Why do we need a linguistic theory to describe learners’ behaviors?

学習者の振る舞いを記述するために言語理論が必要のはなぜか

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Abstract

A number of studies have been carried out since around 2000 to find out the cause of the universality in the acquisition and use of grammatical morphemes and learners’ errors in producing them, a topic that was actively studied from the 1970s to the 80s. Researchers' positions are, roughly speaking, divided into two: Second language acquisition is, like acquisition of other general knowledge, fundamentally based on "memory of a stimulus", and "habit formation", in which factors such as “saliency” and "frequency" are important (Goldschneider & DeKeyser, 2001, among others); and Second language acquisition is based on the same knowledge as native language acquisition, where the mental grammar (interlanguage) plays an extremely important role in use of grammatical morphemes (Wakabayashi, 1997, etc.). In this paper, after clarifying the psychological reality of the interlanguage (Selinker, 1972), it will be shown that interlanguage is itself a kind of “natural language”. Based on data from six studies, we discuss Japanese-speaking English learners’ knowledge and use of 3rd person singular -s. It will be argued that second language learners’ acquisition and use of grammatical morphemes are, though general factors such as memory are also concerned, clearly based on their interlanguage, and that empirical research based on precise designs rooted in linguistics serves as a key to the elucidation of learner knowledge.

要旨

2000年前後から、多くの研究が1970年代から80年代にかけて盛んに研究された文法形態素の習得・使用に見られる普遍性、および第二言語学習者の産出における誤りの原因の解明に取り組んでいる。研究者の立場は、大まかに言って、第二言語習得は他の一般的知識の習得と同様、基本的に「刺激の記憶」「習慣形成」に基づくものであり、その文法形態素の「目立ち度」や「頻度」が重要な要素であるという立場（Goldenschen & DeKeyser, 2001 ほか）と、第二言語習得も母語習得と同じ知識基盤に基づいており、形態素の使用には学習者が持つ心理的文法知識（中間言語）が大きく関わっていると考える立場（若林, 1997 ほか）に分けられる。本稿ではまず、第二言語学習者の持つ中間言語（Selinker, 1972）の心理的実在性を明らかにし、中間言語が他の自然言語と同種の「言語知識」であることを示した上で、6つの研究のデータから、日本人英語学習者の3人称単数現在-sの使用に関する知識基盤とその使用について考察する。その結果、第二言語学習者による文法形態素習得・使用

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In the first chapter of their introductory text on second language acquisition research, Brown & Rodgers (2002) discuss the definition of research. They cite a number of their students' responses to the question of what research is, and one of them is “investigation into how and why things work or don’t work.” I think this is a good answer, and in order to answer such questions, we need to reveal what cannot be seen from the surface. In this paper, I suggest that we need certain reliable theoretical frameworks to carry out this difficult task, and those linguistic theories, especially those within the generative approach, are among the best candidates for it.

1 A very brief review of SLA studies

1.1 Corder 1967, Selinker 1972

At an early stage of SLA research, Corder (1967) noticed that learners make errors that are not predicted as a result of L1 transfer, and suggested that researchers should carefully examine learners’ errors in order to study how learners learn and use their second languages. Selinker (1972) expanded this view and coined the now widely-used term ‘interlanguage’ to refer to learners’ grammatical knowledge of the target language, based on which learners produce and comprehend new sentences. Since then, it has been one of the goals of SLA research to reveal what constitutes interlanguage.

Interlanguage should have certain properties common to people’s knowledge of grammar of natural languages learned as L1, because L1 and L2 share one of the most important aspects of human language, that is, productivity. Both L1 and L2 users produce and comprehend new sentences every day. Most sentences and phrases we read, hear, utter, or write have never before been heard by us. People working in SLA, especially those adopting linguistic approaches to SLA, are trying to reveal what systems make it possible for learners to use their L2 productively.

1.2 The acquisition of grammatical morphemes and developmental stages

A series of studies of the acquisition of grammatical morphemes, a large number of so-called morpheme studies, have been carried out since Dulay & Burt (1973). A good example of this type of study is Shirahata (1988). Shirahata collected data from 31 high school students in Japan through an oral interview and found that there exists an order to correct uses of morphemes (80% or better), which showed implicational relations among them. That is, a certain morpheme is
used correctly earlier than another morpheme, and so this entails an order. In Shirahata, Wakabayashi & Suda (2004), we compared this order with the order of appearance of these morphemes in a textbook widely-used by junior high school students. This is shown in Table 1.

Table 1. The order of the appearance of grammatical morphemes

<table>
<thead>
<tr>
<th>textbook: New Horizon</th>
<th>learners' oral production</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 copula be</td>
<td>1 copula be</td>
</tr>
<tr>
<td>2 indefinite article a/an</td>
<td>2 progressive -ing</td>
</tr>
<tr>
<td>3 definite article the</td>
<td>3 possessive -'s</td>
</tr>
<tr>
<td>4 plural -s</td>
<td>4 auxiliary be</td>
</tr>
<tr>
<td>5 3rd person singular -s</td>
<td>5 plural -s</td>
</tr>
<tr>
<td>6 possessive -'s</td>
<td>6 irregular past</td>
</tr>
<tr>
<td>7 auxiliary be</td>
<td>indefinite article a/an</td>
</tr>
<tr>
<td>8 progressive -ing</td>
<td>3rd person singular -s</td>
</tr>
<tr>
<td>9 regular past -ed</td>
<td>9 regular past -ed</td>
</tr>
<tr>
<td>10 irregular past</td>
<td>10 definite article the</td>
</tr>
</tbody>
</table>

As shown in Table 1, the definite article the is introduced to students at quite an early stage of language teaching, but it is extremely difficult for Japanese speaking learners of English. In the same way, 3rd person singular -s is difficult to acquire. The important point here is that the order of the correct use does not reflect the chronological order of introducing the item in language teaching. This is true even when they are similar in meaning, such as irregular and regular past.

Another important finding in early SLA studies is the existence of developmental sequences to express certain functions in production. It has been suggested that there is a universal developmental order in the acquisition of certain structures, such as interrogatives and negation. The order of the developmental sequence in the use of negation is given in Table 2.

Table 2. Developmental stages in the use of English negation (R. Ellis, 2008: 93)

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>External negation (i.e., ‘no’ or ‘not’ is placed at the</td>
<td>No you are playing here.</td>
</tr>
<tr>
<td></td>
<td>beginning of the utterance)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Internal negation (i.e., the negator—‘no’, ‘not’ or ‘don’t’</td>
<td>Mariana not coming today.</td>
</tr>
<tr>
<td></td>
<td>is placed between the subject and the main verb.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Negative attachment to modal verbs</td>
<td>I can’t play that one.</td>
</tr>
<tr>
<td>4</td>
<td>Negative attachment to auxiliary verb as in target language</td>
<td>She didn’t believe me.</td>
</tr>
<tr>
<td></td>
<td>rule.</td>
<td>He didn’t said it.</td>
</tr>
</tbody>
</table>

If SLA proceeds exclusively by memorizing patterns in input and by proceduralizing and

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1 Placing a negator at the initial point of constituents is not a universal phenomenon at an early phase of SLA. See Meisel (2011, pp. 73-85) variations in L2 French and German.
automatizing of their use, these patterns should not appear in L2 production as they are not included in L2 input. Learners cannot memorize what does not appear in the input. Hence, they should create their own rules (i.e. interlanguage) at least to some extent, and the rules show a universal pattern, which implies that learners depend on a certain system common among human beings.

These kinds of evidence, that is, the fact that order of correct use does not reflect order of instruction (or more precisely, the order of correct use is common among L2 learners in general) was used as evidence to suggest that learner interlanguage develops independently of environment.

1.3 ‘Poverty of Stimulus’ in SLA
The fact that L2 learners productively use in a systematic way certain patterns that are not included in L2 input implies that they create an interlanguage grammar. What is this grammar based on? This is one of the central questions that SLA researchers have been trying to answer. Some researchers argue that interlanguage is based on human knowledge of language, i.e., UG. That is, in principle, the fundamental architecture of SLA is the same as that used for first language acquisition. I will show evidence for this argument, but before that, I must first refer to two common misunderstandings found in counterarguments against UG-based approaches to SLA.

The first misunderstanding is as follows: It is assumed that UG makes it possible for human beings to acquire their first languages. Therefore, if it is the case that UG is available in SLA, L2 learners should be as successful as L1 learners. However, the fact is that L2 learners seldom, if ever, develop native-like mastery, hence UG should not operate in SLA. Even though this argument may appear logical, it is NOT. This argument confuses a necessary condition with a sufficient condition: It is true that it is assumed that UG is necessary for first language acquisition, but it is NOT assumed that UG guarantees the success of first language acquisition. Well-known studies of children brought up in uncommon environments, including Genie in Curtiss (1977), Jim in Sachs, Bard & Johnson (1981), and a group of deaf children in Newport (1990), show that children need sufficient input and interaction at certain periods of life in order to obtain adult native speakers’ competence of a first language, even though they all should have had UG.

No researchers working in a UG-based approach believes that UG guarantees that L2 learners will succeed in learning a second language and gain near-native competence, but some (or most) believe that it would be difficult for L2 learners to use the target language productively without UG, and most (or all) believe that certain data show that UG operates in SLA, i.e., L2 learners’ grammar is constrained by UG. We will come back to this point later.

The second common misunderstanding of the UG-based approach is as follows: UG-based research is aimed at describing L2 learners’ competence, and its argument is very abstract, far from the reality we have in the classroom. Hence, this kind of discussion is irrelevant to language teachers. Well, it is true that the goal of UG-based (or any theoretical) research in SLA is to describe (and explain) learners’ knowledge of L2, and it is also true that the arguments are very abstract. The abstractness is inevitable to a certain extent because human language,
including interlanguage, is so complex that we need a theoretical tool to deal with it. It is the same when we discuss the physical world around us. That is, things sometimes appear to be plain, but when we describe and explain what they are and what principles govern them, we need the abstract theory of physics.

Now let us move on to the evidence that shows L2 learners’ grammar cannot be explained without the involvement of UG.

1.3.1 Two types of intransitive verbs

It has been reported that L2 learners make errors like (1), produced by a native speaker of Arabic (Zobl, 1989: 204):

(1) The most remarkable experience of my life was happened 15 years ago.

In the same way, we expect that the following sentences may occur in L2 learners’ production:

(2)a. An accident was happened here.
   b. A few sailors were arrived on the island after their boat was wrecked in a typhoon.

Some may suggest that be in these sentences may be used as a topic marker, and that the sentence has a so-called topic-comment structure. However, this is not very plausible when we find that the following kinds of errors are NOT observed in L2 learners’ production (Oshita, 2000).

(3)a. A boy was run around here.
   b. Several pirates were danced when they found an island ahead.

What are the differences between the sentences in (2) and those in (3)? Learners may know that the verbs happen, arrive, run, and dance are all intransitive, but very unlikely to know the differences between the first two and the others. In linguistics, these intransitive verbs are divided into two groups: those in (2) are unaccusatives and those in (3) are unergatives (Burzio, 1986). A number of studies have shown that L2 learners distinguish these two types unconsciously (Hirakawa, 1999, 2001, 2003; Oshita, 1997, 2000, 2001, 2002, 2004; Sorace, 1993, 1995, Yuan, 1999 among others). This suggests that they construct an interlanguage grammar based on some system where these two types are divided. What kind of system is it? The answer should be their linguistic knowledge.

This distinction cannot be learned from input because be does not appear in sentences like (1) or (2) in L2 input. Explicit knowledge should not work because learners generally are not aware of this distinction. If the knowledge is not based on input, what is the basis for this distinction? Note that this distinction is widely observed in natural languages, e.g., Italian. This overuse of be has an explanation in UG-based research, but I put this aside here.
1.3.3 Differences in ungrammaticality

Another source of evidence for learners’ grammatical knowledge not based on input concerns wh-questions. Certain items in sentences cannot be asked in wh-questions in English. Consider the following sentences:

(4)a. *What did the picture of it surprise you?  
(cf. The picture of the festival surprised me.)

b. *What did Tom reject the claim that he wrote?  
(cf. Tome rejected the claim that he wrote the letter.)

c. *What did Mike meet the man who was wearing?  
(cf. Mike met the man who was wearing a red jacket.)

These sentences are all ungrammatical and hence are not present in L2 input. The point here is that theoretical consideration predicts that (4a) and (4c) are violating a constraint more severely than (4b) so it is expected that native speakers should judge (4a) and (4c) worse than (4b). Martohardojono’s (1993) data from native speakers support this prediction.

If L2 learners show the same pattern, this strongly supports the claim that the constraint sanctioning wh-movement operates in L2 learners’ knowledge. As expected, L2 learners, including native speakers of a language that has no movement (i.e., Chinese) show a pattern very similar to native speakers. I should repeat, this constraint cannot be learned from input.

Another interesting phenomenon concerning wh-movement is reported in Wakahayashi & Okawara (2003). They carried out an experiment with Japanese speaking learners of English based on Crain & Thornton (1998) and found that both children who are acquiring English as their first language and adults who are learning English in Japan produce similar structures despite the fact that such structures are not produced by adult native speakers of English. (Note that this structure is nevertheless found in natural language.)

(5)a. What do you think what’s in that box?  
(3 years and 11 months old. Cited from Crain & Thornton, 1998)

b. Who did they say who had ants in their pants?  
(4 years and 9 months old. Cited from Crain & Thornton, 1998)

From these kinds of evidence, it is plausible that interlanguage grammar is constrained by and based on linguistic knowledge. Even though L2 input does not include certain structures, L2 learners produce them, when these structures are sanctioned in natural languages.

One important aspect of this fact is that the descriptions and explanations given to the non-target-like structures are not ad hoc. The distinction between two kinds of intransitive verbs, the degree of violation among ungrammatical wh-questions, and the overuse of wh-words in complex wh-questions are all posited to explain natural languages. In this sense, the suggestion that SLA is beyond statistical learning (i.e., not exclusively dependent on input) is empirically supported. If we assume that interlanguage is structured on the basis of human knowledge of language, we can use linguistic theory to describe and explain learners’ behavior.
In the next section, I will outline two trends in SLA studies, dealing with similar sets of data.

2 Two approaches to SLA

2.1 Competing factors model(s)

The first trend is the Competing Factors Approach, where a number of factors are assumed to influence learners’ verbal behavior. In this approach, no independent modules are assumed to exist. In other words, all factors are involved at once with processing linguistic information. A good example of this research is Goldshneider & Dekeyser (2001), where they discuss factors that determine the acquisition order of grammatical morphemes. Since N. Ellis (2007) describes this study as representative of cognitive approaches to second language acquisition, it is worth examining what they offer.

The authors chose 12 representative studies of morpheme acquisition and carried out a meta-analysis of oral production data from 924 learners in total. In order to identify the most determinant factor for the target-like use of grammatical morphemes, they chose the five factors in (6) and examined correlations of these factors with correct use using multiple regression analysis.

\[
\text{(6)} \quad \begin{align*}
\text{a. perceptual saliency} \\
\text{b. semantic complexity} \\
\text{c. morphophonological regularity} \\
\text{d. syntactic category} \\
\text{e. frequency}
\end{align*}
\]

In order to carry out multiple regression analysis, these factors have to be represented numerically. For example, perceptual saliency is determined by three factors, namely, the number of phones in the grammatical morpheme (phonetic substance); the presence/absence of a vowel in the surface form (syllabicity); and the total relative sonority of the grammatical morpheme, while stressed/unstressed and serial position were not considered. The sonority of each grammatical morpheme was calculated based on the hierarchy given by Laver (1994: 504) and numeral values were assigned as in Table 3.
Table 3. Sonority hierarchy with point values (Goldschneider & Dekeyser, 2001: 25)

<table>
<thead>
<tr>
<th>Range</th>
<th>Points</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most sonorous</td>
<td>9</td>
<td>low vowels</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>mid vowels</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>high vowels</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>glides</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>liquids</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>nasals</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>fricatives</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>affricates</td>
</tr>
<tr>
<td>Least sonorous</td>
<td>1</td>
<td>stops</td>
</tr>
</tbody>
</table>

With these 'points' and the results of data collection, the multiple regression analysis showed that the saliency of grammatical morphemes is the most important factor for the correct use of grammatical morphemes; that is, the more salient the morpheme is, the more likely it is used in a target-like way. Moreover, it is reported that all five factors correlate with the relative use of morphemes to some extent. In other words, what the authors interpreted as determinant factors appear to play some role in determining the relative degree of correct use for each grammatical morpheme. These factors are involved in processing simultaneously. This may be illustrated as follows.

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Figure 1. Competing Factors Model (based on Crain and Thornton, 1998)

In fact, this study has at least two important shortcomings in its investigation of second language acquisition. The first problem is that it is not at all clear whether the definitions of the five factors in (6) are reliable. For example, as described just above, perceptual saliency is determined by three factors, one of which, namely, sonority, is based on the hierarchy in Table 3. According to this table, the degree of difference between stops (e.g., /p/) and affricates (e.g., /tʃ/) is the same as that between glides (e.g. /ai/) and high vowels (e.g., /iː/). I am not a specialist in phonetics or phonology, so I cannot offer any further conclusion, but at the very least this does not appear to be very rigorous. The same problem applies to the discussion of semantic complexity. Scoring on syntactic categories is even more problematic, but I do not discuss this
further here.

The second problem is the interpretation of the results of these calculations. Based on their account, the authors suggest:

... the five factors have been shown in this study to account for a large percentage of the variance in order of acquisition constitute phonological, morphological, syntactic, semantic, and numerical aspects of salience. It is possible, therefore, that just one variable, salience, is the ultimate predictor of the order of acquisition. (p. 36)

They further suggest:

..., it is clear that a number of objective characteristics of the morphemes themselves, in all likelihood all related to salience, predict order of acquisition with a high degree of success. Therefore, no appeal to any innate blueprints or specific syntactic models is required to explain order of acquisition. (p. 36)

So, they conclude that saliency is the determinant factor, and this factor determines the order of acquisition. However, there are problems with this claim. First, the authors used particular linguistic notions to decide the saliency of grammatical morphemes, such as syntactic categories, which are notions given in linguistic theories, assumed to be innately available. Second, in educational settings, the morphemes are made salient in the input, especially through explicit teaching using written materials such as textbooks. If the lack of saliency is the reason for L2 learners’ non-native-like behavior, all morphemes should be acquired when they are made ‘salient’ in the input, but this is implausible, as we have seen in Table 1. In Japanese junior and senior high schools, these morphemes are highlighted (i.e., made salient) and taught through explicit grammar teaching, but they appear to be acquired in a predetermined order independent of the order of exposure.

As quoted, Goldschneider & Dekeyser (2001) suggest that we do not have to appeal to “specific models” to explain order of acquisition. If saliency ‘explains’ learners’ behavior sufficiently, their suggestion could be acceptable. However, even though saliency may play some important role in determining the acquisition order, this does not mean that innate knowledge does not operate in the use of grammatical morphemes. Metaphorically speaking, even if it is true that effective breathing is the determinant factor to win a marathon, this does not mean we do not also need muscles: We need the legs to run, and it is plausible to argue that some important aspects of the speed of running is determined by how effectively athletes’ muscle moves.

In the next section, I will introduce theoretical assumptions in generative approaches to SLA and a series of studies concerning the use and processing of 3rd person singular -s by Japanese speaking learners of English.

2.2 Modular model
In the generative approach to language use, as well as in Levelt’s (1989) model of speaking and
Pienemann’s (1998, 2005, 2007) Processability Theory, it is assumed that linguistic knowledge constitutes a module, independent of general knowledge about the world, and the linguistic module has sub-modules, where syntactic knowledge is a module independent of but related to semantic and phonological knowledge sub-modules. In this kind of approach, it is assumed that linguistic knowledge intervenes between the linguistic signal outside the learner (i.e., input and output) and the learners’ knowledge of the world, and hence, all linguistic signals have to be processed through the linguistic module when one produces or perceives linguistic information. This relationship is illustrated in Figure 2.

![Figure 2. A modular-based model of language use (based on Crain & Thornton, 1998)](image-url)

I adopt the Minimalist Program (Chomsky, 1995, 2000, 2001) and the theory of Distributed Morphology (Embick & Noyer, 2007; Halle & Marantz, 1993; Harley & Noyer, 1999) as the framework for the account to follow (see Radford, 2004, for reference to Minimalist syntax). In the Minimalist Program, structuring a sentence begins in the Lexicon, where formal features are associated with relevant lexical items and the required lexical items are taken into an array. Then, derivation starts, and when all operations relevant to sounds are completed, the information associated with sounds are spelled out, that is, sent to the Morphology. The rest will be processed in syntax and sent to Logical Form, that is, a semantic module. At the level of Morphology, certain derivations, such as affix hopping, take place, and then the results will be sent to Phonetic Form, where the information is sent to mechanisms for non-linguistic processing. This is illustrated in Figure 3.

![Figure 3. A model of the derivation of a syntactic object](image-url)

Therefore, simply speaking, there are four stages in the derivation. Let me illustrate this with an example, *This student speaks English.*

First, in the Lexicon, certain lexical items are taken from the mental lexicon, and required
features have to be associated to relevant lexical items. The result consists of an array of lexical items, such as in (7), where T and C refer to functional categories. Irrelevant features and details of the operation are not included here:

(7) \{This \[D, 3^{rd} \text{ person, singular}\], student \[N, 3^{rd} \text{ person, singular}\], speak \[V, \text{ present, 3}^{rd} \text{ person, singular}\], English \[N, 3^{rd} \text{ person, singular}\], T \[\text{present, 3}^{rd} \text{ person, singular}\], C \[\text{declarative, root}\]\}

Second, a lexical item is taken from the array and merges with another lexical item. This process, called Merge, is illustrated in (8) for this student.

(8)\[
\begin{array}{c}
\text{DP} \\
\text{D} & \text{N} \\
\text{this} & \text{student}
\end{array}
\]

This operation moves on until all lexical items are merged. When necessary, Agree takes place between two (or more) lexical items. Besides, when necessary, a lexical item or a syntactic object moves to another place. The result of these operations for This student speaks English appears in (9). In this structure, all irrelevant structures have been excluded.

(9)\[
\begin{array}{c}
\text{CP} \\
\text{C} \\
\text{TP} \\
\text{DP} \\
\text{D} & \text{N} & \text{T}' \\
\text{this} & \text{student} & \text{T} \\
\text{V} & \text{VP} \\
\text{spoke-s} & \text{N} \\
\text{English}
\end{array}
\]

At the third stage, this structure is sent to Morphology, where [present][3\text{rd} \text{ person}][\text{ singular}] on V is satisfied with the insertion of 3\text{rd} \text{ person singular} -s.

At the last stage, the object in Morphology is changed into a corresponding phonetic form, which is sent to articulation (or perception).

Armed with these theoretical assumptions, we turn now to empirical data.

3 Empirical studies
3.1 Differences between [person] and [number]

3.1.1 Wakabayashi (1997)

Wakabayashi (1997) was interested in the fact that the 3rd person singular -s is simultaneously associated with three features, namely, [present][3rd person] and [singular]. He hypothesized that there might be differences in learners’ sensitivity in accordance with different features. Using the following type of sentence, and using a reading time measurement procedure, he examined learners’ behavior. It is known that reading time is delayed when a native speaker encounters an error in a sentence. The same effect is expected if L2 learners have the same level of sensitivity to the grammatical errors.

(10) a. *I hear that you goes to the pub, but I have never seen you there.
   b. *I think that Tom and Susan likes to go to the beach, so I will ask if I can go with them.
   c. *The teacher thinks the students likes discussions more than lectures, but this is not true.
   d. *I hear that Tom go to the pub every night, but I have never seen him there.

Participants read each sentence on a computer screen by pressing a button to advance word by word through the sentence. Each word appears and then disappears with each successive button press, as shown in Figure 4.

![Figure 4. Stimuli on the computer screen](image)

Participants included 15 advanced Japanese speaking learners of English who were students or staff members of Cambridge University, 29 intermediate Japanese speaking learners who were students at English schools in Cambridge, UK, and 24 native speakers of English. The results are given in Table 4.

<table>
<thead>
<tr>
<th>Sentence types</th>
<th>Advanced</th>
<th>Intermediate</th>
<th>Native Speakers</th>
</tr>
</thead>
<tbody>
<tr>
<td>You + -s (10a)</td>
<td>&lt;.05</td>
<td>&lt;.01</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>A and B + -s (10b)</td>
<td>&lt;.07</td>
<td>n.s.</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>plural + -s (10c)</td>
<td>&lt;.01</td>
<td>n.s.</td>
<td>&lt;.07</td>
</tr>
<tr>
<td>3rd person +0 (10d)</td>
<td>n.s.</td>
<td>n.s.</td>
<td>&lt;.05</td>
</tr>
</tbody>
</table>

Native speakers are sensitive to the ungrammaticality in all types. Advanced learners are sensitive to the overuse of 3rd person singular -s, but showed no sensitivity to omissions of 3rd person singular -s. Intermediate learners were sensitive only to the contradiction of [person]
features between subjects and verbs. The results suggest that there is a discrepancy of sensitivity between [person] and [number], at least among intermediate Japanese speaking learners of English.

3.1.2 Wakabayashi, Fukuda, Bannai & Asaoka (2007)
Wakabayashi, Fukuda, Bannai & Asaoka (2007) used ERP data to confirm the findings in Wakabayashi (1997). In their experiment, the following sentences were used.

    b. *Sam and Adam answers our questions.
    c. *I answers your letter.
    d. *My mother answer your question.

A specific reaction in brain waves called P600 was expected when a participant noticed the ungrammaticality of the sentence.

The stimuli were given to participants visually in the following time frame.

![Figure 5. Time frame of ERP measurement in AAAAA et al. (2007)](image)

Participants included nine Japanese university students who majored in psychology. Ten native speakers of English participated in the experiment as a control group. The ERPs were measured at the points depicted in Figure 6.
The results were given in Table 5. The cells where a P600 was observed are shadowed.

<table>
<thead>
<tr>
<th></th>
<th>The teachers answers our questions</th>
<th>Sam and Adam answers my questions</th>
<th>I answers your letter</th>
<th>My mother answers your question</th>
<th></th>
<th>The teachers answers our questions</th>
<th>Sam and Adam answers my questions</th>
<th>I answers your letter</th>
<th>My mother answers your question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japanese</td>
<td>0.495</td>
<td>0.946</td>
<td>0.145</td>
<td>0.497</td>
<td>Native</td>
<td>0.248</td>
<td>0.503</td>
<td>0.159</td>
<td>0.182</td>
</tr>
<tr>
<td>F3</td>
<td>0.707</td>
<td>0.354</td>
<td>0.103</td>
<td>0.535</td>
<td>F3</td>
<td>0.301</td>
<td>0.141</td>
<td>0.096</td>
<td>0.113</td>
</tr>
<tr>
<td>F4</td>
<td>0.841</td>
<td>0.181</td>
<td>0.064</td>
<td>0.559</td>
<td>F4</td>
<td>0.161</td>
<td>0.180</td>
<td>0.096</td>
<td>0.573</td>
</tr>
<tr>
<td>F7</td>
<td>0.390</td>
<td>0.051</td>
<td>0.037</td>
<td>0.321</td>
<td>F7</td>
<td>0.360</td>
<td>0.493</td>
<td>0.305</td>
<td>0.125</td>
</tr>
<tr>
<td>F8</td>
<td>0.590</td>
<td>0.447</td>
<td>0.134</td>
<td>0.744</td>
<td>F8</td>
<td>0.088</td>
<td>0.404</td>
<td>0.651</td>
<td>0.450</td>
</tr>
<tr>
<td>C3</td>
<td>0.755</td>
<td>0.873</td>
<td>0.188</td>
<td>0.946</td>
<td>C3</td>
<td>0.300</td>
<td>0.259</td>
<td>0.098</td>
<td>0.725</td>
</tr>
<tr>
<td>C4</td>
<td>0.674</td>
<td>0.707</td>
<td>0.097</td>
<td>0.818</td>
<td>C4</td>
<td>0.122</td>
<td>0.324</td>
<td>0.319</td>
<td>0.491</td>
</tr>
<tr>
<td>C5</td>
<td>0.764</td>
<td>0.849</td>
<td>0.218</td>
<td>0.890</td>
<td>C5</td>
<td>0.911</td>
<td>0.928</td>
<td>0.130</td>
<td>0.189</td>
</tr>
<tr>
<td>P3</td>
<td>0.573</td>
<td>0.950</td>
<td>0.206</td>
<td>0.127</td>
<td>P3</td>
<td>0.112</td>
<td>0.324</td>
<td>0.319</td>
<td>0.491</td>
</tr>
<tr>
<td>P4</td>
<td>0.726</td>
<td>0.794</td>
<td>0.164</td>
<td>0.981</td>
<td>P4</td>
<td>0.608</td>
<td>0.649</td>
<td>0.065</td>
<td>0.181</td>
</tr>
<tr>
<td>P2</td>
<td>0.492</td>
<td>0.843</td>
<td>0.033</td>
<td>0.612</td>
<td>P2</td>
<td>0.226</td>
<td>0.916</td>
<td>0.156</td>
<td>0.536</td>
</tr>
<tr>
<td>T5</td>
<td>0.628</td>
<td>0.097</td>
<td>0.080</td>
<td>0.747</td>
<td>T5</td>
<td>0.089</td>
<td>0.580</td>
<td>0.196</td>
<td>0.348</td>
</tr>
<tr>
<td>T6</td>
<td>0.086</td>
<td>0.457</td>
<td>0.063</td>
<td>0.496</td>
<td>T6</td>
<td>0.392</td>
<td>0.876</td>
<td>0.053</td>
<td>0.016</td>
</tr>
<tr>
<td>O1</td>
<td>0.563</td>
<td>0.517</td>
<td>0.106</td>
<td>0.242</td>
<td>O1</td>
<td>0.633</td>
<td>0.456</td>
<td>0.157</td>
<td>0.202</td>
</tr>
<tr>
<td>O2</td>
<td>0.583</td>
<td>0.318</td>
<td>0.033</td>
<td>0.642</td>
<td>O2</td>
<td>0.539</td>
<td>0.882</td>
<td>0.372</td>
<td>0.115</td>
</tr>
</tbody>
</table>

Note $p < .05$ in red cells, and $p < .10$ in yellow cells

The results confirmed the findings in Wakabayashi (1997); that is, Japanese speaking learners of English are not sensitive to the omission of 3rd person singular $-s$ and consequently no P600 was observed for My mother answer your question, but they were sensitive to the overuse of $-s$ when [person] feature did not agree between subject and verb, resulting in the observed P600 for I answers your letter. Moreover, Japanese learners did not show any significant effect when subjects and verbs did not agree in terms of [number] feature, although
there was a marginal effect in sentences like *Sam and Adam answers my question.*

### 3.1.3 Shibuya & Wakabayashi (2008)

If the marginal effect of P600 in sentences like *Sam and Adam answers my question* reflect Japanese learners’ sensitivity to the violation of subject-verb agreement, how plurality is marked on the subject noun phrase may have some effect on learners’ behavior. Shibuya & Wakabayashi (2008) conducted reading time measurements with several types of sentences that vary in terms of the ways [plural] is marked. Sentences in (12) exemplify the types of sentences used in the experiment.

(12) a. *You eats a good meal for health every day.
   b. *Tim and Paul bakes an apple pie every Sunday.
   c. *The chefs cooks the shrimp in butter every time.
   d. *These two secretaries gets a cup of coffee for their boss every morning
   e. *The child speak a lot of English during dinner.

Participants included twenty Japanese university students and nine native speakers of English. The results are given in Table 6.

<table>
<thead>
<tr>
<th>Sentence types</th>
<th>Japanese learners</th>
<th>Native Speakers</th>
</tr>
</thead>
<tbody>
<tr>
<td>You + 3ps-s (12a)</td>
<td>&lt;.05</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>A and B + 3ps-s (12b)</td>
<td>&lt;.05</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>plural-s + 3ps-s (12c)</td>
<td>n.s.</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>these + numeral + plural-s + 3ps-s</td>
<td>&lt;.05</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>3rd person + 0 (12e)</td>
<td>n.s. <em>a</em></td>
<td>&lt;.05</td>
</tr>
</tbody>
</table>

*Reading times for grammatical sentences were longer than that for ungrammatical sentences (p < .05 by item analysis only)

The results show that Japanese learners overlook the overuse of 3rd person singular -s when the plurality of subjects is marked solely by the bound morpheme -s.

In summary, the results of the three experiments showed:

i) Japanese learners of English are insensitive to the omission of 3rd person singular -s.

ii) Intermediate Japanese learners of English are sensitive to the lack of [person] agreement when 3rd person singular -s is overused.

iii) Intermediate Japanese learners of English are less sensitive to the lack of [number]
agreement.

iv) Intermediate Japanese learners of English are sensitive to the lack of [number] agreement when 3rd person singular –s is overused only if [plural] is marked syntactically (i.e., by conjunctions or free morphemes).

Intermediate learners of English in Wakabayashi (1997) did not show sensitivity to the lack of agreement in sentences like Sam and Adam answers our questions; Those in Wakabayashi, et al.'s (2008) data showed marginal effects; and those in Shibuya & Wakabayashi (2008) were sensitive to this kind of ungrammaticality. We assume this difference is attributable to the differences in general proficiency of participants.

3.1.3 Brief discussion
Why are Japanese learners insensitive to the lack of 3rd person singular –s but sensitive to its overuse? Why are they insensitive to [number] but sensitive to [person]? What are possible causes for their insensitivity?

Goldshneider & Dekeyser’s (2001) explanation is very unlikely to answer these questions because ‘saliency’ has nothing to do with the differences between these two features, both marked with an affixed –s. What is offered here is based on the theoretical account described in the last section. I suggest that learners’ insensitivity is attributable to non-native-like operations in Lexicon, where appropriate features have to be associated with relevant lexical items.

Learners are insensitive to the lack of 3rd person singular –s because they fail to associate the person and number features (and possibly the tense feature) with V in setting the array of lexical items before starting to structure a sentence. Hence, they use a ‘default’ form, which is spelled out as the bare form of a verb.

When 3rd person singular –s is overused, learners tend to notice the contradiction of features, especially when the subject is associated with a different person feature or when it is marked for [plural] syntactically. When [plural] of the subject is marked only with the bound morpheme –s, Japanese intermediate learners tend to overlook it, not only because this morpheme is not perceptually salient but also because the syntactic structure of the subject NP is identical to the subject NP with [singular]. I do not discuss this further here but I should just insist that the cause is not only a lack of ‘saliency.’

The discrepancy between [person] and [number] is attributable to the difference in their optionality. All noun phrases have a [person] feature, so this feature is obligatorily associated with a noun phrase, but the [person] feature is only required in English. In Japanese, noun phrases do not have to have this feature, so Japanese learners of English have to learn to obligatorily associate this feature with noun phrases (and verb phrases).

3.2 Linear and structural distance
Now let us move on to another set of empirical studies. Since 3rd person singular –s is a reflection of subject-verb agreement, the distance between a subject and verb may influence the use of this morpheme. Several studies have investigated whether this is correct or not, and
interesting findings have been reported.

3.2.1 Fukushima (2001)
Fukushima (2001, see also Wakabayashi, Fukushima & Maemura, 2006) was interested in the effect of syntactic contexts on the use of 3rd person singular –s. She used an oral translation task in order to elicit the types of sentences in (13) from Japanese learners. Four items were used for each type of sentence:

(13) a. Taro speaks Spanish.
    b. Hanako often eats almonds.
    c. I think that Jiro knows Hanako.
    d. I think that Momoko often goes shopping.
    e. We eat almonds.
    f. You often go to Chiba.
    g. We hear that you like soccer.
    h. We know that you always forget an umbrella.

The participants were given a Japanese sentence on a sheet of paper with some instructions and asked to translate it into English. An example of the instructions is in Figure 7.

私は、桃子がよく買い物に行くと思う。 (often)
[I で始めて that 節を使ってください]

**Figure 7. Instruction in Fukushima (2001)**

The word in the parentheses was to be used in the translation. The instruction in the square bracket says “Begin with I, and use a that-clause.” The expected response was I think that Momoko often goes shopping. Participants included 45 Japanese university students. There was no native control group in this experiment because the task was oral translation. The ratios of errors are given in Figure 8.

![Figure 8: Error ratios in Fukushima's (2001) experiment](image-url)
In (12b) and (12d) adverbs appear between subjects and verbs, which clearly caused the increase in errors where 3rd person singular -s was omitted. The results of ANOVA and LSD showed a significant difference between (12a, c) on one hand and (12b, d) on the other.

3.2.2 Maemura (2002)
Maemura (2002, see also Wakahayashi, Fukushima & Maemura, 2006) investigated whether the length of the adverbs intervening between subjects and verbs has any influence on the use of 3rd person singular -s. In her experiment, she used often, always, sometimes, and usually. In order to find out which adverbs are perceived as longer than the others, she carried out a small test. In that test, almost all Japanese learners of English answered that they regard sometimes and usually to be longer than often and always ($n = 10, \chi^2=19.6, df=1, p<.01$).

The types of sentences used in the study are given in (13). Among twelve types, four types (13a-d) did not have adverbs; four types (13e-h) had ‘short’ adverbs (i.e., often or always); and four types (13i, j, k, and l) had long adverbs (i.e., sometimes or usually). In the experiment, three tokens were used for each type.

(13)a. I have a small dog at my house.
    b. You have a TV in your room.
    c. Tom has a new red car.
    d. They go to high school by bus.
    e. I often play the guitar at night.
    f. You always listen to the radio.
    g. Mary often goes shopping with her boyfriend.
    h. They always read the newspaper at school.
    i. I sometimes study English at the library.
    j. You usually walk in the park.
    k. Tom sometimes plays the piano at school.
    l. They usually play the guitar in the park.

Twenty-one Japanese university students participated in the experiment. The task was the same oral translation task as in Fukushima (2002). The error ratios are given in Figure 9.
As shown in Figure 9, not only did the existence of adverbs increase the error ratio, but also the length of the adverbs influenced on the production of errors. The results of ANOVA and LSD showed that the error ratios in producing sentences with 3rd person singular -s were significantly different among the three stimulus types.

3.2.3 Wakabayashi & Yamazaki (2006)

Wakabayashi & Yamazaki (2006) investigated the effects of objects intervening between subjects and verbs. They used sentence types as in (14). Subjects and verbs were adjacent to one another in four types of sentences (14a-d); short adverbs appeared between subjects and verbs in one type of sentences (14e); and long adverbs did so in another type of sentence (14f); prepositional phrases intervened between the head noun in subject noun phrases and verbs in three types of sentences (14g-i); and demonstratives and quantifiers preceded the head noun in subject noun phrase in one type (14j).

(14)a. The child speaks English very well.
   b. You work very hard every day.
   c. Ken and Peter play basketball every Saturday.
   d. My parents clean our house every Sunday.
   e. The student often walks to school.
   f. The teacher usually makes dinner for his mother.
   g. The boy with the blue eyes speaks Japanese very well.
   h. The lady with the red flag guides us in this tour.
   i. The driver with two bags drives a bus from here to Kyoto.
   j. Those two doctors live near my house.

Among the three types of sentences with a prepositional phrase, the complement of the preposition differed in terms of its number marking. In one type (14j), the complement is [plural], marked only by the plural marker -s; in another type (14k), the complement is singular; and in the third type (14i), the complement noun phrase is [plural] but it is marked by both a
quantifier and the plural morpheme -s. In all three types, the preposition was with. Each type of sentences had four tokens.

The task was the same oral translation task as in Fukushima (2001) and Maemura (2002). Participants included 32 Japanese university students. The results are given in Figure 10. In this figure, the ratios indicate the proportion of correct answers.

Figure 10. Correct responses in Wakabayashi & Yamazaki (2006)

The results of ANOVA showed that the mean correct responses were significantly different among sentence types (F (9, 300) = 11.39, p < .01). It is clear that learners failed to produce correct responses in Types (14e) and (14f) where adverbs intervene between subjects and verbs. Interestingly, there were no significant differences between Type (14a) and Types (14g, h, i), which shows that the existence of a prepositional phrase between the head noun of subject a NP and the verb has no effect on the use of 3rd person singular -s. The difference between sentences with long adverbs (14f) and those with short adverbs (14e) was not statistically significant although the mean scores of the correct use appeared to be different.

Wakabayashi & Yamazaki (2006) compared correct responses with sentences with sometimes and always on the one hand, and those with often and usually on the other in order to see whether /sl at the end of adverbs has any effect in the use of 3rd person singular -s but found no significant difference between the two groups (t=1.96 n.s.).

In summary, the results of the three experiments showed that:

i) learners tend to omit 3rd person singular -s more often when adverbs are inserted between subjects and verbs.

ii) long adverbs are greater obstacles than short adverbs.

iii) the existence of a prepositional phrase between a subject and a verb does not seem to have any effect on the use of 3rd person singular -s.
3.2.4 Brief discussion
First, let us consider why prepositional phrases do not influence on the use of 3rd person singular –s even though it is longer than an intervening adverb. Compare the sentences in (15):

(15) a. The student often walks to school. (= 14d)

b. The boy with the blue eyes speaks Japanese very well. (= 14f)

What Wakabayashi & Yamazaki (2006) proposed was that prepositional phrases do NOT intervene between subjects and verbs, but they in fact exist within the subject noun phrase. Structurally, the subjects and verbs are adjacent in (15b). On the other hand, adverbs require the projection of an additional layer between subject NPs and verbs. Compare the structures in (16), which show the structures for (15a, b):

(16) a. 

![Diagram showing the structure of the sentences in (15a, b)]
Subject-verb agreement is structured among a DP subject, T, and V. As clearly shown in (16a), the insertion of an adverb intervenes between T and V, while the insertion of a prepositional phrase has no effect on the structural relationship among these three elements. Therefore, it is plausible that the structural distance between subjects and verbs matters, but the linear distance between them does not matter. Without assuming the existence of underlying structure, the difference in error ratios between (15a) and (15b) cannot be explained. Since it is natural to posit that underlying structures are sanctioned by our linguistic knowledge, it is plausible to argue that the use of grammatical morphemes is very likely to be constrained by our innate system.

However, when adverbs are used between subjects and verbs, the length of the adverb appears to cause different effects. I suggest that because of the difficulty in producing sentences with correct use of 3rd person singular -s and adverbs, this small difference between short and long adverbs matters. Since the length of the adverb has nothing to do with linguistic structures, this difference reflects performance factors.

It should be noted here, saying that L2 learners have problems with performance factors does not mean that they do not also have problems with structure construction in the derivation of sentences as well as with associating relevant features with lexical items. It is clear that L2 learners face multiple problems when they need to use 3rd person singular -s.

4 Discussion

Let us reflect on the findings from the empirical studies based on the model of derivation illustrated above. We saw the following diagram earlier.
We found that learners are more sensitive to [person] than to [number]. This is attributable to the process of making an array of lexical items in the Lexicon. I suggested that [person] is a feature inherent to all noun phrases but [number] has to be associated in the course of the derivation. It may be also the case that the relevant features may not be associated with verbs, so that verbs have default (i.e., uninflected) forms. In Syntax or Morphology, the structural distance between subjects and verbs influence the success or failure of marking verbs with the 3rd person singular -s morpheme. It might also be the case that the mapping of the feature bundle [3rd person] [singular] and [present] on -s at Morphology may cause the omission of this morpheme. After the linguistic object is sent from Phonetic Form to the system for articulation, performance factors on real-time processing are likely to influence the correct use of 3rd person singular -s. This is shown in the data where long adverbs have more effects than short adverbs in the ratios of errors.

In short, errors in the use of 3rd person singular -s are caused by multiple factors. By controlling syntactic contexts and the features associated with lexical items, it was made clear that a number of factors are involved, and the system illustrated in Figure 3 appears to explain why certain errors were more likely. It is clear that Goldshneider & Dekeyser’s (2001) explanation, or in fact any account without formal features or structures underlying surface forms, fails to account for the findings in the six studies cited in this section.

What makes it possible to conduct such empirical studies? There are at least two important reasons. One is that researchers have some sort of intuition about L2 learners’ behavior and SLA. This is a requirement for any research in SLA studies. The second is that certain predictions require a robust theoretical framework. Only through a theoretical framework that adequately describes learners’ linguistic knowledge and linguistic behavior can researchers posit hypotheses to test.

5 Further Discussion: How does development take place?

Goldshneider & Dekeyser (2001) suggest that saliency, both formal and semantic, explains why certain grammatical morphemes are difficult. Development may then take place (or become easier to take place) when the target form and its meaning are made ‘salient’ in a learner’s mind. However, how development takes place is not addressed in their study. What we found in the data suggests that learners’ errors are attributable to multiple factors. Some may be overcome but others are not likely to be, even if the target form is made ‘salient’ in any sense.

With regard to feature association in Lexicon and mapping formal features on relevant
sounds after PF, these processes may be learned implicitly or explicitly, following learning principles such as the ACT* model, for example. This consideration is compatible with the position held by Towell & Hawkins (1994). They suggest that UG-based knowledge and L1 knowledge become available in L2 processing as expected by the ACT* model. It might be the case, however, that [person] feature is extremely difficult for learners with certain L1s to acquire because this feature is not grammaticalized in their L1, and hence they have to acquire it from scratch. Most researchers say it is not impossible (Haznedar & Schwartz, 1997; Lardiere, 1998a, b; Prévost & White, 2000a, b) but it is extremely difficult, as we can be seen from data in Lardiere’s series of studies of a very advanced learner of English (Lardiere, 1998a, b, 2006, 2007, 2009).

If we assume that syntactic derivation takes place every time a new sentence is structured and that the operation in Lexicon and the one in Morphology take place whenever the syntactic derivation takes place, we expect that development should be gradual.

With regard to the effect of structural distance on the use of 3rd person singular -s, it may reflect limited working memory available for processing AGREE, MOVE or affix hopping in Syntax in the development of L2 use and that capacity may change over the course of SLA. If this is on the right track, the relationship between memory and linguistic knowledge needs to be investigated. Currently, such studies are practically non-existent, as far as I am aware.

One additional point that should be mentioned here is that the feature [singular] may not be primitive but composite. Lardiere (2009) suggests that the [plural] feature may vary across languages. The same may be applicable to the number feature we discuss here. When we examine very advanced learners’ knowledge and behavior, we may find that learners are able to acquire some composites of this feature more easily than others. We need to leave this question open to further research.

6 Summary and conclusion

In this paper, I presented a brief review of early findings in SLA research, which suggest that learners follow certain sequences in acquiring certain aspects of grammar. We moved on to Competing Factors Approaches where I focused on Goldschneider & Dekeyser’s (2001) meta-analysis of morpheme studies, which tried to explain the order of acquisition of grammatical morphemes in terms of ‘saliency’. After that, I presented a series of studies on Japanese learners’ use of English 3rd person singular -s. In this part, it should be made clear that ‘saliency’ is not likely to explain learners’ behavior to a full extent. These well-prepared empirical studies revealed that a number of aspects of learners’ grammatical knowledge and its use are involved in learners’ non-native-like behavior. These studies showed that learners show differences in their sensitivity to errors between [person] and [number] feature; they have problems with [number]; structural distances are more pertinent than linear distances; and linear distance matters in some cases. These finding were made possible only by paying careful attention to the structure, the features associated with the target form, and the syntactic (and other) contexts within which the target form is used.

Lastly, I should emphasize that the conclusions of these two approaches were very
different. Goldschneider & Dekeyser (2001) propose that the lack of saliency is the sole reason for the difficulty in acquiring and/or using certain morphemes. The results of studies within Modularity Approaches presented above imply that the difficulty of particular morphemes differs at least according to the kinds of features with which morphemes are associated, and the syntactic environments where they appear. It should be further emphasized that these features and syntactic descriptions are not posited for the sole purpose of these studies but have been independently motivated within theoretical linguistics.

Without detailed analysis of the properties of a target item and the contexts where it is used, we only scratch the surface of observable phenomena in second language acquisition. This point is especially important in the current situation where we have sophisticated equipment for experimentation and powerful computational tools for statistical analysis, all of which are available for scratching the surface, but no further than that: What is required is a deep understanding of human knowledge systems, particularly linguistic knowledge, psychological processing, and accounts that put forth falsifiable models / hypotheses based on logical reasoning.

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References
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