A reanalysis: a developmental study of intransitive verbs, transitive verbs, ditransitive verbs and logical subjects in Xcomps among Japanese learners of English based on Item Response Theory (IRT) and Latent Rank Theory(LRT)

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Abstract

This paper deals with Grammar Development among Japanese University students in the area of intransitive verbs, transitive verbs, ditransitive verbs and logical subjects in Xcomps. By analyzing a learners' grammatical judgment data based on Item Response Theory (IRT), we can estimate difficulty values of individual grammatical constructions, as shown in Nakano et al. 2006. As a result, we could suggest tentative developmental stages across grammatical constructions with respect to intransitive verbs, transitive verbs, ditransitive verbs and logical subjects in Xcomps. This paper summarizes our investigation in the past among approximately 3000 students. In this reanalysis, we chose 275 students who took all three tests. Shojima's Exemetrika Version 3.1 enabled us to run LRT as well as IRT (Shojima, 2010). In spite of the smaller number of subjects, the difficulty values indicate the identical developmental stages and ranked subjects demonstrate our interpretation of the six stages of development.

Keywords

Grammatical judgment tests, IRT, LRT, Unaccusative verbs, Unergative verbs, Transitive verbs, Ditransitive verbs, Logical subjects, Xcomp

1　Introduction

In order to relate our data analysis to the learner's grammatical growth, all the participants' grammatical ability was individually assessed by measure of English Grammar (MEG): see Shimizu et al. (2003). Sugino et al. (2003) illustrated that there were four types of subjects: syntax dependent, transitional, meaning dependent and cue unconscious groups who can be defined by MEG scores as follows:

Cue unconscious participants:　below 49 points
Meaning dependent participants: between 50 -59 points
Transitional participants:　between 60 – 79 points
Syntax dependent participants:　more than 80 points

All our data had been analyzed in view of Competition Model which proposes that learners go through the four stages. The most primitive stage is called 'cue-unconsicous' stage where learners do not possess any means to judge the grammaticality of a sentence, hence their responses are at random or their judgments depends not on the word order, but if they recognize some words in the sentences given, on the lexical semantics and argument structures. The next developmental stage is called 'meaning dependent' in which learners can understand the thematic roles of the entities denoted by the noun phrases, but thematic understanding are not mapped onto the grammatical functions, in short, incomplete understanding of syntax. Our grammatical judgment tasks are relevant in eliciting cue-unconsious or meaning dependent participants. Let us consider the following examples from logical subjects in xcomp:

The mother told the baby-sitter to take the baby to the park. (congruent condition)
The baby-sitter told the mother to take the baby to the park. (conflicting condition)
Mary promised Tom to go to the park.　(neutral condition)
The doctor promised the patient to take some medicine. (conflicting condition)
The patient promised the doctor to take some medicine. (congruent condition)
The mother promised the boy to go to the school. (conflicting condition)
The mother told the boy to go to the school. (congruent condition)

The congruent conditions are those which accord with our world knowledge about the thematic roles denoted by noun phrases; e/g., the roles of mother, baby-sitter and baby or the roles of doctors, patients and medicine. It is usually the case that the mother is entitled to ask the baby-sitter to take the baby to the park. It is also the case that the doctors tell their patients to take the medicine. So, if we ask the participants in the experiment who takes the baby to the park, congruent conditions help them to answer correctly. In contrast, the conflicting conditions are contrary to our expectations of thematic roles; for this reason, unless the participants knows the subject control and object control, they tend to make erroneous responses.

The logical subject of the XCOMP is determined whether the main verb is subject-control or object-control. This is specified in the lexicon as follows:

Promise V ↑ pred = promise < ↑subj ↑obj ↑xcomp>
  ↑xcomp subj = subj
Tell V ↑ pred = 'tell <↑subj ↑obj ↑xcomp>
  ↑xcomp subj = ↑obj

When the learner does not possess this lexical knowledge, we expect erroneous responses from the participants.

The next stage is called transitional stage where the thematic roles of the entities denoted by the noun phrases can be sometimes mapped onto grammatical functions, but this mapping is not stable. In the last stage of development, learners can map the thematic roles onto grammatical functions successfully, hence, this group is called 'syntax-dependent'. This interpretation of Competition Model is based on the Lexical Mapping Theory (LMT) in Lexical Functional Syntax (LFS): Bresnan (2001). LMT bridges the connection derived from argument structures to grammatical functions, suggesting that learners' semantic understanding in the form of argument structures influence learners' grammatical judgments.

We can characterize these groups as learner development, since cue unconscious participants are those whose grammatical judgments are 'uncertain', relying on imperfect lexico-semantic projection; meaning dependents are those whose grammatical judgments rely on argument structure proposed below in LFG; syntax dependents are those who can map from argument structures to grammatical functions; that is, they can possess Lexical mapping abilities which is represented lexico-syntactic projection below. Transitional participants are between meaning dependents and syntax dependents.
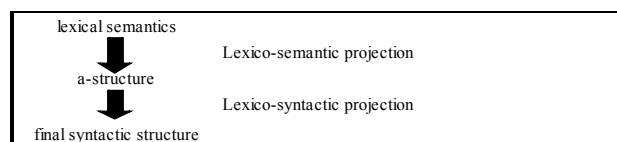
Figure 1: Basis of Lexical Mapping Theory

Let us now review LMT. LMT relates arguments (theta roles in Generative Grammars) to grammatical functions such as subj, obj, obj2 and obl(ique). LMT assigns four features to each argument:

[-o] means that it cannot be obj; therefore, it is a candidate for subj. Agent-like arguments receive [-o].
[+o] means that it must be obj or obj2. Secondary patient-like roles tend to receive [+o].
[-r] means that it is unrestricted; therefore, it can be subj or obj. Patient-like roles tend to get [-r].
[+r] means that it is restricted; in the case of English, to prepositional phrases [+r] is typically assigned.

Rule 1: If an argument is given [-o] and it is the initial argument in the argument-structure, it is given a subject function.
Rule 2: If not, the item with [-r] is given a subject function.
Rule 3: The item with [+r] is given an oblique function.
Rule 4: The function assignment follows the partial ordering:
  subj > obj and obl > obj2

Let us apply these LMT rules for the passive constructions. For the following sentence, the argument structure is specified as below:

  Tom gave me an apple.
  Give < agent, goal, theme>

Then, the features will be assigned:

  Give < agent, goal, theme>
    [-o]   [-r]   [+o]

Goal is given [-r] and therefore it can be either object or subject. It is chosen as a subject, we will get the passive sentence:

  I was given an apple by Tom.

However, theme role cannot be a subject, since it is marked as [+o]. Therefore, the following sentence is ill-formed:

*An apple was given me by Tom.

Consequently, we have the following active/passive alterations:

Give <agent, goal, theme>⇔give< subj, obj, obj2>
Be given< goal, theme, by (agent)> give < subj, obj, obl$_{ag}$>

So far, we discussed the grammatical development from the perspective of the target-language orientation. LFG architecture might start with a NL-oriented perspective, particularly when a learner is at the stage of cue-unconscious and meaning-dependent stage:
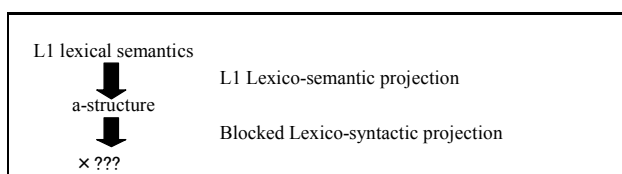
L1 lexical semantics
                        L1 Lexico-semantic projection
    a-structure
                        Blocked Lexico-syntactic projection
    ✕ ???

Figure2: Blocked Mapping

L1 lexico-semantic projection would suggest that once the target sentences can be translatable into their L1 and semantics hold acceptable in L1, these learners would accept the target sentences as grammatical. Some learners in the EFL context rely on translations, that is, if the translated sentences in their L1 are grammatically acceptable in L1, they would respond as acceptable. Particularly adversative passives and stative passives would then be accepted more readily. We will call these acceptance as L1 lexico-semantic acceptance.

2 The grammatical items analyzed

The present reanalysis of our grammatical judgment data involves the three tests we had analyzed separately in the past: Y-test, N-test and S-test.. The Y test examined unaccusative, and unergative verbs. The previous studies showed that the unergative verbs are acquired earlier than unaccusative verbs. It has been argued that the underlying forms are different in these verbs:

Unergative verbs: *laugh* (X_): [John [VP laughed]]
Unaccusative verbs: *arrive* (_<Y>): [empty [VP arrived John]]

cf. Transitive verbs (alternating unaccusative verbs) : *break* (X_<Y>): [John [VP broke the vase]]

To test this hypothesis, Y test contained transitive verbs and the passivized forms, since if learners believe that some implicit agent causes Y to do the action denoted by the verb, it can be erroneously passivized in unaccusative verbs. According to

the LMT, the subjects of unergative verbs are assigned as [-o] and those of unaccusative verbs, as [-r]. The LMT thus predicts the earlier acquisition of the unergative constructions.

In N-test, there were four kinds of sentences: (1) prepositional to-datives and for-datives; (2) their di-transitive counterparts; (3) passive sentences of prepositional datives; (4) passive sentences of the di-transitive ones. There were some items which cannot be regarded as dative sentences so that we can test whether the learners can differentiate dative constructions from non-dative constructions. We also tested whether animacy and iconicity effects in subject nouns can influence learners' grammatical judgments.

As we have already discussed, S test examined the grammatical knowledge of identifying logical subjects in Xcomps, involving subject-control verbs and object-control verbs. S-test provided three conditions: congruent, neutral and conflicting conditions. The logical subjects in object control verbs are assigned as [-r].

tell <subj, obj   xcomp<subj>>
        -o   -r   -r
        ↑ xcomp   subj = obj
                            -r   =   -r

However, the logical subjects in subject control verbs are assigned as [-o].

        promise < subj, obj, xcomp<subj>>
                    -o   -r   -o
        ↑ xcomp   subj = subj
                            -o   =   -o

Thus, LMT predicts that the acquisition of subj in subject control verbs is easier than those in object control verbs. But some grammarians such as O'Grady assume that the minimal distance principle is operative; in this case the acquisition of object control verbs should be earlier than that in subject control verbs.

In this presentation, we will reanalyze a part of our original data in 2006 in view of the difficulty values estimated by the Item Response Theory (IRT) and Neural Net Theory (NTT). This time, we restricted our data analysis for those who participated in all the three tests, Y-test, N-test and S-test. It totaled in 275 participants. We will compare our IRT analysis in the past as well.

2.1 Reanalysis: IRT

2.1.1 Y-test: Intrantive, transitive verbs and passivization

Y test contained 8 types of grammatical judgments, a-h. The following table illustrates the target sentences.

Table 1 Sample target sentences in Y-test

Category	Verb	Construction	Example
a	unaccusative	NP+V	Your letter arrived yesterday.
b	unergative		Her father cried at her wedding ceremony.
c	unaccusative	*NP+be+p.p.	*Because of the rain, the train was arrived late.
d	unergative		*He was cried when he heard of his mother's death.
e	unaccusative	*NP+V+NP	*Finally the waitress arrived the salad to us.
f	unergative		*The boy hit his little sister and cried her.
g	ergative	NP+be+p.p.	The door was broken by the police.
h	ergative	NP+V+NP	I broke a glass in the kitchen.

The difficulty mean values suggest the following rank order in the past data and in the present data:

Table 2: a comparison of difficulty values between 2006 and 2011

Type		difficulty values in 2006	in 2011
g	VTpassive	-1.51	-3.959
b	VIunergatives	-1.48	-3.274
a	VIunaccusatives	-1.12	-2.454
h	VT(ergative)	-0.95	-2.112
f	*causativized unergatives	-0.64	-0.796
e	*cauzativized unaccusatives	-0.49	-0.550
d	*passivized unergatives	-0.25	0.106
c	*passivized unaccusatives	0.26	2.977

Although the difficulty values are different in the two versions of IRT, we notice that the rank-order is identical in the two IRT analyses. If we assume that grammatical sensitivities to detect erroneous sentences as ungrammatical are highly advanced, we can simply ignore them and suggest the following grammatical growth.

Table3: Summary of Y-Test

	2006 data	2011 data
Transitive verbs (passivized)	-1.52	-3.959
Intransitive (unergative verbs)	-1.48	-3.274
Intransitve (unaccusative verbs)	-1.17	-2.454
Transitive verbs	-0.96	-2.112

We have assumed that the greatest acceptance rate of passivized transitive verbs are due to L1 lexico-semantic acceptance, since when the translated sentences in their L1 are grammatically acceptable in L1, they would respond as acceptable. Particularly adversative passives and stative passives would then be accepted more readily, as we have argued in Section 1.0.

2.1.2   N-test: di-transitive verbs, transitives and passivization

N Test is to test grammatical knowledge of dative alterations. It contains six kinds of test items which we call here A, B, C, D, E, and F:

A: Well-formed ditransitives
a. A01-A04: to-datives: predicate < -o, -r, +o > :
e.g., The family sent him ten apples.
(A01 and A03: + Human Subject Noun;
A02 and A04: － Human Subject Noun)

b. A05 – A08: for-datives: predicate < -o, -r, +o> :
e.g., John found me a new dress.
(A05 and A07: + Human Subject Noun;
A06 and A08: － Human Subject Noun)

B: Ill-formed ditransitives
a. B01 － B04: ill-formed to-datives: e.g., *The police reported Bill the fire.
(B01 and B03: + Human Subject Noun;
B02 and B04:－Human Subject Noun)

b. B05 – B08: ill-formed for-datives: e.g., *King fought the queen the monster.
(B05 and B07: + Human Subject Noun;
B06 and B08:－Human Subject Noun)

C: Prepositional datives
a. C01- C04: Prepositional to-datives: predicate <-o, -r, +r>:
e.g., The company gave a new job to him.
(C01 and C03: + Human Subject Noun;
C02 and C04:－Human Subject Noun)

b. C05 － C08: Prepositional for-datives: predicate <-o, -r, +r>:
e.g., Simon made a new dinner table for us.
(C05 and C07: + Human Subject Noun;
C06 and C08:－Human Subject Noun)

D: VT + PP (non-dative sentences)
D01:   Mr. Jones reported the accident to me. <agent, theme, goal>, <-o, -r, +r>
D02:   The police reported the fire to Bill.
D03:   My wife moved three golf clubs to me.
D04:   The family moved a box of apples to me.
D05:   King Arthur fought the monster for the queen. <agent, patient, beneficiary>, <-o, -r, +r>
D06:   The company burned a lot of boxes for me. <agent, theme/patient, beneficiary>
D07:   Simon discovered a nice dinner table for us.

<agent, theme, beneficiary>

D08: The company discovered a new house for them

E: Well-formed passives: human subject.

E01 – E04: to-datives: e.g., I was given some money by Mr. Jones.

E05 – E08: for-datives: e.g., I was found a new dress by John.

F: Ill-formed passives: theme subject

F01 – F04: to-datives: e.g., *Some money was given me by Mr. Jones.

F05 – F08: for-datives: e.g., *The new dress was found me by John.

Our previous analysis was based on Lexical Functional Grammar (LFG, henceforth) (e.g., Nakano et al., 2005). We offered four predictions based on LFG: (1) the higher acceptability of unmarked forms, (2) the animacy effect derived from Subjecthood Hierarchy, (3) the presence of iconicity in to-datives vs. for-datives which favours the higher rate of acceptability for to-datives than that of for-datives, and (4) ill-formed passives would be rejected due to the lexical mapping from argument structures to grammatical functions.

The C-D-A developmental pattern was again born out in the present study. Once we averaged difficulty scores according to each of the six types. Group C was the easiest and therefore accepted most. On the other hand, Group E was the most difficult and therefore accepted least. The order of difficulty may be assumed to reflect learners' average acceptance order.

Table4: A Comparison of IRT in 2006 and 2011

	2006 data	2011 data
C (prepositional datives):	-1.27	-1.646
D (prepositional non-datives):	-1.10	-1.629
A (ditransitives):	-0.34	0.337
*B (*non-ditransitive verbs turned into transitives):	-0.15	3.003
*F(*theme subject passives):	.09	3.178
E (human subject passives):	0.16	1.5

It must be noted that all well-formed sentences receive the identical ran-order in 2006 and 2011.

When we combine the results of Y test with N-test, we can suggest the following, ignoring the intuitions for ungrammatical sentences:

Table 5: A Comparison of IRT in 2006 and 2011

	2006 data	2011 data
Transitive verbs (passivized)	-1.52	-3.959
Intransitive (unergative verbs)	-1.48	-3.274
Intransitive (unaccusative verbs)	-1.17	-2.454
Transitive verbs	-0.96	-2.112

Prepositional datives	-1.27	-1.646
Prepositional non-datives	-1.10	-1.629
Ditransitives	-0.34	0.377

2006 and 2011 analysis yields the identical ran-order correlations. When we assume that the difficulty values predict grammatical growth, 2011 data confirms the same tendency of grammar growth among our subjects.

Table 6: S-test Logical subjects in Xcomp

	2006 data	2011 data
Convergent (subject control verbs)	-1.49	-2.051
Convergent (object control verbs)	-1.16	-1.605
Neutral (subject control verbs)	-0.94	-1.353
Neutral (object control verbs)	-0.51	-0.480
Conflicting (object control verbs)	0.04	0.4474
Conflicting (subject control verbs)	0.84	2.201

The results of S-test confirms the identical rank-order correlations in 2006 and 2011.

When we combine the rank-order relations of these data, we can suggest the following grammatical growth:

Table 7: Summary of Y-, S-, N-Test

	2006 data	2011 data
Transitive verbs (passivized)	-1.52	-3.959
Convergent (subject control verbs)	-1.49	-2.051
Intransitive (unergative verbs)	-1.48	-3.2
Prepositional datives	-1.27	-1.646
Intransitve (unaccusative verbs)	-1.17	-2.454
Convergent (object control verbs)	-1.16	-1.605
Prepositional non-datives (VT+PP)	-1.10	-1.629
Transitive verbs	-0.96	-2.112
Neutral (subject control verbs)	-0.94	-1.353
Neutral (object control verbs)	-0.51	-0.480
Ditransitives	-0.34	0.337
Conflicting (object control verbs)	0.04	0.4474
Conflicting (subject control verbs)	0.84	2.201

The rank-order correlation rho is 0.9956. The data in 2011 suggest the following judgment order.

Table 8: 2011 Rank-Order Results

	2006 data	2011 data
Transitive verbs (passivized)	-1.52	-3.959
Intransitive (unergative verbs)	-1.48	-3.2
Intransitve (unaccusative verbs)	-1.17	-2.454
Transitive verbs	-0.96	-2.112
Convergent (subject control verbs)	-1.49	-2.051
Prepositional datives	-1.27	-1.646
Prepositional non-datives (VT+PP)	-1.10	-1.629
Convergent (object control verbs)	-1.16	-1.605
Neutral (subject control verbs)	-0.94	-1.353
Neutral (object control verbs)	-0.51	-0.480
Ditransitives	-0.34	0.337
Conflicting (object control verbs)	0.04	0.4474
Conflicting (subject control verbs)	0.84	2.201

Since we are dealing with the restricted number of subjects in this paper, we regard the 2011 rank order as relevant to this study.

3 Ranked subjects' linguistic behavior abstracted by Neural Test Theory

Shojima's Exametrika was run among response data given by 275 participants. Nakano et al. (2007b) yielded the result of 6 stages of grammar development, based on the Bilog IRT. In running ExametrikaJ53(Shojima, 2010), we set the number of ranks as 6: see for the goodness of fit values in Appendix 1.

The following Table summarizes our result. We have assumed that by looking at the membership profile value for each rank reflects the earlier acquisition items. For instance, For rank 1, the following items are estimated as those rank 1 participants answer fairly correctly (60%).

Table 9: Sentences elicited 60% correct responses among Rank 1 participants

Item	Sentence Type	Sentence Used	Rank 1
N11	C08	The company made a new uniform for the secretary.	0.552
S17	S-Test Distractor		0.553
S43	S-Test Distractor		0.556
N08	C03	My wife sent three golf clubs to me.	0.557
N29	C04	The family sent ten apples to me.	0.564
N40	E06	He was found a new office by the company.	0.565
Y17	Yf	*The boy hit his little sister and cried her.	0.571
N35	C06	The company found a new office for him.	0.572
Y06	Ya	My grandmother died when I was five.	0.574
N22	B08	The company discovered them a new house.	0.574
Y31	Yf	*The boss worked his employees very hard.	0.577
Y25	Yg	A lot of roses are grown in the village.	0.580
S29	NEUTs.	John promised Mary to attend the lecture.	0.582
S11	CONVo	The mother told her son to clean up the room.	0.582
Y04	Ye	*Finally the waitress arrived the salad to us.	0.586
S13	CONVs.	The student promised the teacher to hand in his report by tomorrow.	0.596
N12	A01	Mr. Jones gave me some money.	0.596
N19	C07	Simon made a new dinner table for us.	0.599
S27	NEUTs.	Ken promised John to show his new computer.	0.601
N03	C02	The company gave a new job to him.	0.609
N26	A02	The company gave him a new job.	0.611
N31	C05	John found a new dress for me.	0.613
S20	CONVo	The police officer told the driver to stop the car immediately	0.615
Y37	Yh	The sun soon melted the ice in the lake.	0.621
S36	NEUTo.	Peter asked Ken to come and see his new computer.	0.626
Y23	Yb	Children played with a ball on the beach.	0.631
S16	S-Test Distractor		0.635
Y05	Yg	Their shirts were dried in the room.	0.637
S41	S-Test Distractor		0.638
Y46	Yb	They danced all night at the bar.	0.643
N39	D07	Simon discovered a nice dinner table for us.	0.664
N47	E04	He was sent ten apples by the family.	0.664
S42	CONV.o	The customer asked the waitress to bring a new spoon.	0.671
S34	S-Test Distractor		0.702
Y30	Yh	He closed the gate at six o'clock.	0.712
N07	B05	*King fought the queen the monster.	0.717
S08	S-Test Distractor		0.765
Y19	Yg	The door was broken by the police.	0.772
Y42	Yb	She works for a computer company.	0.814

After the membership profile values are rounded off at the third decimal point, the ratio of the

acquisition rate is set as 0.60, The percentage indicates the ratio derived from the number of items which the participants surpassed each acquisition rate (0.6), divided by the total number of test items belonging to each grammatical construction.

Table 10: NTT Ranks and Correct Response Ratio

Sentence Type	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5	Rank 6	Beyond
b VI unergative	50%	83%	100%	100%	100%	100%	
g VT pass.	50%	50%	100%	100%	100%	100%	
a VI unaccusative	17%	17%	67%	100%	100%	100%	
h VT (ergative)	33%	50%	67%	100%	100%	100%	
Conv. S	25%	50%	100%	100%	100%	100%	
C	87.5%	87.5%	87.5%	100%	100%	100%	
D	12.5%	12.5%	75%	87.5%	100%	100%	
Conv. O	50%	50%	87.5%	100%	100%	100%	
Neut. S	50%	50%	75%	75%	100%	100%	
Neut. O	12.5%	25%	37.5%	50%	87.5%	100%	
A(ditransitives)	0	12.5%	50%	75%	75%	100%	
Conf. O	0	0	0	12.5%	50%	75%	100%
Conf. S	0	0	0	0	0	0	100%

Note: VT pass. stands for passivized transitive constructions.
Note: C stands for prepositional datives.
Note: D stands for VT+PP (non-dative prepositional transitive constructions).

Rank 1 result indicates that g (passivized transitive sentences) is no longer the easiest item for our students. C (prepositional datives) i.e., VT +PP receives higher rate of acceptance. This might mean that L1 lexico-semantic effect is weakened in g and kernel construction of VT+PP is accepted more readily. We also notice that the subject nouns in Rank 1 sentences are marked as [-o], except for Ya; Construction 'a' is marked as [-r]. This supports the LMT in LFG. In Rank 2 sentences, apart from A (ditransitives), the grammar knowledge of our learners remains the same. Rank 3 participants correctly respond to all of the b[intransitive verbs (unergative)], g[passivized VT] and convergent sentences with object control verbs. Rank 4 participants begin to respond correctly to all of the a [VI unaccusative], h [VT (ergative)], C[prepositional datives], and Conv. O[convergent sentences with subject control verbs]. So far, the LMT predictions are met, since b is accepted by Rank 2 participants and a is accepted by Rank 3 participants; i.e., [-o] is acquired earlier than [-r]. Further, subject control verbs elicit more correct responses than object control verbs. Rank 5 participants begin to respond correctly to all of the D[VT+PP (non-dative prepositional transitive constructions)] and Neut. S[neutral sentences with subject control verbs]. Rank 6 participants begin to respond correctly to Neut. O[neutral sentences with object control verbs] and A[ditransitive constructions] most of the time. Some learners beyond Rank 6 respond correctly to Conflicting conditions with object control verbs and subject control verbs. Conf. O is more difficult than Conf. S, which contradicts the prediction made by the LMT. Conflicting sentences supports the minimal distnce hypothesis. However, in considering the process of sentence parsing, our World Knowledge interacts with the semantic processing. This interpretation might apply to our participants.

Having argued this way, we can be certain that the LRT provides us with an appropriate and efficient framework of measurement in which we can examine the theoretical assumptions in linguistics.

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Appendix 1 Goodness of fit to LRT

$\chi 2$	57.925
Degrees of freedom	2736
P	1.000
NFI	0.962
RFI	0.962
IFI	1.000
TLI	1.000
CFI	1.000
RMSEA	0.000
AIC	−5414.075
CAIC	−18045.560
BIC	−15309.560