Blocking and Learned Attention in Language Acquisition

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Abstract

Adult language acquisition typically falls far short of nativelike competence. Various explanations have been proposed for this limited attainment of adults compared to children, including critical periods for language acquisition, sociocultural differences, motivational differences, and restricted input. This paper considers an alternative explanation in terms of the associative learning phenomenon of the attentional blocking of later experienced cues by earlier learned ones. It illustrates this phenomenon in investigations of learned attention in the acquisition of temporal reference in a small subset of Latin under experimental conditions. Within the experiment, early experience of adverbial cues blocked the acquisition of verbal tense morphology, and, contrariwise, early experience of tense blocked later learning of adverbs. There were also long-term language transfer effects: first language speakers of Chinese languages, which do not exhibit verb tense morphology, failed to acquire inflectional cues when adverbial and verbal cues were equally available.

Keywords: Second language acquisition; attention; blocking; language learning; transfer; tense morphology; time reference.

Cues in First and Second Language Acquisition

Languages allow the same idea to be expressed in a variety of ways. Consider time, a concept fundamental to human cognition and action. All languages have rich means to express the position of events in a time line; they variously utilize tense (verbal inflectional morphology, e.g. *walked* vs. *walk*), lexical adverbs (e.g. *now*, *next*, *yesterday*, *tomorrow*), prepositional phrases (*in the morning*, *in the future*), serialization (presenting events in their order of occurrence), and calendric reference (*May 12*, *Monday*). Any stretch of discourse typically uses a variety of these cues in combination (e.g. *yesterday I walked to the university but next Tuesday I'll ride the bus*).

Children acquiring their first language (L1) eventually learn all of these constructions for expressing time. Adults learning a second language (L2) naturalistically typically do not. Uninstructed L2A from usage is limited in its end-state, with naturalistic or communicatively-based L2A stabilizing at levels far short of nativelike ability at a 'Basic Variety' of interlanguage which, although sufficient for everyday communicative purposes, predominantly comprises just nouns, verbs and adverbs, with closed-class items, in particular grammatical morphemes and prepositions, being rare, if present at all. There is typically no functional inflection: no tense, no aspect, no mood, no agreement, no casemarking, no gender assignment (Klein, 1998). L2 temporal reference is initially made exclusively by use of devices such as temporal adverbials, prepositional phrases, serialization, and calendric reference, with the grammatical expression of tense and aspect emerging only slowly thereafter, if at all (Bardovi-Harlig, 2000).

One likely explanation for this is the salience of the formal cues. Prepositional phrases, temporal adverbs, and other lexical cues to time are quite pronounced in the speech stream. Verbal inflections are not (consider *yesterday I walked*). Zipf's (1949) principle of least effort describes how frequent words become shorter with use. Speakers want to minimize articulatory effort and hence encourage brevity and phonological reduction. The more they use the more frequent words, automatization of production causes shortening. The most frequent items of language are the closed class words and grammatical morphemes, hence it is these items that are the least salient in the speech stream and, because shorter words tend to be more homophonous, they are also more ambiguous in their interpretations. The low salience and low reliability of grammatical cues tends to make them less learnable (Ellis, 2006).

But salience and reliability affect L1A and L2A alike. There has to be something else which explains the limited endstate of L2A. The classic explanations center upon a critical period for language acquisition, with adult brains being less capable of language learning (perhaps because they no longer have access to universal grammar), or upon social interactional factors (adults are less immersed in the L2, their language development is less scaffolded by their interlocutors). This paper describes experiments exploring a competing line of explanation in terms of standard associative learning effects of 'learned attention': blocking, overshadowing, and other effects of transfer and inhibition that shift learners' attention to language as a result of language experience.

Kruschke and Blair (2000) describe the associative learning phenomenon of blocking. Learning that a particular stimulus (A) is associated with a particular outcome (X), makes it harder to learn that another cue (B), subsequently paired with that same outcome, is also a good predictor of it, as schematized in Figure 1. Thus, for example, someone who knows that the rooster's crowing signals dawn may be less likely to notice that increasing traffic noise can reliably be used as a sign of wake-up-time than is someone who hasn't been exposed to the animal's alarm.

Blocking is an effect of learned attention. For those who previously learned that "A" predicts "X", "B" is merely distracting them from a perfectly predictive symptom. To avoid this error-inducing distraction, they shift their attention away from cue "B" to cue "A", and consequently

learn only a weak association from "B" to "X". They also learn that when symptoms "B" and "A" appear together, "B" should be ignored and "A" should be attended to, i.e., symptom "B" should be attentionally blocked.

Learning Phase	**Cue⇒Outcome**
Early training	A⇒X
Late training	A&B⇒X C&D⇒Y
Test	B&D⇒? (preferred response is Y)

Figure 1: Blocking

When children are learning their native language they are at the same time learning about the world and about various discourse strategies. Young children do not yet know about the custom of recounting events in their usual script order of occurrence nor do they clearly understand the meaning of temporal adverbs. Adults however, as a result of their L1 experience, do know these things; they know there are reliable and salient means of expressing past time (e.g. *yesterday*) that are far simpler than the non-salient and ambiguous morphological means which vary in complex ways by person and number, etc. Perhaps these already known cues block the acquisition of temporal morphology. On hearing *yesterday I walked*, the morphological tense marker is redundant; successful interpretation of the message does not require its processing, and lack of processing entails lack of acquisition. Similarly, if a learner knows the French word for yesterday, then in the utterance *Hier nous sommes allés au cinéma* (Yesterday we went to the movies) both the auxiliary and past participle are redundant past markers.

It is not just tense that is subject to such effects. Inflexions for number are often overshadowed by the more obvious plurality of the clear subject of the verb (*seven cats run down the road*, *the black cat runs down the road*. Naturalistic L2 learners, but not instructed learners, tend to omit plural *–s* endings on nouns that are premodified by quantifiers. This nonredundant marking of plurality is characteristic of L2 learners and pidgin speakers alike. There are many such examples. Thus second language acquisition seems a problem space that is particularly susceptible to effects of blocking and overshadowing. This paper explores these phenomena in two language learning experiments. The first investigates short-term instructional sequence effects in adults learning temporal reference in Latin. The second explores long term language transfer effects whereby the nature of the learners' L1 (+/- verb tense morphology) biases the acquisition of verbal inflectional vs. lexical cues to temporal reference in Latin.

Experiment 1

Experiment 1 involves the learning of a small number of Latin expressions and their English translations. It investigates the effects of successive learning of different types of cue for temporal reference, adverbs (*hodie*, today; *heri*, yesterday; *cras*; tomorrow) and verbal inflections (*cogito*, I think; *cogitavi*, I thought; *cogitabo*, I will think). It determines if the acquisition of one set of cues is impaired if another is already known as a reliable indicator of event time.

Participants

Participants were students from the University of Michigan. They were volunteers and were paid $10 for their participation in the experiment. None had learned Latin before. They were randomly allocated to one of three conditions. The Adverb Pretraining group comprised 10 males and 12 females of age range 19-35 (mean 21.7 years), native languages 19 English, 2 Chinese, 1 Korean. The Verb Pretraining group comprised 8 males and 13 females of age range 18-33 (mean 21.8 years), native languages 18 English, 3 Chinese, 1 Russian. The No Pretraining control group comprised 10 males and 12 females of age range 18-33 (mean 21.0 years), native languages 18 English, 4 Chinese.

Procedure

The experiment was programmed in E-Prime. It took less than one hour. It comprised three phases, Phase 1 – Pretraining, Phase 2 – Sentence decoding, Phase 3 – Reception testing. The procedure is schematized in Figure 2.

Participants in the Adverb Pretraining condition in Phase 1 had 36 randomized trials where they saw either the adverb *hodie* or the adverb *heri*. Note that Phase 1 involved only present and past temporal reference, no future. The participants had to choose whether *today* or *yesterday* was the correct translation by clicking the appropriate alternative with the mouse. These alternatives appeared in counterbalanced positions on the screen. A correct choice returned the feedback 'Correct', an incorrect one 'Wrong – the meaning of [Latin] is [English]' with these slots filled appropriately. After this, in Phase 2 they were exposed to 6 sentences which appropriately combined the adverb with a verb, three in adverb-verb word order and three in verb-adverb, and had to choose whether these sentences referred to the present, the past, or the future. There were six blocks of these trials to consolidate learning. Again, they were given feedback if incorrect. Following the lead of Competition Model studies of cue use (MacWhinney, 1987), in the Reception test, Phase 3, all combinations of adverb (*hodie*, *heri*, *cras*) and verb tense marking (*cogito*, *cogitavi*, *cogitabo*) were combined and the participants were asked to judge whether each sentence referred to the past, present, or future on a 5 point scale ranging from extreme past 1, through present 3, to extreme future 5. The ideal responses which averaged over the cues present in the sentence are shown on the right hand side of the Phase 3 panel of Figure 2.

There was no feedback in Phase 3. Both permissible word orders were tested and the block was repeated twice to allow reliable assessment of the relative weight that learners put on interpreting adverbial and inflectional cues to temporal

CONDITION	PHASE 1 Pretraining (+ feedback)	PHASE 2 Sentence Decoding (+ feedback)	PHASE 3 Reception testing (- feedback)
ntrials	36 randomised	36 (these x 6 = 3 x 12) randomised in blocks	48 (24 x 2) randomised in blocks
Adverb Pretraining condition	hodie today heri yesterday	hodie cogito present cogito hodie present heri cogitavi past cogitavi heri past cras cogitabo future cogitabo cras future	Test with Past….Present….Future 1….2…..3…..4…..5 hodie 3 heri 1 cras 5 cogito 3 cogitavi 1 cogitabo 5 hodie cogito 3 hodie cogitavi 2 hodie cogitabo 4 heri cogito 2 heri cogitavi 1 heri cogitabo 3
Verb Pretraining condition	cogito I think cogitavi I thought		Test with Past….Present….Future 1….2…..3…..4…..5 cras cogito 4 cras cogitavi 3 cras cogitabo 5 cogito hodie 3 cogitavi hodie 2 cogitabo hodie 4 cogito heri 2 cogitavi heri 1 cogitabo heri 3 cogito cras 4 cogitavi cras 3 cogitabo cras 5
Control	No phase 1		

Figure 2: The design of Experiment 1

reference. The accuracy of learner responses on the adverbs and verbs reflected the relative degree of their learning of these temporal reference cues from their language experiences in the earlier phases. In this Adverb Pretraining condition, any blocking would evidence itself as a detrimental effect of prior learning of lexical cues to time upon later learning of inflectional cues.

Participants in the Verb Pretraining condition underwent identical Phase 2 – Sentence decoding, Phase 3 – Reception testing to the above. The only difference concerned Phase 1 where instead of the adverbial cues to tense, they were exposed to the inflectional cues. For these participants, blocking would show itself as detrimental effects of early exposure to the inflectional cues reducing learning from later experience of the adverbial cues.

Participants in the No Pretraining condition had no Phase 1, and so they first met the adverbial and inflectional cues to tense simultaneously in Phase 2 and had to induce their meanings. They underwent identical Phase 3 – Reception testing to the above.

The dependent variables were accuracy and latency of responding. Comparisons between and across the learners in the three conditions illustrate whether first learned cues block those experienced subsequently and also the degree to which more salient lexical cues overshadow less obvious morphological ones.

Results

Despite having no pretraining, Control condition learning of the temporal reference of the sentences as a whole in Phase 2 was much the same as it was in the Adverb and Verb Pretraining groups. By the second half of Phase 2, Control performance was 87% correct compared to 97% for both the Adverb and Verb Pretraining conditions.

However, participants in these three groups were very different in the particular cues they used in understanding the sentences of Phase 2, and from this usage, learned to attend subsequently as important communicators of temporal information. The key to their cue use is their performance in Phase 3. Figure 3 illustrates the average group understanding of the time referred to by each of the constructions of Phase 3 in terms of the deviations from ideal interpretation shown in the right column of Phase 3 Figure 2. The sentences are ordered from extreme past on the left to extreme future on the right. It can be seen in Figure 3 that the three groups react to the cues present in the sentences of Phase 3 in very different ways. In two word sentences, where there is temporal information cued by both an adverb and a verbal inflection, when these cues deviate, the Verb pretraining group follows the verbal cue and the Adverb pretraining group follows the adverbial cue, so that these two groups move in opposite directions, as one leans to the future so the other leans to the past. In these cases of cue conflict, the Control group lies in between, seemingly attending to both cues equally.

These impressions are confirmed by three multiple regression analyses, one for each group, where the dependent variable is group mean temporal interpretation for each of the 24 sentences and the independent variables are the interpretation cued by the adverbial cue and that predicted by the verbal inflection. The differential cue use by each of the three groups, in standardized β coefficients, are as follows:

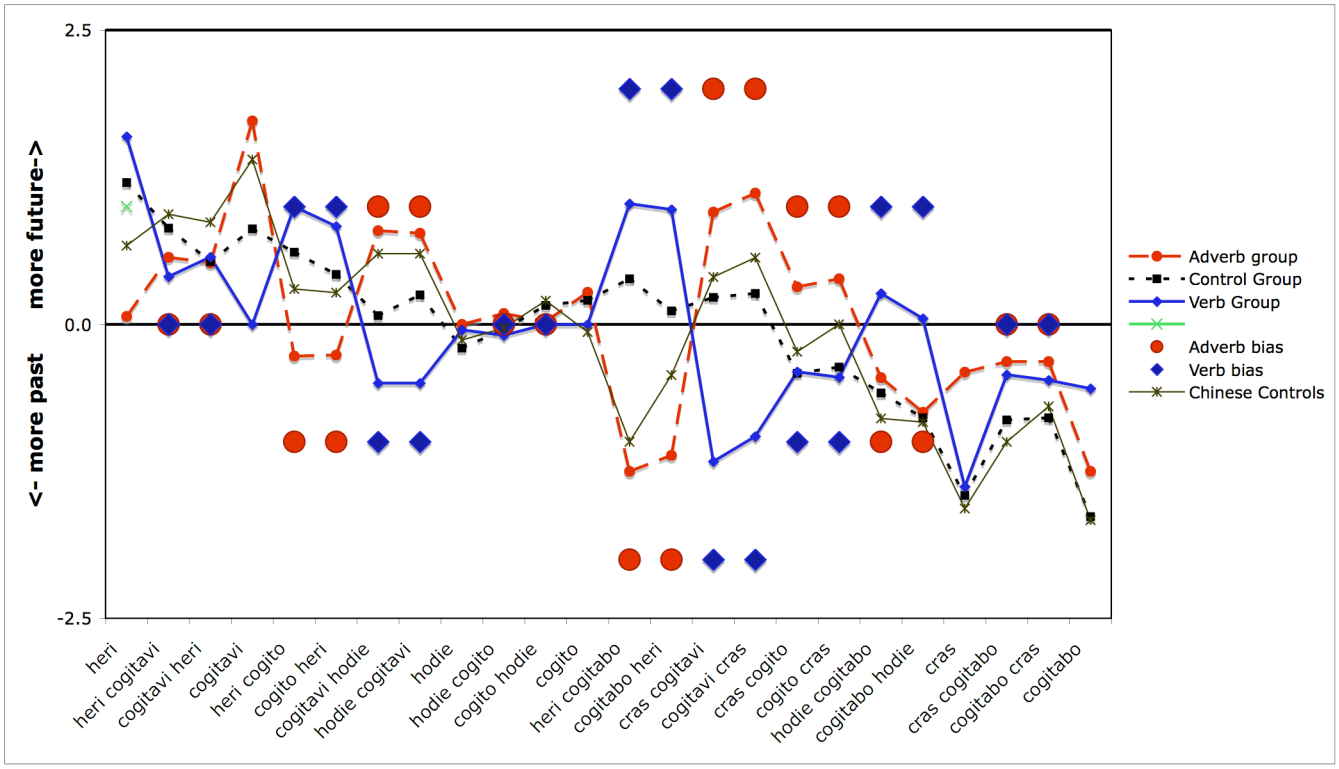

Figure 3: Group mean deviations from ideal temporal interpretations in Phase 3. The solid bias symbols mark the interpretation that would be made for the Adverbial cues only (circles) and Verb inflection cues only (diamonds)

Adverb Group:
Time = 0.98 Adverb + 0.19 Verb $R^2 = 0.99$
responses explain 66% of ideal
Verb Group:
Time = 0.97 Verb + 0.21 Adverb $R^2 = 0.98$
responses explain 67% of ideal
Control Group:
Time = 0.69 Verb + 0.67 Adverb $R^2 = 0.91$
responses explain 85% of ideal

Participants who first learned adverbial cues to temporal reference continued to use those cues to the exclusion of others. In subsequent sentences that contained both adverbial and inflectional cues to event time, verbal morphology accounted for less than 4% of their performance, whilst adverbial cues determined 96%.

Likewise, participants who first learned inflectional cues to temporal reference continued to use those cues to the exclusion of others. In subsequent sentences that contained both adverbial and inflectional cues to event time, adverbial cues accounted for 4.4% of their performance, verbal morphology determined 94%.

Control participants, however, who had no prior experience of Latin adverbial morphological cues to time before they were exposed to sentences containing both cues learned to attend to both cues, with 48% of the variance in their judgments being accounted for by the verbal cues and 45% by the adverbs. The control group's performance is thus much closer to the ideal, explaining 85% of the correct averaged interpretations, compared to just 66% for the Adverb Pretraining and 67% for the Verb Pretraining groups respectively.

The matched attention to verbal and adverbial cues in the control participants here, however clearly it differentiates them from those pretrained with verbal or adverbial cues, is unlikely reflective of natural language learning. The stimuli in the present experiment were a meager subset of Latin, a minilanguage which by chance allowed the three adverbs to differ from each other in relatively slight ways (*hodie*, *heri*, *cras*) approximating the similarity in here of the verbal inflections (*cogito*, *cogitavi*, *cogitabo*). In natural languages this is not the typical case. Verbal morphology, due to its high frequency, is typically of low salience in its surface manifestations compared to lexical cues (*yesterday, today, tomorrow* vs. I walk*ed*, I walk*Ø*, I*'ll* walk), and hence inflections are typically overshadowed and adumbrated by more salient lexical and discourse cues (Ellis, in press).

These quantitative results illustrate large and significant effects of blocking in the early acquisition of language. Note that these effects reflect attentional biases to particular dimensions of cue (adverb vs. verbal inflection) rather than to particular words. These are not merely proactive interference effects where, in paired associate learning experiments, memory for association A-B is worse after prior learning of A-C in comparison with a control condition involving prior learning of unrelated

material D-E (Baddeley, 1976, chapter 5). That this is the case is clearly demonstrated by the participants' performance on judging future time reference in Phase 3. In Phase 1, participants in the Adverb and Verb pretraining conditions learned particular constructions relating to the present and the past. There was no reference to future at this stage. Thus, while subsequent responses relating to past and present judgments could reflect interference from these specific prior-learned associations, responses relating to future judgments could not. Any bias in interpretation of adverb or inflectional cues to future time must have come from generalized attention to these cues, not from particular memories of specific items. Figure 3 demonstrates that the Adverb and Verb Pretraining groups are as unalike and dissociated in their performance on *cras* and *cogitabo* items referring to the future as they are on the other past and present reference ones.

As with all learning experiments, it is appropriate to ask whether the group performance means are truly reflective of the individuals within that group or whether they provide a central tendency that blurs individual within-group differences. As in the multiple regression analyses reported for each group above, it is possible to take each individual's responses in Phase 3 and assess the degree to which their temporal rating on each construction reflected the information provided by the verb cue and that separately provided by the adverbial cue. Figure 4, which plots each individual in the space defined in this way, shows the large majority of Verb Pretrained individuals heavily influenced by the verb cue and hardly at all by the adverbs, and, conversely, the large majority of the Adverb pretraining participants strongly influenced by the adverbial cues to the exclusion of any information provided by the verb inflections. The control group participants, in contrast, do not lie along the 45% diagonal, equally affected by these two cues as the group mean suggests. Instead their distribution is rather more bimodal, with some individuals picking up more on the adverbial cues and others on the inflections. This finding is in line with 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 only introducing others later, one-by-one, as they reduce error of estimation (Cheng & Holyoak, 1995; MacWhinney, 1987; Matessa & Anderson, 2000).

Thus, as in the case of associative learning of other cue-outcome interpretations in medical diagnosis or in stock market prediction (Kruschke & Blair, 2000; Shanks, 1995), these data demonstrate that for linguistic constructions too, early learning of one cue blocks the later acquisition of other cues, however reliable they are as predictors in their own right.

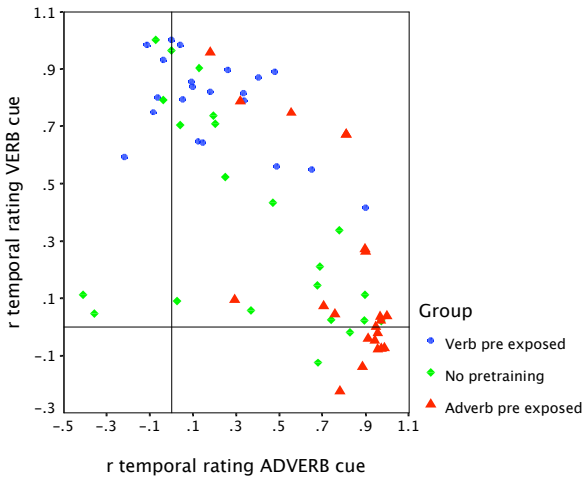

Figure 4: Individual participants from the three training groups as they are affected by adverbial and verbal inflectional cues to temporal reference in Phase 3

Experiment 2

Usage-based views of language acquisition hold that short-term effects sum to long-term effects (Barlow & Kemmer, 2000), as the individual increments of learning integrate over time to form the processes, representations, and attentional biases that fill our minds. Thus experience of how our native language maps on to experience colors our expectations and learning of second language – there are large effects of cross-linguistic transfer upon L2A (MacWhinney, 1997; Robinson & Ellis, to appear). By these accounts, limited adult language attainment is grounded in L1 entrenchment and transfer, rather than in age or biology per se.

Experiment 2 investigated whether long-term learned attention affects that stem from L1 experience also bias cue acquisition in this experimental paradigm. The impetus for assessing this came from observations of the few Chinese first language participants who participated in Experiment 1 and who, especially in the Control condition, seems more to behave like those from the Adverb pretraining group. There are no tenses in Chinese languages and instead temporal information is typically conveyed using direct time reference in the form of temporal adverbs or prepositional phrases. One would expect, therefore, that L1 experience would sum to long-term biases towards these types of cue, with consequent blocking of verbal inflectional cues.

Participants

Participants were 15 Chinese native-language students from the University of Michigan. All students were, of course, bilingual with quite an advanced English language proficiency sufficient – one assessed to be sufficient to allow their study through the medium of English. They were volunteers and were paid $10 for their participation in the experiment.

Procedure

The participants partook in an exact replication of the No Pretraining control group condition of Experiment 1. It comprised Phase 2 – Sentence decoding, Phase 3 – Reception testing.

Results

The performance of the Chinese native individuals in terms of deviation from ideal judgment in Phase 3 of the experiment is shown in Figure 3 as the starred line. It can be seen that their performance lies to the Adverb side of the prior Control group line, tracking the information given by the adverbial cue much more than by that from the verbal morphology. This is confirmed by the results of the multiple regression analyses for the whole group:

Control Group (Native Chinese)

Time = 0.93 Adverb + 0.30 Verb $R^2 = 0.96$

responses explain 72% of ideal

Comparing these results with those from Experiment 1, it can be seen that they lie closer to those of the original Adverb group rather than the original Control group:

Control Group (Expt 1. Predominantly L1 English):

Time = 0.69 Verb + 0.67 Adverb $R^2 = 0.91$

Adverb Group:

Time = 0.98 Adverb + 0.19 Verb $R^2 = 0.99$

These findings confirm a long-term influence of attention to language, a processing bias and subsequent blocking of cue learning that comes from a lifetime of prior L1 usage. It is perhaps especially compelling in that these participants had been exposed to a subsequent second language prior to the Latin learning experiment, the English in which they had become quite proficient and which, as a second language learning experience, must have brought to their awareness the potential productivity of inflectional cues in tense marking.

Conclusions

These experiments demonstrate clear effects of attentional bias and subsequent blocking of cue acquisition that stem from both short-term and long-term learning sequence effects. Early learned language cues block the acquisition of later ones. It is possible then that L2 learners' use of adverbs and other devices for expressing time blocks their acquisition of less salient and less reliable verb morphology, thus resulting in the 'Basic Variety' of limited L2 endstate (Ellis, 2006).

There are many questions still to be answered. Can these effects be shown in the classroom learning of a more naturalistic sample of language where a wide range of cues conspire and compete for attention? To what extent are these attentional biases overt or covert – there is scope for extending these experiments using eye movements (Kruschke, Kappenman, & Hetrick, 2005). Given that proficient language users do use cues in combination, and that multiple cues in interaction provide highly constraining solutions unattainable from individual cues alone, how do other cues become integrated into the learner's inference (MacWhinney, 1987)? Does the relative salience of these cues affect their relative use?

Meanwhile, the findings of these experiments reinforce the possibility that understanding the limited attainment of adult second and foreign language learning needs posit no critical periods or language acquisition devices, but instead falls within the remit of the cognitive science of the associative learning of linguistic constructions.

References

Baddeley, A. D. (1976). *The psychology of memory*. New York: Harper and Row.

Bardovi-Harlig, K. (2000). *Tense and aspect in second language acquisition.* Oxford: Blackwell.

Barlow, M., & Kemmer, S. (Eds.). (2000). *Usage based models of language.* Stanford, CA: CSLI Publications.

Cheng, P. W., & Holyoak, K. J. (1995). Adaptive systems as intuitive statisticians: causality, contingency, and prediction. In J.-A. Meyer & H. Roitblat (Eds.), *Comparative approaches to cognition* (pp. 271-302). Cambridge MA: MIT Press.

Ellis, N. C. (2006). Selective attention and transfer phenomena in SLA: Contingency, cue competition, salience, interference, overshadowing, blocking, and perceptual learning. *Applied Linguistics, 27*(2), 1-31.

Ellis, N. C. (in press). The dynamics of language use, language change, and first and second language acquisition. *Modern Language Journal.*

Klein, W. (1998). The contribution of second language acquisition research. *Language Learning, 48*, 527-550.

Kruschke, J. K., & Blair, N. J. (2000). Blocking and backward blocking involve learned inattention. *Psychonomic Bulletin & Review, 7*, 636-645.

Kruschke, J. K., Kappenman, E. S., & Hetrick, W. P. (2005). Eye gaze and individual differences consistent with learned attention in associative blocking and highlighting. *Journal of Experimental Psychology: Learning, Memory & Cognition, 31*(5), 830-845.

MacWhinney, B. (1987). The Competition Model. In B. MacWhinney (Ed.), *Mechanisms of language acquisition* (pp. 249-308).

MacWhinney, B. (1997). Second language acquisition and the Competition Model. In A. M. B. De Groot & J. F. Kroll (Eds.), *Tutorials in bilingualism: Psycholinguistic perspectives* (pp. 113-142). Mahwah, NJ: Lawrence Erlbaum Associates.

Matessa, M., & Anderson, J. R. (2000). Modeling focused learning in role assignment. *Language & Cognitive Processes, 15*(3), 263-292.

Robinson, P., & Ellis, N. C. (Eds.). (to appear). *A handbook of cognitive linguistics and SLA*. Mahwah, NJ: Lawrence Erlbaum.

Shanks, D. R. (1995). *The psychology of associative learning*. New York: Cambridge University Press.

Zipf, G. K. (1949). *Human behaviour and the principle of least effort: An introduction to human ecology*. Cambridge, MA: Addison-Wesley.