Implicit Artificial Grammar, and Incidental L2 Learning: How Comparable Are They?

Peter Robinson

Aoyama Gakuin University

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- How related are the cognitive abilities and processes drawn on during artificial grammar (AG) learning, and those drawn on during incidental natural language learning?

- To examine the generalizability of AG learning to natural language learning by experienced Japanese L1 learners of L2 English, I directly compared, in a repeated measure design, implicit learning of an AG and incidental learning of a novel language, Samoan.

- Specifically, I attempted to replicate findings from two influential AG studies to examine their generalizability to incidental natural language learning.

- **Study 1.** Reber, Walkenfeld & Hernstadt (1991) argued implicit (in contrast to explicit) learning, being evolutionarily and ontogenetically earlier evolved, should display fewer individual differences, and tighter variance in scores, and operate largely independently of standard measures of cognitive capability, such as IQ.

- Confirming this they showed significantly greater variance in explicit learning, than in implicit AG learning, and a positive correlation with IQ (.69, $p < .01$) for explicit, but not implicit AG learning (.25, $p > .05$)

- Issues addressed:
- 1) will the independence of IQ and AG learning also be found for experienced L2 learners?
- 2) do those L2 learners who do well at AG learning also do well at incidental Samoan learning?
- 3) is AG learning similarly independent of other abilities for SLA, such as aptitude and WM?

- **Study 2.** Knowlton & Squire (1996) showed that manipulating the frequency of chunks in AG training set items, influenced learners to wrongly judge ungrammatical items containing many chunks as acceptable, but had no effect on judgments of grammatical items.

- Issues addressed:
- 1) will experienced L2 learners also show the same effects for frequency and chunking on AG learning?
- 2) will chunk-strength similarly affect incidental learning of Samoan?
- 3) do aptitude, WM or IQ subtests predict learning of items low, versus high in chunk-strength?

- **The Study**
- **Participants:** 54 L1 Japanese, experienced (and successful) L2 learners of English, aged19-24 yrs.
- **Explicit Learning task:** This was the series solution task used in Reber et al. (1991). Twelve were completed, 6 alphabetic problems (e.g., ABCBCDCDE_ D* or C; and 6 mirroring problems (e.g., CDEADCA_ E* or D).
- These were completed on a computer screen, without feedback, and percent correct scores were calculated as in Reber et al.

- **Implicit Learning Task:** As in Reber et al., and Knowlton and Squire, participants saw 26 strings (e.g., XXVT, VXJJJJ) in each of the two trials of training.
- The AG was from Abrams & Reber (1989) and the training and transfer sets were from Knowlton & Squire (1996).
- In training they saw each string for 3 seconds on a computer screen then were instructed to write it down so as to remember it.

- **Transfer set items and Chunk-strength:** As in Knowlton & Squire, transfer set items were grammatical/ungrammatical, high/low chunk strength (four types). Chunk strength of each transfer item was calculated by summing the number of bigrams (XJ) and trigrams (VJT) it contained that appeared in training, and their respective frequency of occurrence.

- So if a transfer item (XJVJT) contained two chunks, occurring a combined total of 10 times (2/10) its mean associative chunk strength was 5.

- **Incidental Learning task:** Participants first rote learned English and Japanese meanings of 27 new Samoan words, 1 article, 15 nouns, and 11 verbs, e.g., taavale (car kuruma).
- They then completed ten trials of training, spread over two days. In each trial they saw 45 Samoan sentences of three constructional types (450 tokens in total).
- Ergative: ave e le tama le taavale (the boy drives the car)
- Locative: taalo le tama i le paka (the boy plays in the park)
- Incorporated: ave-taavale le tama (drives car the boy)

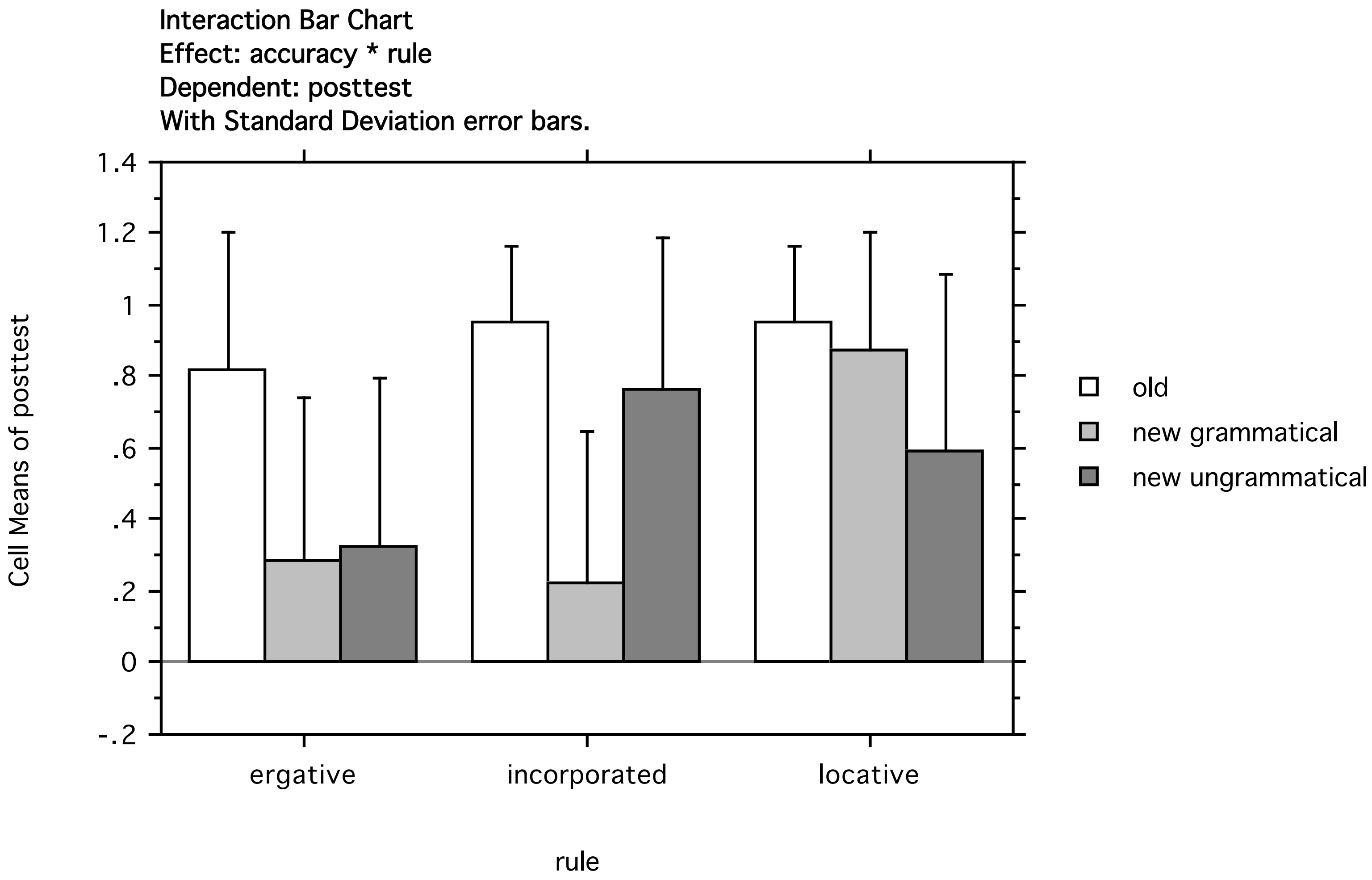
- During training a sentence appeared on the screen, e.g., taalo le tama i le paka, for 10 seconds, followed by a question, e.g., Does the boy swim in the sea? After responding yes or no, participants got correct/incorrect feedback.

- **Transfer:** After the last trial of training they saw 9 old grammatical items viewed in training, 9 new grammatical and 9 new ungrammatical items. They were asked to judge yes/no if these followed the same rules as the sentences they had just viewed in training. High/low chunk-strength was calculated for the new grammatical/ ungrammatical items as it was for the AG items.

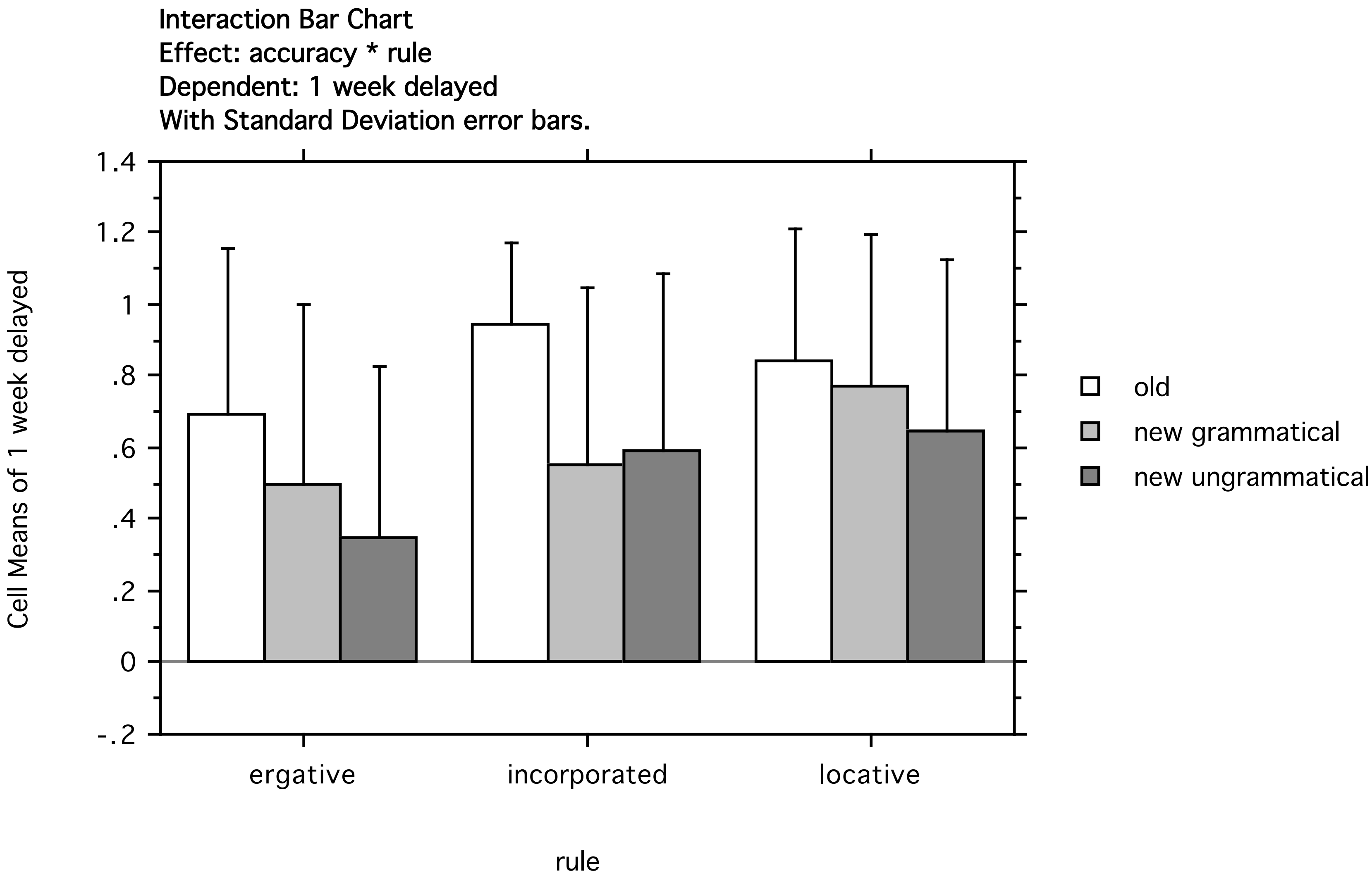
Listening GJ test and word sort test: Following the computerized GJ transfer test, participants completed an aural GJ test—the same items as in the computerized GJ test, in a different order—and a guided written production test, in which they sorted Samoan words and particles into the correct word order for a sentence.

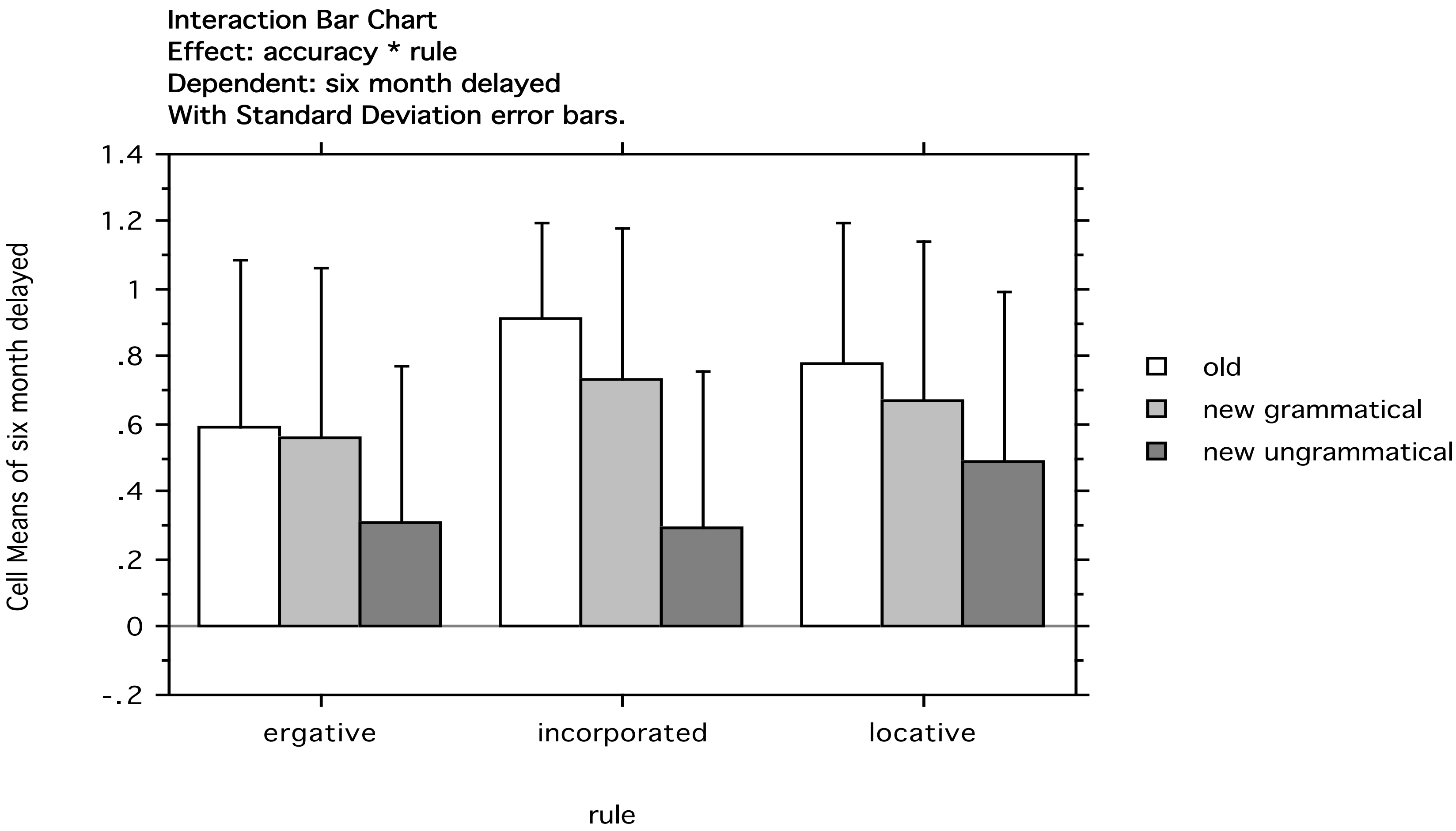
One week delayed transfer test: The computerized GJ, Listening GJ and word sort were completed again.

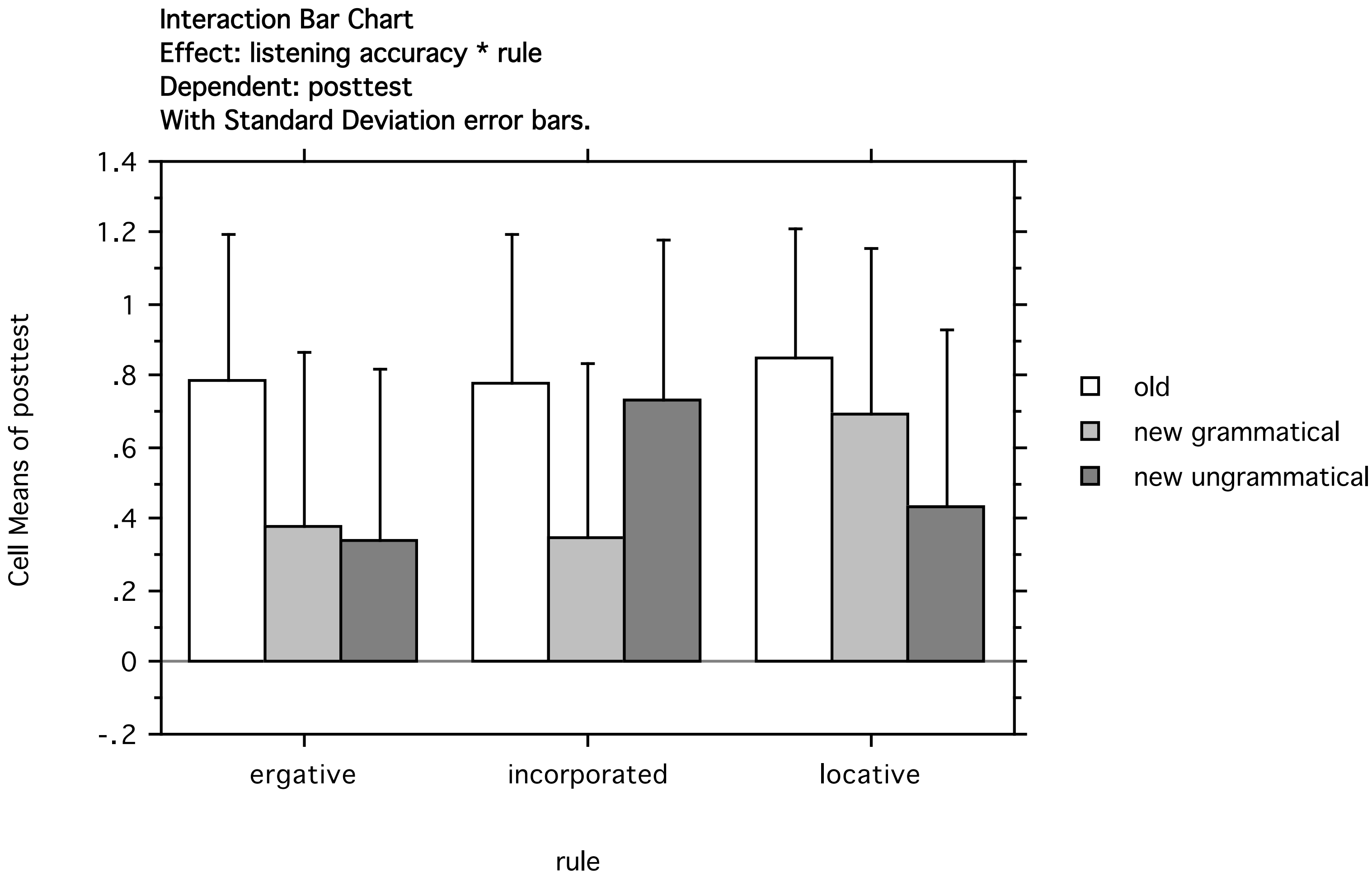
Six month delayed transfer test: Only the computerized GJ and word sort were completed.



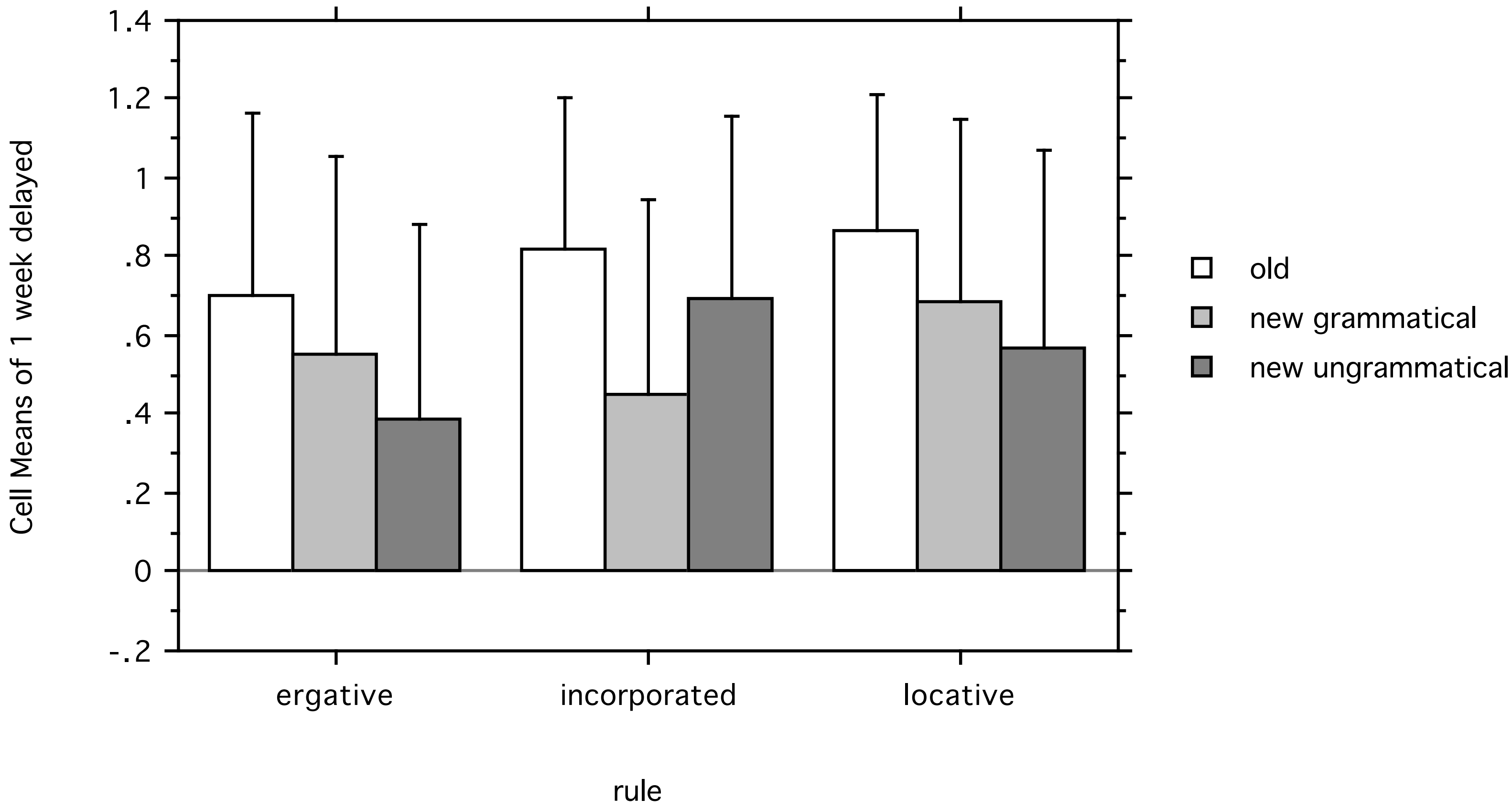
Interaction Bar Chart
Effect: accuracy * rule
Dependent: posttest
With Standard Deviation error bars.
1.4
1.2
1
.8
.6
.4
.2
0
-.2
Cell Means of posttest
ergative
incorporated
locative
rule
old
new grammatical
new ungrammatical

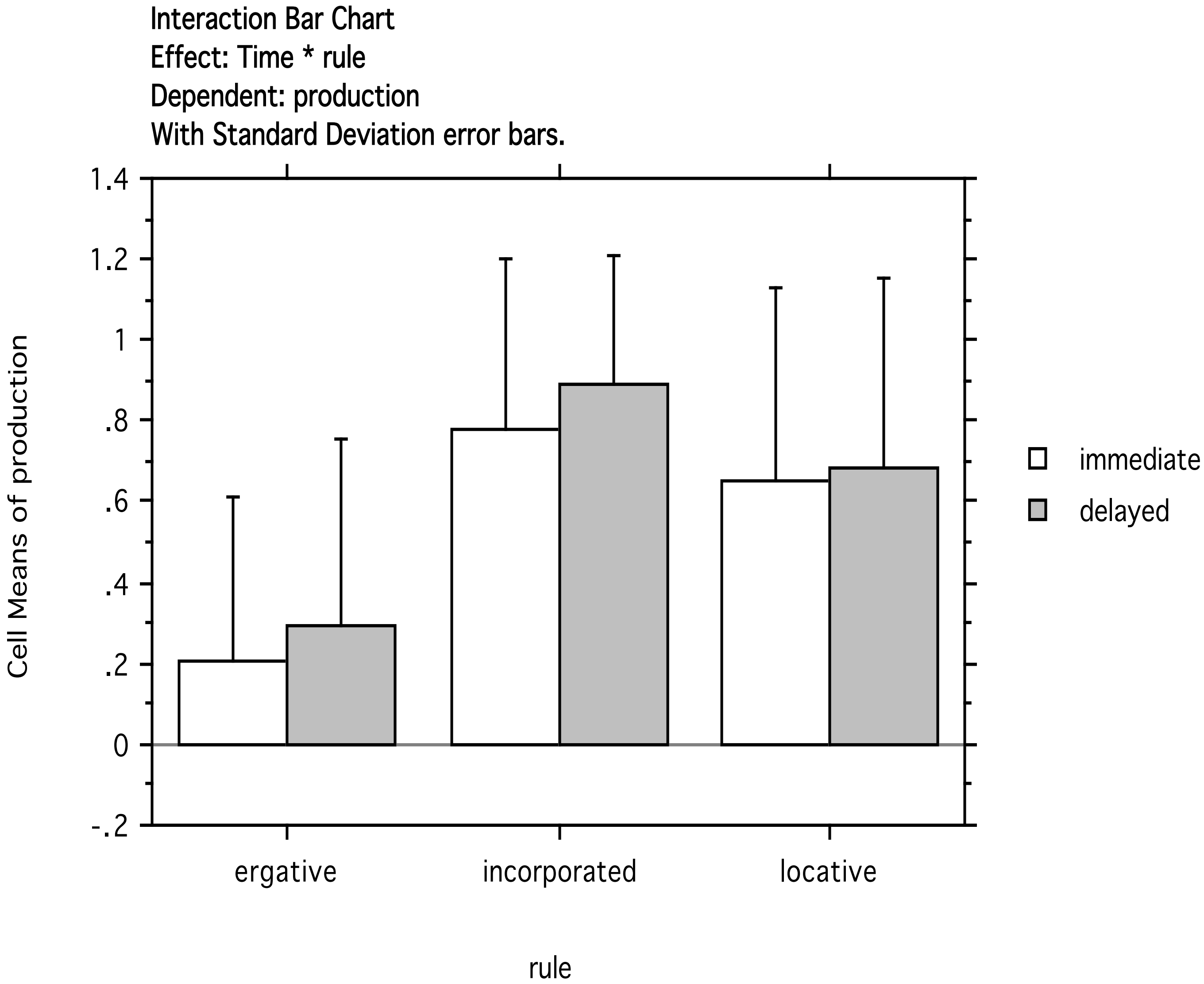

Interaction Bar Chart
Effect: accuracy * rule
Dependent: 1 week delayed
With Standard Deviation error bars.
Cell Means of 1 week delayed
1.4
1.2
1
.8
.6
.4
.2
0
-.2
ergative
incorporated
locative
rule
old
new grammatical
new ungrammatical


Interaction Bar Chart
Effect: accuracy * rule
Dependent: six month delayed
With Standard Deviation error bars.
Cell Means of six month delayed
1.4
1.2
1
.8
.6
.4
.2
0
-.2
ergative
incorporated
locative
rule
old
new grammatical
new ungrammatical


Interaction Bar Chart
Effect: listening accuracy * rule
Dependent: posttest
With Standard Deviation error bars.
Cell Means of posttest
1.4
1.2
1
.8
.6
.4
.2
0
-.2
ergative
incorporated
locative
rule
old
new grammatical
new ungrammatical

Interaction Bar Chart
Effect: listening accuracy * rule
Dependent: 1 week delayed
With Standard Deviation error bars.





Interaction Bar Chart
Effect: Time * rule
Dependent: production
With Standard Deviation error bars.
Cell Means of production
1.4
1.2
1
.8
.6
.4
.2
0
-.2
ergative
incorporated
locative
rule
immediate
delayed

- **Individual Differences/Cognitive Ability Measures:**
- **IQ.** As in Reber et al. I calculated IQ on the basis of a short form of the Wechsler Adult Intelligence test (Vocabulary, Block design, Arithmetic).
- **Working Memory.** I used Osaka and Osaka's reading span test scored using total number of correctly recalled words.
- **Aptitude**. I used Sasaki's LABJ, a measure of rote memory for paired associates, grammatical sensitivity, and phonemic sensitivity (a Japanese version of three MLAT subtests).

Table 3. Intercorrelations of IDs, awareness and measures of incidental learning over time

	GJ test			LGJ test		Production test		
	T1	T2	T3	T1	T2	T1	T2	T3
Apt	-.25	-.09	.13	.22	.08	.3	.18	.56 **
Int	-.09	-.03	-.07	.18	-.02	-.007	.1	.16
WM	.07	.06	-.12	.42 **	.48 **	.06	.33 *	.44 *
Aw	.003	.11	-.02	.11	.12	-.03	.04	.28
Aw2	—	—	.18	—	—	—	—	.45 *

Key: * = $p < .05$ ** = $p < .01$, Apt = Aptitude, Int = Intelligence, WM = Working memory, Aw = Awareness, immediate posttest, Aw2 = Awareness, six month delayed posttest, GJ = Grammaticality judgement, LGJ = Aural grammaticality judgement, T1 = Immediate posttest, T2 = One week delayed posttest, T3 = Six month delayed posttest

Table 5. Intercorrelations of IDs, awareness and incidental learning of three rules, as measured by performance on the GJ test over time.

% Correct	Apt	Int	WM	Aw
Ergative T1	-.26	-.11	-.04	-.22
Ergative T2	-.27	-.03	.002	-.25
Ergative T3	-.13	-.15	-.06	-.16
Incorporated T1	-.02	-.03	-.06	.17
Incorporated T2	.11	-.003	.24	.35*
Incorporated T3	-.22	.2	-.13	.15
Locative T1	-.13	-.03	.27	.19
Locative T2	.05	-.08	-.06	.28
Locative T3	.47*	-.19	.16	.36

Key: * = $p < .05$, T1 = immediate posttest ,T2 = one week delayed posttest, T3 = six month delayed posttest, Apt = Aptitude, Int = Intelligence, WM = Working memory, Aw = Awareness

- **Results:Comparing AG and Samoan Learning**
- **Cognitive abilities in implicit and explicit learning:** As Table 1 shows, contra Reber et al.’s finding, implicit AG learning is significantly negatively correlated with IQ (-.34) and explicit learning is nonsignificantly positively correlated.
- AG and incidental learning show different patterns of correlation with aptitude and IQ subtests (Tables 3 and 4)
- However, as in Reber et al. an F-test shows significantly lower variance in implicit learning than explicit learning (Table 2).
- But variance in incidental Samoan learning is not significantly different from implicit AG or explicit learning.

- **Chunk-strength and implicit AG learning:** As Table 5 shows, Knowlton & Squires results are replicated for AG learning. High chunk-strength does not influence correct acceptance of grammatical items (59% v. 62%), but does influence incorrect acceptance of ungrammatical items (34% correct v. 65%).

- **Chunk-strength and incidental Samoan learning:** As Table 5 also shows, high chunk-strength has the same negative effect on incorrect acceptance of ungrammatical items, but unlike in AG learning, it also negatively influences learners to wrongly reject grammatical items.

- **Input frequency and similarity in incidental natural language learning:**
- The 'number of chunks' an item contains in the incidental learning GJ transfer set, that previously occurred in the training set, influences correct acceptance of grammatical sentences (see Table 6).
- The more previously experienced chunks grammatical items contain, the more they are correctly accepted (r .68).Similarly, the more chunks ungrammatical items contain, the more wrongly they are judged acceptable (r -.45).
- Global similarity alone is the biggest influence on incidental natural language learning.

- **So how comparable are AG and natural language learning?**
- Success in each draws on different clusters of cognitive abilities, and is not significantly related in this study (Tables 1, 3 & 4).
- As Table 6 shows, frequency of occurrence of chunks in training alone, had little influence on the accuracy of response to grammatical ungrammatical Samoan items. However, frequency in the sense of chunk-strength had a powerful, and replicated influence on AG learning.

- But as Table 6 shows, the greater the number of chunks a transfer set Samoan item contained that had also appeared in training (its global similarity to training examples) the more likely it was to be judged (rightly or wrongly) acceptable:
- So a summary answer could be:
- **While AG learning is very sensitive to frequency effects (associative, data-driven processing—procedural learning in the neocortex), adult incidental L2 learning is more global similarity driven (episodic, conceptually-driven processing—declarative learning in the medial temporal lobe), at least in the early stages.**

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