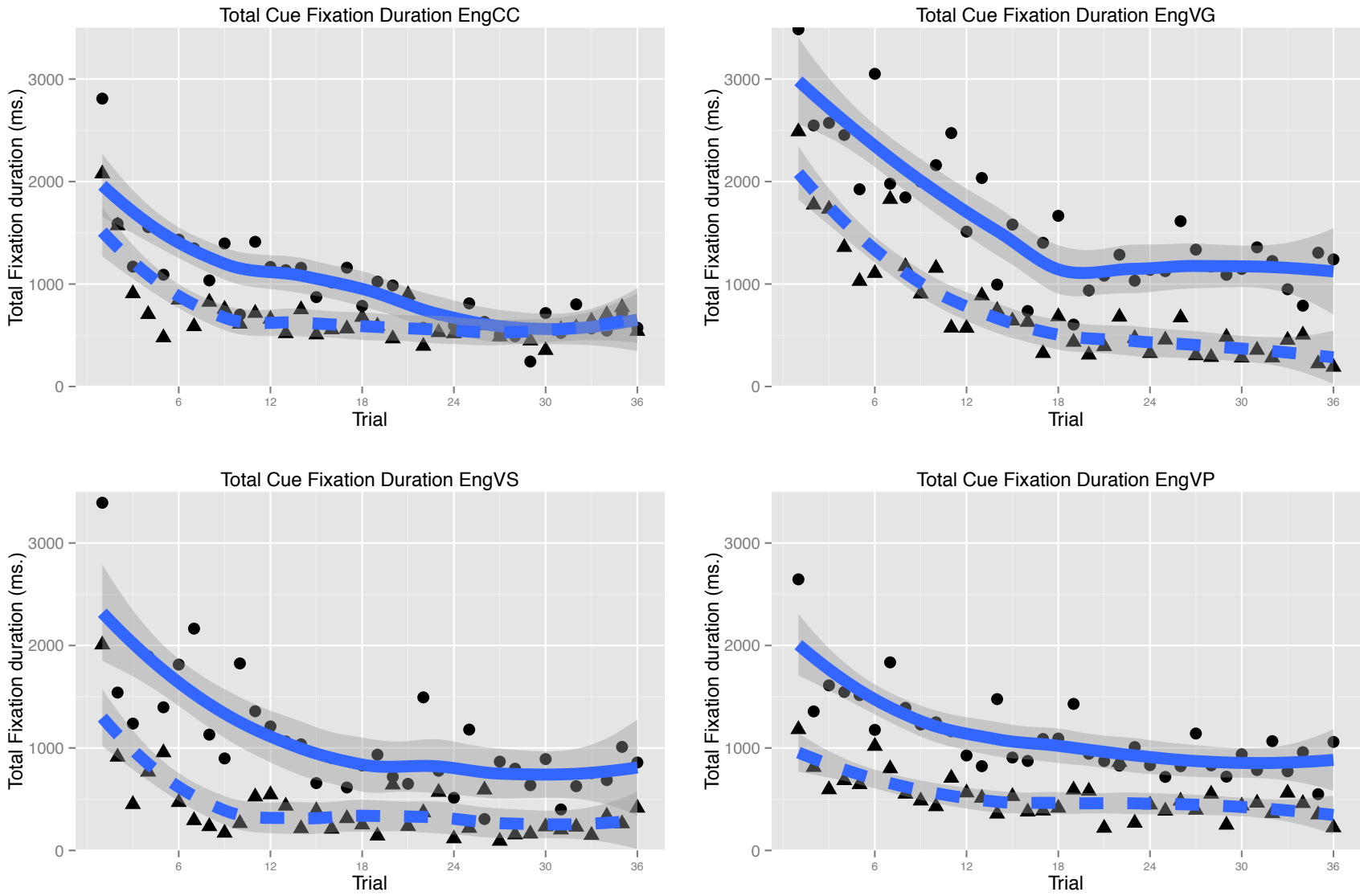


Figure 8. Mean Fixation Duration on the Adverb and Verb cues Over Trials (Solid line/circles Verb, Dotted line/triangles Adverb).

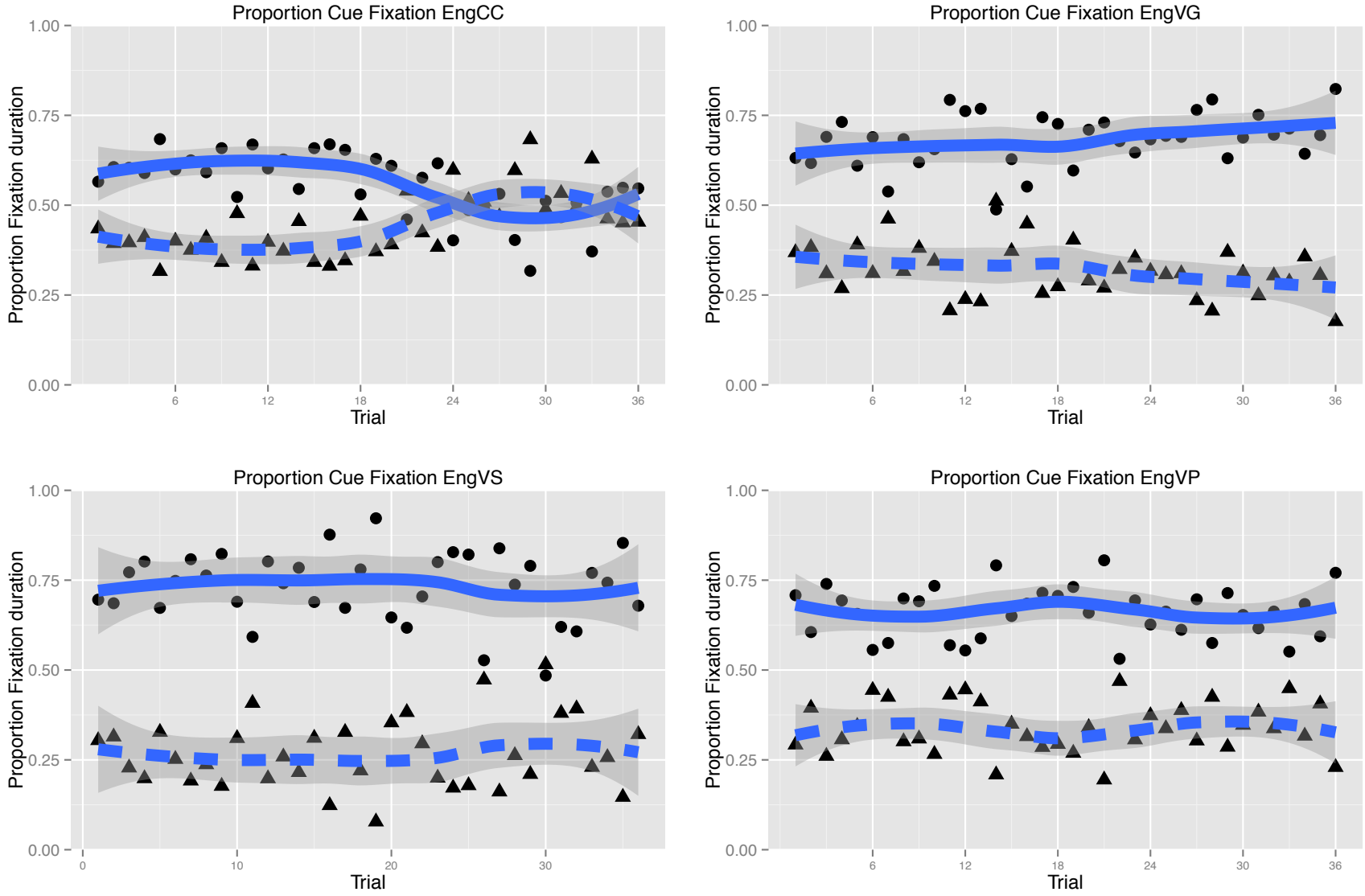


Figure 9. Mean Proportion Fixation on the Adverb and Verb cues Over Trials (Solid line/circles Verb, Dotted line/triangles Adverb).

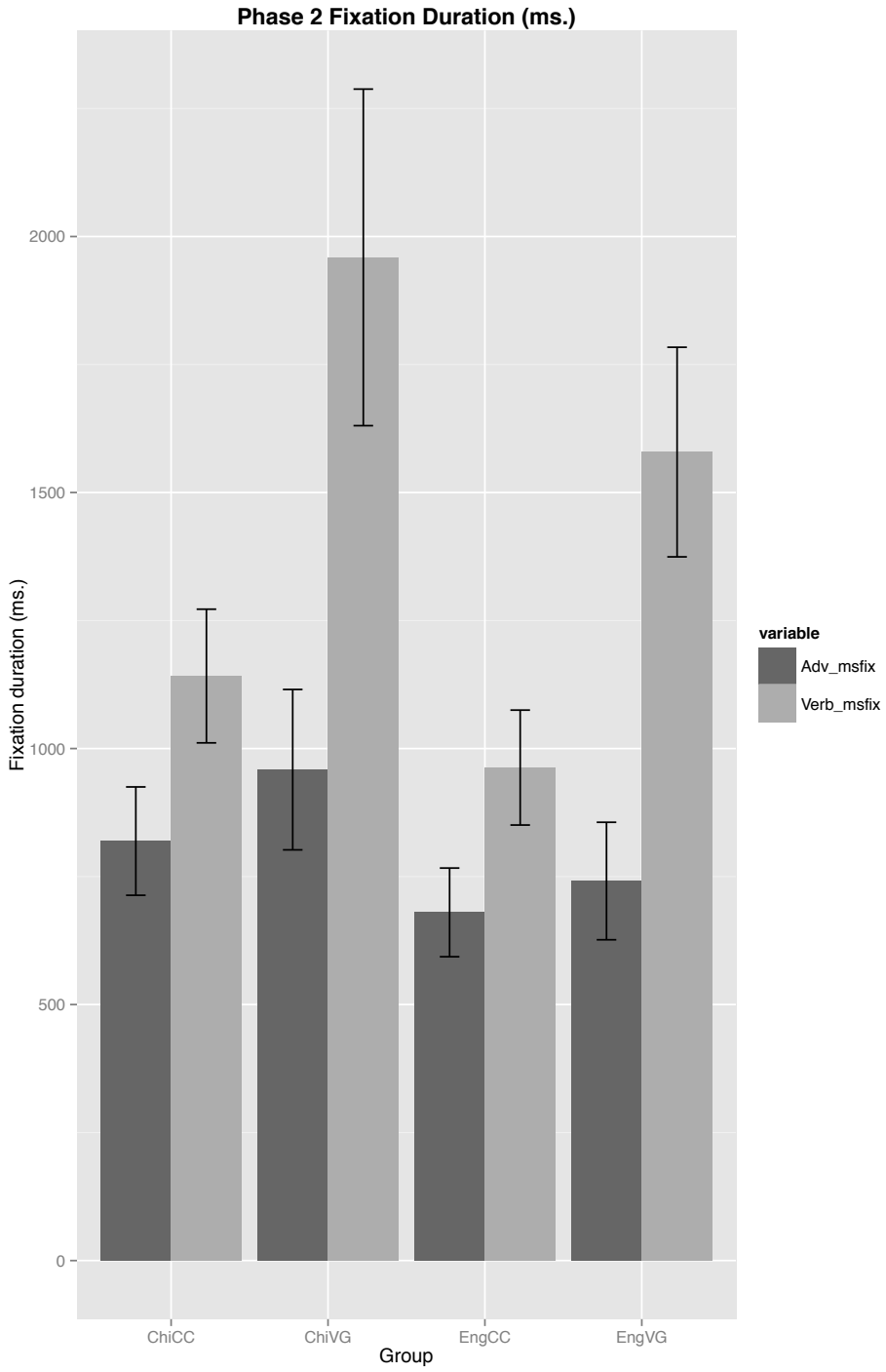


Figure 10. Mean Group Fixation Duration on Adverb and Verb cues in Exposure Phase 2 for Chinese CC and VG participants alongside English CC and VG participants from Experiment 2. Error bars are 2 standard errors long.

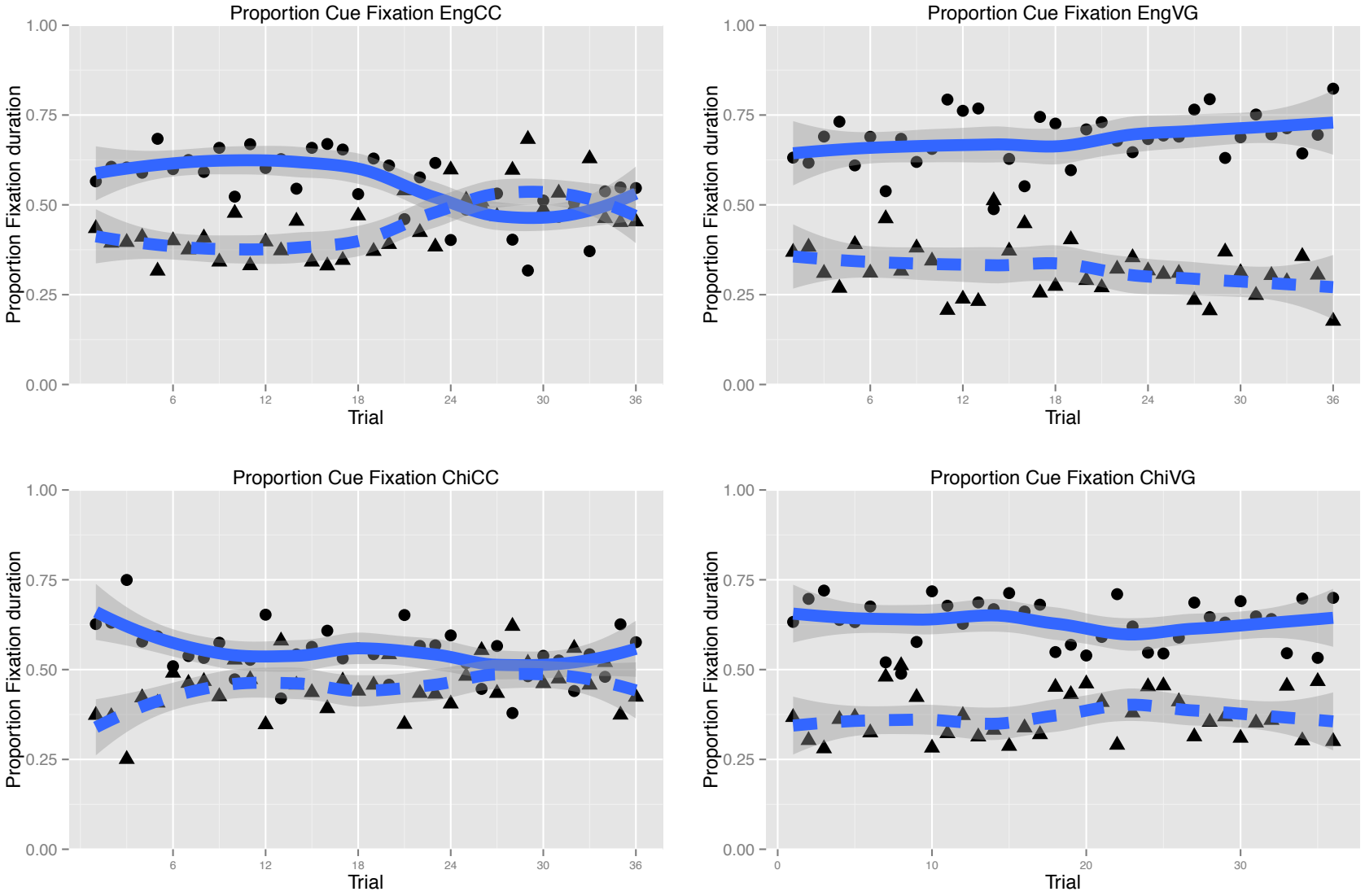


Figure 11. Mean Proportion Fixation for English (top) and Chinese (bottom) on the Adverb and Verb cues Over Trials (Solid line/circles Verb, Dotted line/triangles Adverb)