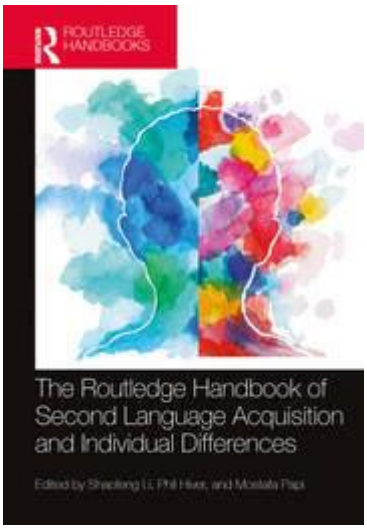
[Preprint version] Please cite as:
Suzuki, Y. (2022). Individual Difference Factors for Second Language Grammar.
In S. Li, P. Hiver, & P. Mostafa (Eds.), *The Routledge Handbook of Second Language Acquisition and Individual Differences* (pp. 294-309). New York: Routledge.



ABSTRACT

A great number of individual difference factors has been examined to account for considerable variations in L2 grammar attainment. In the first part of this chapter, the roles of two major factors (age of onset and cognitive aptitudes) that received focal attention in predictive research of L2 grammar learning are reviewed. L2 grammar acquisition in both naturalistic and classroom settings are viewed from the perspectives of L2 theories on explicit and implicit learning. The second part of this review focuses on how learners' individual difference factors, particularly cognitive aptitudes, moderate the effectiveness of different types of L2 grammar learning conditions in instructed settings. In particular, aptitude-treatment interaction patterns are summarized for extant research on oral and written corrective feedback types and timing of grammar instruction and practice. Future directions of research that strike the balance between theoretical integrity and pedagogical relevance are presented to further advance our understanding of individual difference factor in L2 grammar learning.

Keywords: L2 grammar learning, age of onset, cognitive aptitude, explicit and implicit knowledge and learning, aptitude-treatment interaction, corrective feedback, timing of instruction

Chapter 19. Individual Difference Factors for L2 Grammar
Yuichi Suzuki

BACKGROUND

Grammar has always been at the center of debates in second language (L2) teaching and learning. Given the considerable individual differences in L2 grammar acquisition, two lines of research are reviewed in this chapter. The first theme pertains to predictive research aiming to establish the extent to which individual difference factors can explain the variations in L2 grammar attainment in both naturalistic and classroom settings. Development of grammatical knowledge is a complex and dynamic process, influenced by a plethora of internal (age, cognitive, conative, and affective factors) and external (context, amount of experience, teaching methods) factors. In this chapter, focus is given to the two key factors—age of onset (AO) and cognitive aptitudes—both of which are strong predictors of L2 learning. AO accounts for around 30% of L2 grammar attainment in naturalistic L2 acquisition contexts (Qureshi, 2016), and aptitude explains 10−20% of L2 grammar acquisition in both naturalistic and classroom L2 acquisition contexts (Granena & Long, 2013; Li, 2015). Cognitive aptitudes are conceived of as a multi-componential construct (Carroll & Sapon, 1959). Key aptitude components for L2 grammar learninginclude grammatical sensitivity (the ability to identify grammatical functions of words in sentences) and inductive language learning ability (the ability to induce rules from language input), both subsumed under language analytic ability. Furthermore, it is recently proposed that cognitive aptitudes can be conceptualized as abilities for explicit learning (i.e., conscious, attention-driven learning processes) and implicit learning (i.e., learning without intention or awareness) (Granena, 2019; Linck et al., 2013). In addition to language analytic ability (conceived as explicit learning aptitude), statistical sequence learning ability has received increasing attention as a potential aptitude component for implicit learning. In the first part of this chapter, the roles of age and cognitive aptitudes, as well as their interaction effects, are reviewed particularly through the lens of L2 theories on explicit and implicit learning.

The second theme concerns how learners' individual characteristics, particularly cognitive aptitudes, moderate the effectiveness of different types of L2 grammar instruction, broadly categorized as aptitude−treatment interaction (ATI) in educational research. Cronbach and Snow (1977) proposed that optimal learning is the result of alignment between instruction and learners' aptitudes, and this idea was adopted in the early stages of L2 research. In these earlier studies, the roles of aptitude were examined at the level of teaching methods and approaches, such as grammar translation approach versus communicative approach (e.g., Ando et al., 1992). As the "macro" ATI research makes it difficult to isolate specific variables embedded intricately in the teaching methods and approaches, contemporary ATI research takes a more "micro" approach that focuses more on how the roles of aptitudes vary depending on L2 instructional treatment that differs in one or more specific aspects (e.g., provision/omission of explicit instruction). Two frequently investigated cognitive abilities in ATI research are language analytic ability and working memory (Linck et al., 2013; Wen et al., 2017). Understanding ATI patterns by investigating a variety of aptitude components has become increasingly important, as it helps elucidate underlying learning processes that are potentially facilitated or hindered by specific aptitude components (DeKeyser, 2012b). Given its theoretical and pedagogical value, a focused review of ATI research on L2

grammar learning is provided here to highlight emerging key topics in the subdomain of instructed second language acquisition (SLA) research.

RESEARCH

Evidence

Predictive Research on L2 Grammar Acquisition

*Naturalistic Settings***.** It is widely accepted that AO is a strong and consistent predictor of L2 acquisition in naturalistic settings with medium-to-large effect sizes (Qureshi, 2016; see also Chapter 16). Recently, a large-scale study was conducted by Hartshorne et al. (2018), where an unprecedented number of participants (246,497 L1 and 311,768 L2 English speakers) took an online quiz that assessed their knowledge of various grammatical structures. By using the largest dataset collected to date, the authors tackled the core question: At what age the learning rate of grammar declines? Their analyses showed that the uninstructed learning rate declines at around 17.4 years old. According to these findings, in order to receive enough meaningful L2 exposure in immersion settings to reach native-like grammatical knowledge, L2 learning should start at the age of 10−12 years, allowing at least 5−7 years before the naturalistic learning rate starts to decline.

Although Hartshorne et al.'s study is impressive in many respects, it has failed to uncover *why* L2 acquisition is constrained by age. While there are various socio-psychological factors (e.g., motivation, attitude, age at testing, L2 exposure, affiliation with L2 culture, L1 use) that impact L2 learning, these effects covary or confound AO and often become insignificant after AO is accounted for in naturalistic settings (for thorough reviews on the issue of critical or sensitive period, see DeKeyser, 2012a). What then is a most likely explanation of maturational constraints? Ample evidence comes from investigations on the role of explicit and implicit learning aptitudes in L2 grammar learning, which aimed to elucidate the underlying explicit and implicit learning mechanisms of child and adult L2 learnersby making inferences through the relationships between aptitude and L2 grammar attainment.

Most notably, DeKeyser (2000) hypothesized that the ability to learn implicitly declines with maturation and the role of explicit aptitude increases among adult L2 learners. DeKeyser (2000) tested this hypothesis by investigating L2 acquisition of English syntax by Hungarian immigrants in the United States. He found that explicit learning aptitude (grammatical sensitivity) significantly correlated with the grammaticality judgement test (GJT) score only among adult L2 learners (AO > 16), suggesting that explicit learning processes are crucial for adults to achieve higher-level grammatical attainment. Subsequent research involving different samples of adult L2 learners who migrated to their new country essentially corroborated this finding (Abrahamsson & Hyltenstam, 2008; DeKeyser et al., 2010). In these studies, however, the outcome measures (e.g., untimed GJT) targeted the "explicit" domain of grammatical knowledge. It is thus uncertain to which extent explicit aptitude is necessary for the acquisition of more automatic and implicit knowledge. Recent advancements in the validation of grammar knowledge tests (e.g., Ellis, 2009; Suzuki, 2017) can contribute to a greater understanding of these issues (see the Data Elicitation section).

Using a real-time grammar task called word-monitoring task, Granena (2012) assessed implicit grammatical knowledge of highly advanced adult L2 Spanish learners and found a negligible role of explicit aptitude in L2 grammar learning. She further found

that implicit learning aptitude (measured by a serial-reaction time [SRT] task, indicating sequence learning ability without awareness) was associated with implicit grammatical knowledge. Suzuki and DeKeyser (2015) also revealed that among advanced L2 Japanese adult learners, implicit grammatical knowledge (word-monitoring) was related to implicit learning aptitude (SRT). Critically, this relationship was found only when L2 learners lived in Japan for a certain number of years (e.g., 2+ years). These findings suggest that implicit learning does take place to some extent even among adult L2 learners, when implicit knowledge was tapped by a finely-tuned instrument and meaningful exposure is sufficiently provided in immersion contexts.

The previous paragraphs provided snapshots of the complex relationships between aptitude and L2 grammar acquisition from explicit−implicit perspectives. In order to demystify the whole picture, Suzuki and DeKeyser (2017b) probed the relationships among explicit−implicit aptitude and explicit−implicit grammatical knowledge among adult L2 learners. 100 advanced L2 Japanese speakers with Chinese as their L1, who had lived in Japan for at least two years, took a battery of automatized explicit and implicit knowledge grammatical tests and cognitive aptitude tests for explicit and implicit learning, as well as phonological short-term memory test. As shown in Figure 1, structural equation modelling analyses revealed significant loadings (paths) from explicit aptitude to automatized explicit knowledge, and finally to implicit knowledge. This evidence lends initial empirical support for the presence of a strong interface between explicit and implicit knowledge. It was further found that explicit aptitude (language analytic ability), rather than implicit aptitude (unconscious sequence learning ability), was a significant predictor of automatized explicit knowledge, which eventually resulted in implicit knowledge. This proposed path suggests that explicit learning mechanisms are more dominant than implicit learning mechanisms for adult L2 learners in naturalistic settings. More research is nonetheless needed to replicate this pattern and further investigate the explicit−implicit learning mechanisms employed by different types of L2 learners (see FUTURE DIRECTIONS).

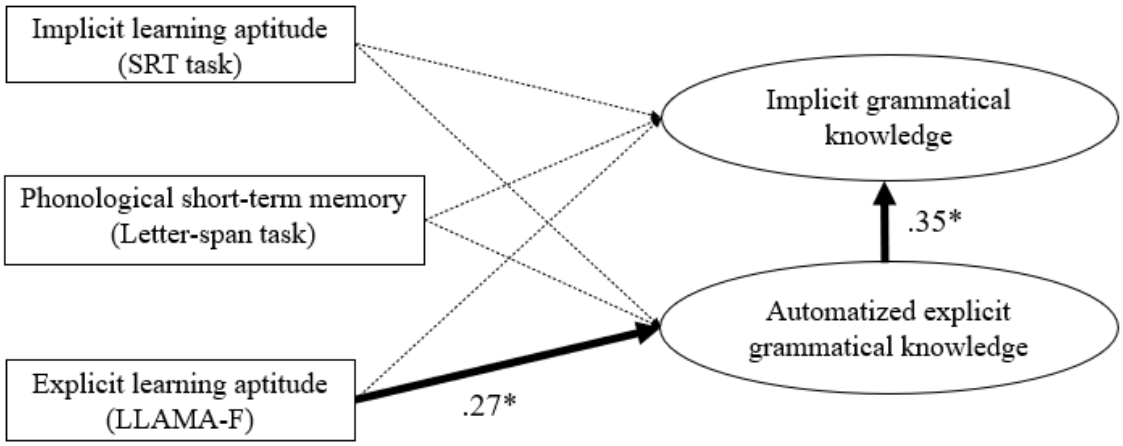


Figure 1. Significant findings that emerged from the Suzuki and DeKeyser's (2017b) study.

Note. Only significant paths ($p < .05$) in the structural equation model were presented by the bolded lines. Automatized explicit and implicit grammatical knowledge were measured by multiple linguistic tasks and were estimated at the latent level (see the Data elicitation section).

Instructed Settings. A different pattern emerges for the role of AO in foreign language classroom contexts. A meta-analysis on the association between AO and L2 grammar learning conducted by Qureshi (2016) suggests that there is little difference between early and late starters in foreign language learning contexts. Since the amount and quality of L2 exposure in classrooms is rarely comparable to naturalistic settings, the amount of L2 exposure is a stronger predictor than AO of L2 acquisition in the foreign language context (Ojima et al., 2011). Yet, a few studies suggest that, when meaningful L2 exposure and interaction are provided extensively in certain classroom types (e.g., immersion programs), AO can still potentially have long-lasting effects on L2 grammatical development in foreign language settings (e.g., Larson-Hall, 2008). In regular EFL programs (e.g., four 60-minute classes per week), however, when the amount of classroom instruction is held constant, older learners, who can take advantage of their more developed cognitive abilities, tend to outperform younger learners in grammatical development (Munoz, 2007). Research findings on the age effects in classroom settings have high relevance and important implications for education policy as well as classroom teaching. Age effects thus need to be further examined in a wider variety of educational settings, while providing detailed descriptions of context, amount and quality of learning, and L2 activities, as well as learner and teacher characteristics.

In extant research on aptitude effects, explicit aptitude, particularly language analytic ability, was found to be a strong predictor of grammar acquisition in classroom settings (e.g., Roehr-Brackin & Tellier, 2019; Rosa González, 2011, see also Li, 2015 for a meta-analysis). The effects of language analytic ability emerged as a stronger predictor than motivation of grammatical development among Grade 5 Spanish EFL learners (Rosa González, 2011). Interestingly, language analytic ability played a more important role in older learners (starting L2 learning after Grade 7) thanyounger learners (starting L2 learning after Grade 1) in an immersion classroom (Harley & Hart, 1997), suggesting an interaction effect between age and aptitude. Furthermore, while language analytic ability is associated with grammar use in writing tasks (Kormos & Trebits, 2012; Rosa González, 2011), this relationship may not hold for grammar use when speaking (Saito, 2017). Consistent with our understanding of aptitude effects in naturalistic L2 acquisition, this pattern suggests that its role is moderated by the nature of grammar knowledge elicited by different modality tasks. Although classroom research rarely focuses on different types of grammatical knowledge (e.g., metalinguistic knowledge vs. automatized explicit knowledge), these need to be examined and compared with those in L2 naturalistic acquisition settings.

Aptitude−Treatment Interaction Research in L2 Grammar Acquisition

Overview. ATI research in instructed SLA settings started to flourish in the last decade (DeKeyser, 2019). L2 researchers have a vested interest in ATI research pertaining to L2 grammar learning because the findings can inform when and how L2 grammar instruction should be provided to learners with different strengths and weaknesses profiles of their cognitive abilities, such as language analytic ability and working memory. Major ATI topics in L2 grammar learning are summarized in Table 1. However, in the following subsections, focus is given to two most-researched subdomains under extensive discussion in instructed SLA research—corrective feedback (CF) and instruction timing—to interpret and evaluate nuanced and complex patterns of ATI

findings and provide some suggestions for future research. Before that, the general pattern of ATI findings is delineated.

Table 1. *Major ATI Topics in L2 Grammar Learning*

Topic	Aptitude Components	Exemplary Study
Corrective feedback (CF)		
(1) Oral CF	LAA and WM	(1) Li (2013)
(2) Written CF	LAA	(2) Benson and DeKeyser (2018)
Timing of instruction		
(1) Timing of explicit instruction	LAA and WM	(1)Kachinske and DeKeyser (2019)
(2) Timing of oral CF	WM	(2) Fu and Li (2019)
(3) Timing of grammar practice	LAA and WM	(3) Suzuki (2019)
Deductive versus inductive instruction	LAA, PSTM, PCA	Erlam (2005)
Intentional versus incidental learning	LAA and AM	Robinson (1997)
Provision of metalinguistic information	WM	Sanz et al. (2016)
Input variation	IQ	Brooks et al. (2006)
Blocked and interleaved practice	WM	Suzuki et al. (2020)

Note. Language analytic ability (LAA), working memory (WM), phonological short-term memory (PSTM), phonetic coding ability (PCA), associative memory (AM)

In principle, ATI findings can be used for pedagogical decisions in terms of: (a) capitalization onstrengths (i.e., tailoring instruction to the strengths of individual learners), (b) compensation for weaknesses (i.e., tailoring instruction that provides support for what the learner cannot do), and (c) remediation (i.e., implementing training regimen to fill the specific gaps in the learners' initial abilities). The first two patterns are of interest in this chapter and illustrated in Figure 2 (for the remediation approach, see Hayashi, 2019, who conducted an innovative dual intervention study on working memory and L2 English training). The cross-over interaction pattern—denoted as (a) in Figure 2—characterizes capitalization on learners' strengths for Treatment A and B. This pattern indicates that Treatment A optimizes outcomes for higher aptitude learners, while Treatment B optimizes outcomes for lower aptitude learners. This ATI type has been documented in only a few L2 studies (e.g., Benson & Dekeyser, 2019, which is discussed in detail below). This trend is similar to the finding yielded by psychology research in that cross-over ATI patterns are rarely documented or reported (Pashler et al., 2008).

A more common ATI type is the compensation pattern—denoted as (b) in Figure 2. This pattern indicates that all learners, irrespective of their aptitude, can achieve asimilar level of outcome in one type of treatment (Treatment A). In other words, learners' weakness (i.e., low aptitude) can be compensated by a specific type of instructional treatment. This compensation type has been documented in a significant number of

studies listed in Table 1 (e.g., Erlam, 2005; Sanz et al., 2016; Suzuki, 2019; Suzuki, Yokosawa, Aline, 2020). For instance, when explicit information was provided (deductive instruction), it yielded superior outcomes irrespective of aptitude scores (Treatment A in (b)), while learning condition without the aid of explicit information (inductive instruction) was found to be largely influenced by learners' aptitude (Treatment B in (b)). This is one of the most general ATI patterns, suggesting that, when learners' cognitive aptitudes are taxed or overloaded because little support is provided for learning, extra support (e.g., the aid of explicit information) can level out learners' differences (Cronbach & Snow, 1977).

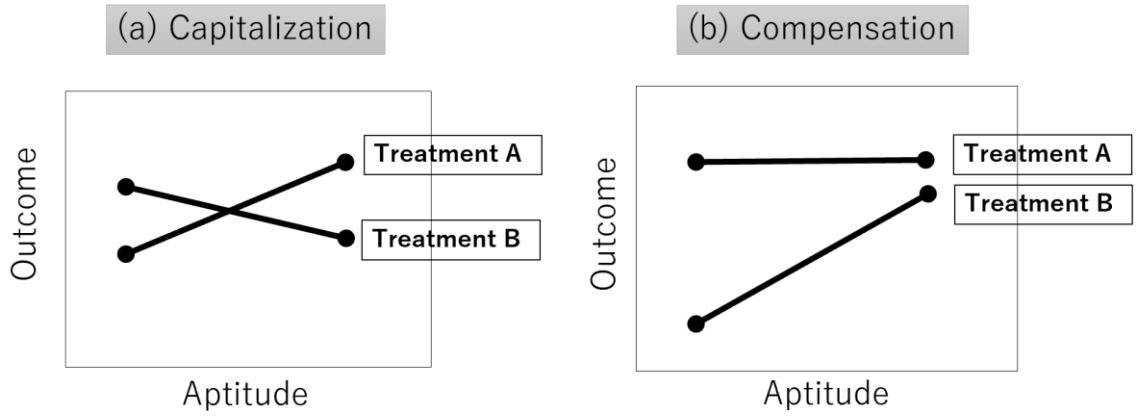


Figure 2. ATI patterns.

ATI research on oral CF. As demonstrated in several meta-analyses, oral CF is effective for the development of grammatical knowledge (e.g., Lyster & Saito, 2010). One primary issue examined in the CF research is the relative efficacy of explicit (e.g., provision of metalinguistic information) and implicit CF (e.g., recast). Within this subdomain, Li (2017) synthesized seven studies on the role of aptitude in the effectiveness of explicit and implicit CF. According to the results yielded by this meta-analysis, while working memory is not systematically related to CF treatment outcomes, language analytic ability is related to explicit CF (r = .51) but not to implicit CF (r = .09). It appears that learners who are good at conscious (explicit) linguistic analysis tend to benefit more from explicit CF. Yet, both outcome and aptitude tests tapped only explicit domains. In order to address this shortcoming, both implicit aptitude and grammar tests were used by Granena and Yilmaz (2019). In their laboratory study, implicit aptitude predicted L2 grammatical knowledge measured by a self-paced reading task (indicating online sensitivity to a grammatical structure) in the implicit CF group, but not in the explicit CF group. This line of research is expected to advance our theoretical understanding of cognitive aptitudes in explicit and implicit CF. Critically, laboratory intervention studies need to be extended to longitudinal (classroom) investigations, given that acquisition of implicit grammatical knowledge requires an extended period of practice.

ATI research on written CF. Considerable empirical evidence has accumulated to lend strong support for the beneficial roles of written CF (see Ferris & Kurzer, 2019 for an overview). As in the case of oral CF, not all learners equally benefit from written CF. Hence, the same set of cognitive aptitudes—language analytic ability and working memory capacity—are increasingly being linked to grammatical development through writing practice with CF. However, what type of written CF can reduce the effects of

aptitudes is still far from clear. The role of language analytic ability was found to be significant for metalinguistic feedback in Sheen's (2007) study, whereas it was important for direct feedback in Stefanou & Révész's (2015) study. This discrepancy may be due to factors such as participants' background (ESL versus EFL learners) and types of target linguistic features (both studies focus on English article use, but the functions targeted were different). Furthermore, a more complex cross-over ATI pattern was reported by Benson and DeKeyser (2019), who provided ESL learners with direct written CF and metalinguistic CF on simple past and present perfect as a part of their study. Their findings suggest that the group given direct CF was more likely to benefit from higher language analytic ability, whereas metalinguistic CF was more effective for learners with lower language analytic ability. This interesting pattern suggests that learners possessing higher language analytic ability were able to induce rules from direct CF, while less capable learners were assisted by extra metalinguistic CF aimed at improving their accuracy. However, this pattern was only noted for one of the linguistic structures (simple past) in the immediate test, not in the delayed posttest. In order to disambiguate these mixed findings and gain better understanding of more nuanced ATI patterns that can be generalized, potential moderating factors need to be taken into consideration, such as the types, timing of assessment measurements, and linguistic structure features, as well as the presence of opportunity to revise after written CF (e.g., Li & Roshan, 2019).

ATI Research on Instruction Timing (1): Explicit Instruction. The issue of instruction timing deserves more focal attention in instructed SLA research. First and foremost, it is crucial to determine the best time to provide L2 form-focused instruction (e.g., provision of CF and explicit grammar instruction) and how that can be integrated with meaningful (communicative) L2 activities. The timing of grammar instruction does make a significant difference in learning processes and outcomes, while at the same time it is also moderated by differences in learners' cognitive aptitudes.

In the spirit of identifying optimal L2 grammar instruction timing, Kachinske and DeKeyser (2019) investigated the effects of timing to provide explicit information about target grammatical structures. As a part of this investigation, L2 Spanish classroom learners engaged in grammar practice on target structures under different treatment conditions where the timing of explicit information was manipulated, i.e., *before* and/or *during* grammar practice. Participants' language analytic ability and working memory capacity were measured. Findings reported by the authors suggest that, when learners were provided with the explicit information when they needed it the most (i.e., during practice), they attained better outcomes with minimal burden on their aptitudes. When explicit information was provided only before the practice, heavier burden was placed on working memory, because learners needed to hold the explicit information in their working memory during practice. When no provision of explicit information was given at all neither before nor during the practice, an excessive learning burden was placed solely on the learners to induce the target grammatical rules from input, leading to a significant association of learning outcome with both working memory and language-analytic ability. These results suggest that, while the unguided learning condition can be too demanding for learners with lower cognitive aptitudes, providing extra form-focused instructional support—crucially, at the right time—is necessary to compensate for their weak aptitudes. However, there is a paucity of research on this topic, necessitating further studies to tackle this pedagogically important question.

ATI Research on Instruction Timing (2): Oral CF. Two recent studies have

examined the roles of cognitive aptitudes in the timing of CF. In the study conducted by Li et al. (2019), eight-grade Chinese students studied the English past passive structure by engaging in dictogloss tasks. The timing of oral CF was manipulated such that corrective recasts on the target passive construction were provided *during* the dictogloss tasks in the immediate CF condition, whereas in the delayed CF condition, corrective recasts were provided *after* the tasks were completed. Subsequent analyses showed that working memory was associated with learning gains in the immediate CF condition, and language analytic ability was implicated in the delayed CF condition.

Fu and Li (2019) further investigated the role of working memory capacity in immediate and delayed CF to a different grammar target (English simple past) in a similar group of seven-grade Chinese EFL learners that were provided three training sessions, as a part of which the timing of CF was manipulated. In the immediate CF group, corrective recasts were provided only in the first training session, whereas in the delayed CF condition, corrective recasts were provided only in the final (third) training session. The results showed that working memory was a significant predictor of learning gains only in the delayed CF condition. These two studies seem to offer contradicting evidence for the role of working memory. On the one hand, immediate CF imposed a heavy burden on learners' working memory in Li et al.'s (2019) study, whereas delayed CF, rather than immediate CF, was more sensitive to learners' working memory capacity in Fu and Li's (2019) study. This discrepancy may be in part due to how feedback timing was operationalized in the two studies. In Li et al's (2019) study, feedback timing was manipulated as online (during task) and offline (after task). In contrast, in Fu & Li (2019), feedback was provided during task performance in both immediate and delayed conditions, but immediate feedback was provided in the first treatment session while delayed feedback in the final session. Both operationalizations are pedagogically relevant and important CF timing options, so future researchers need to give careful consideration to the consequence of the operationalizations of CF timing to the roles of cognitive aptitudes in L2 grammar learning through oral CF.

ATI Research on Instruction Timing (3): Repeated Grammar Practice. A growing body of research informed by cognitive psychology is being dedicated to the optimal schedules of repeated grammar practice (see Suzuki, 2021 for a recent review). An emerging line of investigations has revealed that the optimal timing to repeat grammar practice is contingent on learners' strengths and weaknesses of language analytic ability and working memory.

Suzuki and DeKeyser (2017a) conducted the first study on the relationships between cognitive aptitudes and the distribution of grammar practice. Lower-intermediate Japanese L2 learners practiced a morphosyntactic structure, *-te iru*, expressing present progressive for two 60-minute practice sessions that were repeated under shorter-spaced (1-day interval) or longer-spaced (7-day interval) conditions. Two cognitive aptitudes—language analytic ability and working memory capacity—were measured by the LLAMA-F and an operation span task. The results showed an interesting ATI pattern (see the upper panel in Figure 3): working memory capacity predicted learning gains in the 1-day interval condition, whereas language analytic ability predicted learning gains in the 7-day interval condition. The significant association of working memory with learning outcome in the 1-day interval may indicate that, when the spacing is too short for learners with lower working memory capacity, they tend to experience stronger memory interference from similar Japanese morphological features (e.g., *nobot-te*, *migai-te*, *tatan-*

de). On the other hand, when the spacing is too long for learners with lower language analytic ability, they cannot retain grammatical rules they learned until the next learning session one week later.

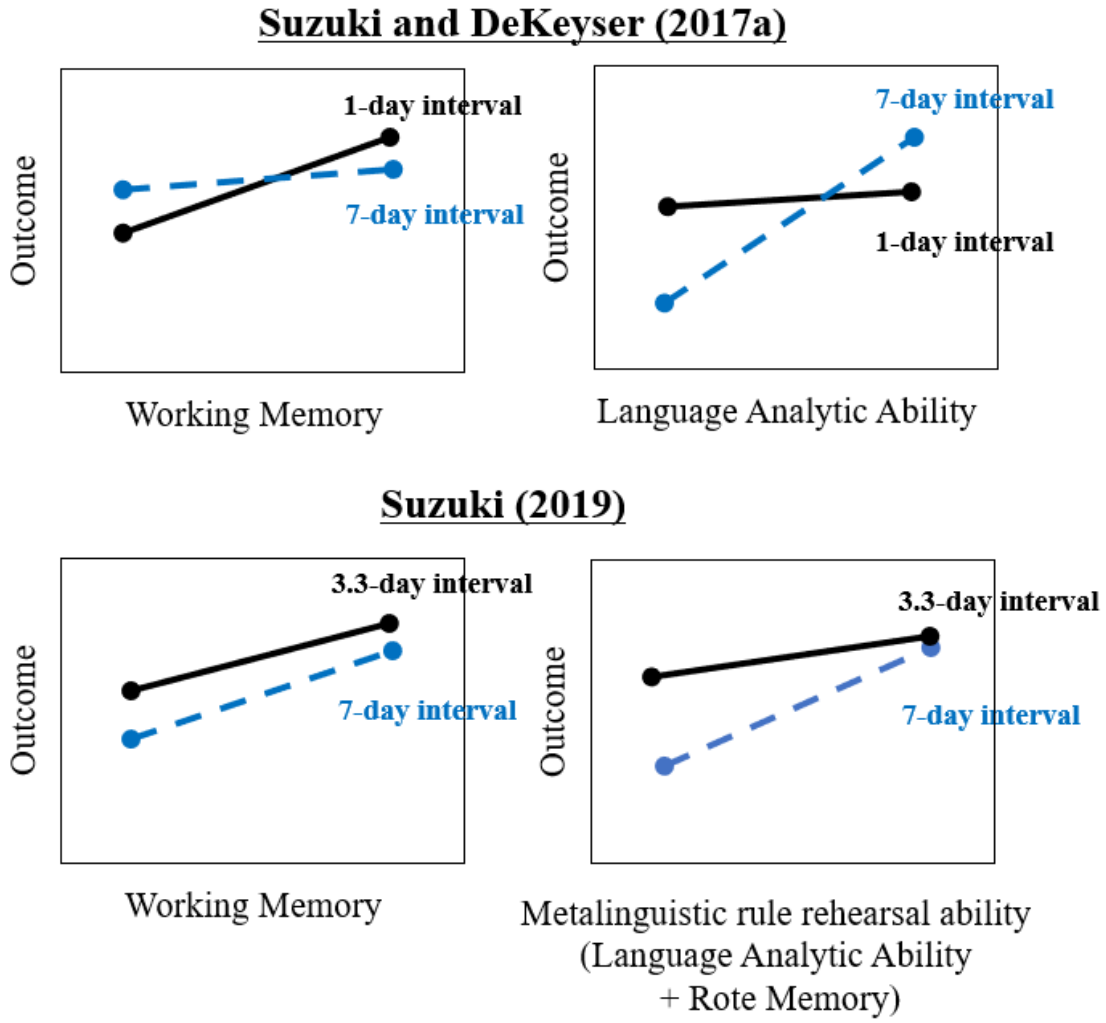


Figure 3. Contrasting ATI patterns between the results reported by Suzuki and DeKeyser (2017a) and Suzuki (2019).

In an attempt to replicate and extend the ATI pattern observed by Suzuki and DeKeyser (2017a), Suzuki (2019) trained learners on a miniature L2 morphological system and compared shorter-spaced (3.3-day interval) with longer-spaced (7-day interval) conditions. An aptitude complex for L2 repeated grammar practice was created by measuring metalinguistic rehearsal ability (a composite of language analytic ability and rote memory scores) and working memory. The findings originally reported by Suzuki and DeKeyser (2017a) were partially supported. As shown in the lower panel in Figure 3, metalinguistic rule rehearsal ability played a significant role in L2 learning in the 7-day interval condition only, while in the 3.3-day interval, the effects of working memory capacity were weak and comparable for both groups. The role of working memory became negligible in this study as opposed to Suzuki and DeKeyser's (2017a) study, possibly because the extended practice interval (from 1 day to 3.3 days) might have

reduced the memory interference from similar morphological features.

Summarizing the findings obtained in these two studies, a 1-day interval is too short and imposes heavy burden on working memory, whereas a 7-day interval is too long and necessitated high metalinguistic rehearsal ability for retaining previously learned examples and rules. Hence, the most optimal timing that is impervious to individuals' cognitive aptitudes seems to be somewhere in between, such as a 3-day interval (cf., Kasprowicz, Marsden, and Sephton, 2019). This pattern of findings needs to be further examined through systematic replication and extension studies to explore the potential of individualizing grammar practice schedules for learners with different aptitude profiles.

Data elicitation

Linguistic measurements

The conclusions derived from any empirical study are only as good as the quality of measurements employed for both grammatical knowledge and aptitudes. In classroom-based research, learning outcomes are typically measured by overall grammatical accuracy on writing and speaking assessments. For instance, participants perform an oral picture narrative task, and their transcripts are analyzed in terms of grammatical accuracy (e.g., morphological features such as tense, aspect, modality, and agreement) and complexity (e.g., the number of clauses per Analysis of Speech [AS] unit and the number of words per clause) (Saito, 2017). This analytical approach is advantageous in using natural L2 production, but it is harder to elicit specific linguistic structures that researchers would like to investigate.

In naturalistic settings, psycholinguistic tasks like GJT and online processing tasks are used more commonly. In particular, GJT have traditionally been used in assessments of grammatical knowledge (e.g., DeKeyser, 2000). It is argued that imposing time pressure on GJT (e.g., participants need to make grammaticality judgement within pre-specified time limits) may render it a test of implicit grammatical knowledge; however, the construct validity of timed GJTs is still controversial and leaves ambiguous interpretations (Godfroid et al., 2015; Vafaee et al., 2017). Hence, online psycholinguistic tests have been proposed as potentially more valid measures of implicit knowledge, because they can measure real-time grammar processing within less than one second, which is too short a period for conscious processing to take place (Suzuki, 2017; Suzuki & DeKeyser, 2015). For such purposes, a word-monitoring task can be adopted to assess the online sensitivity to grammatical errors (Figure 4). In the word-monitoring task, participants listen to a sentence and are instructed to press the keyboard button as soon as they hear the monitoring word in the sentence. After they hear the sentence, they answer a comprehension question, such that their attention is directed to meaning rather than form. For instance, participants monitor the word "college" while listening to the following spoken (a) grammatical and (b) ungrammatical sentences.

Monitoring word: college
(a) The man wearing a T-shirt watch college basketball games.
(b) The man wearing a T-shirt watches college basketball games.
Comprehension question: Does the man watch baseball?

They are expected to slow down to respond to the monitoring word in Sentence (b) relative to Sentence (a), if they can detect the grammatical error (i.e., third-person *s*)

that precedes the monitoring word. The difference of reaction time to the monitoring word between Sentence (a) and Sentence (b) reflects the automatic detection of grammatical errors in spoken/written input, which istaken as an index of implicit knowledge (see Suzuki et al., 2022 for neuroimaging support). Another common real-time grammar processing measure is a self-paced reading task (Figure 4). In this task, participants read each word in the sentence by pressing the keyboard button to show the next word. Based on the same rationale as the word-monitoring task, reaction time difference between (a) and (b) is used as an index of implicit knowledge.

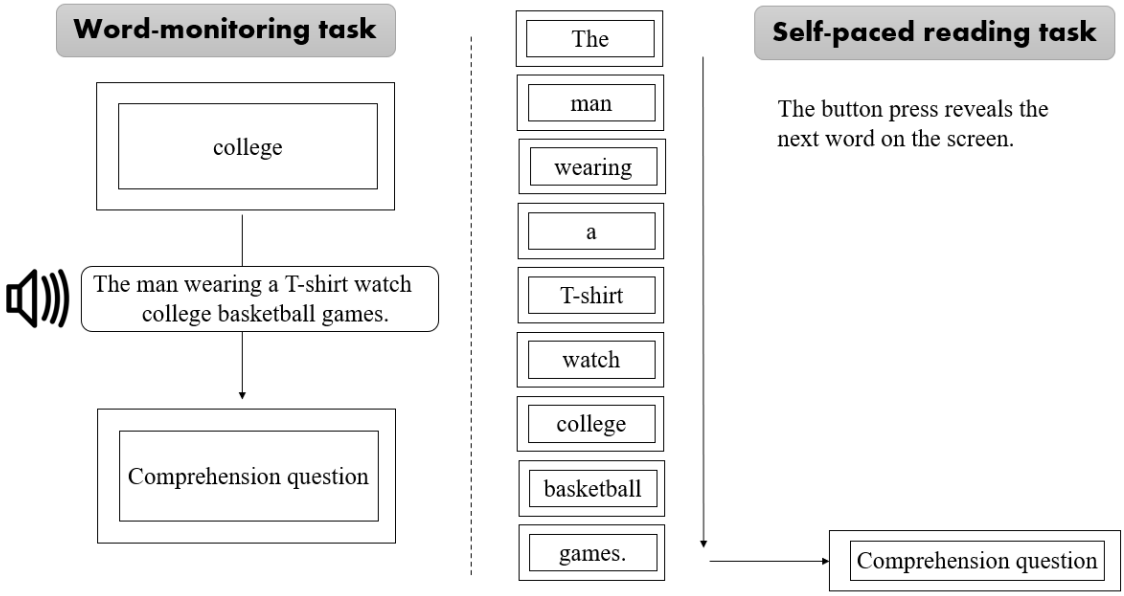


Figure 4. Illustrations of word-monitoring and self-paced reading tasks.

Through a series of confirmatory factor analyses, Suzuki (2017) provided evidence that three real-time grammar processing tasks (word-monitoring and self-paced reading tasks, as well as eye-tracking-while-listening task) can be distinguished from time-pressured GJTs and can indicate L2 implicit grammar knowledge among advanced L2 learners who acquired the target language in the immersion context for several years. As explained above, implicit grammar tests are already being applied to instructed SLA research (e.g., Godfroid, 2016; Granena & Yilmaz, 2019). These new grammar tests will allow us to explore the potential and the limits of L2 grammar acquisition both in classroom settings and in naturalistic contexts.

Aptitude measurements

The progress in aptitude test development and theorizing has started to catch up with that achieved in linguistic measurements. Table 2 summarizes common aptitude measurements used in the predictive and ATI research reviewed in this chapter (see XX chapter in this handbook for more details of each instrument). In predictive research, explicit learning aptitude is typically operationalized as language analytic ability, whereas implicit learning aptitude is operationalized as sequence learning ability. For language analytic ability, both MLAT Words in Sentences and LLAMA-F are most commonly used, and the latter is used particularly in recent laboratory-based research as LLAMA-F is a newer test and is administeredon the computer. Only one measure of implicit aptitude

is used in the previous studies, i.e., the SRT task in which participants respond to the sequences of dots by pressing the button and are expected to identify the sequence pattern incidentally.

Table 2. *Common Aptitude Measurements in Previous Research on L2 Grammar Learning*

Aptitude Components	Measurements	Predictive Research	ATI Research
Language Analytic Ability	MLAT Words in Sentences	DeKeyser (2000), Roehr-Brackin & Tellier (2019), Rosa González (2011), Kormos & Trebits (2012)	Erlam (2005), Li (2013), Robinson (1997), Stefanou & Revesz (2015)
	PLAB Language analysis	Harley & Hart (1997)	Li et al. (2019)
	LLAMA-F	Granena (2012), Saito (2017), Suzuki & DeKeyser (2017b)	Benson & DeKeyser (2019), Kachinske & DeKeyser (2019), Suzuki & DeKeyser (2017a), Suzuki (2019)
Sequence Learning Ability (Implicit Aptitude)	SRT task	Granena (2012), Suzuki and DeKeyser (2015), Suzuki & DeKeyser (2017b)	Granena & Yilmaz (2019b)
Working Memory	Reading span task		Li & Roshan (2019)
	Listening span task		Li (2013), Sanz et al. (2016), Suzuki et al. (2020)
	Operation span task		Li et al. (2019), Fu & Li (2019), Suzuki & DeKeyser (2017a), Suzuki (2019), Kachinske & DeKeyser (2019)

Note. MLAT (Modern Language Aptitude Test) and PLAB (Pimsleur Language Aptitude Battery)

The focused review of ATI research on L2 grammar learning revealed that attention has been primarily directed to two aptitude components: language analytic ability and working memory capacity. The measurements for language analytic ability used in ATI research are not different from those in predictive research. For the working memory measurements, complex span tasks that require both storage and processing are

commonly used in previous research. Both reading and listening span tasks require participants to use the first language of participants and are dependent heavily on language. In contrast, an operation span task requires solving mathematical problems and remembering Englishletters, which is considered less language-dependent but can be used for any participants who know the English alphabet.

PRACTICAL APPLICATIONS

Broad implications of both predictive and ATI classroom research findings are that teachers need to be aware of key cognitive and psychological factors that vary among L2 learners. How they can provide optimal instructional support that can either capitalize on learners' strengths or compensate for their weaker abilities is what ATI research can offer. At this point, concrete practical "applications" are unrealistic; the broad guideline is that teachers should minimize the effects of aptitude and avoid providing instruction and activities that are too demanding (overloading learners' capacity). At the same time, it is recommended that learning conditions be challenging enough for learners to stretch their grammatical development with maximum effort using resources at their disposal (Suzuki et al., 2019). Of course, it is hard to discern which instruction and practice activities would be challenging enough for the whole class, because every learner in the classroom is at a different developmental stage and has unique cognitive and psychological characteristics. The important thing is that teachers need to keep that in mind and try to adjust their instruction while closely monitoring each learner's L2 performance.

More research is needed to identify and develop practical tools that can be used for profiling learners' strengths and weaknesses (e.g., memory and analytic learners) for which treatment can be tailored. Computer-delivered instruction is definitely a promising technique for providing instruction tailored to each L2 learner. For instance, mobile-assisted language learning applications, in tandem with regular classroom activities, can be utilized for providing extra activities targeting specific grammatical features that are problematic for less analytic learners. In order to offer concrete and reliable guidelines, further replications of the ATI patterns that are already documented are needed to further attest the generalizability of these findings.

FUTURE DIRECTIONS

Several major directions can be identified for future research on individual differences in L2 grammar learning. First, while conceptualization of cognitive aptitudes for explicit and implicit learning has stimulated interest in L2 grammar research (e.g., Granena, 2012; Suzuki & DeKeyser, 2017b), the declarative and procedural memory model (Buffington & Morgan-Short, 2019) may also be a promising framework for probing the role of aptitudes in L2 grammar learning. At this point, there are large overlaps in the constructs and measurements between explicit learning and declarative memory (e.g., LLAMA_B [associative memory]), as well as between implicit learning and procedural memory (e.g., SRT task [sequence learning ability]). Furthermore, while implicit aptitude was solely operationalized as sequence learning ability in the previous L2 grammar research reviewed in this chapter (see Elicitation section), implicit aptitude may be multi-componential including associative priming and others (Granena, 2019; Li & DeKeyser, 2021; Linck et al., 2013). Further research developments in theorizations and instrument validations are thus essential in this area.

Second, language analytic ability and working memory capacity have been identified as the most common combination of cognitive aptitudes examined in ATI research. This set of aptitude components can be combined into an aptitude complex for L2 grammar learning (see Suzuki, 2019 in Figure 3 for an illustration). Creating a specific set of multiple aptitudes allows us to maximize their predictive power and increase the practical value of identifying learner aptitude profiles that can be ultimately matched to different types of L2 grammar instruction. While the direction of research for increasing pedagogical values is important, it should not lose theoretical integrity. For instance, "analytic" ability is a composite construct of grammatical sensitivity (MLAT Part IV) and language inductive ability (e.g., LLAMA_F). "Memory" is even more multifaceted, and involves updating, inhibitory control, and task switching in the executive functioning of working memory, as well as phonological short-term memory (see, e.g., Linck et al., 2013). Therefore, researchers need to strive for finding the middle ground between theoretical integrity and pedagogical relevance of data elicitation techniques.

Third, concerning ATI research, "A" in the acronym has been traditionally conceived as "ability" or readiness for learning, in line with Cronbach and Snow's (1977) definition. While the current review and previous studies tend to focus on cognitive aptitudes, other individual difference factors should also be examined, such as motivation, personality, affective factors, and prior knowledge relevant for L2 grammar acquisition. Individual difference factors that may have potential links to L2 grammar learning, as well as the "T" aspect of ATI research, needs further expansion from a variety of angles.

Relatedly, it is also important to take into account L2 learners' characteristics particularly when examining the nature of L2 knowledge in predictive research. While advanced L2 learners are typically recruited for research in naturalistic settings, recent research has suggested that the type of grammatical knowledge used by adult L2 learners in immersion settings may shift from explicit to implicit knowledge in the first several years of residence (Suzuki, 2017; Suzuki & DeKeyser, 2015). More attention needs to be paid to the length and intensity of L2 naturalistic exposure in future research. Another interesting case pertains to heritage learners, who have unique psychosocial and biographical propensities as well as cognitive abilities. Recently, Torres et al. (2019) revealed that the status of sequential bilinguals (who spoke their heritage language at home and started learning a majority language at school), generation, willingness to communicate, and motivation contributed to different aspects of explicit and implicit grammatical knowledge. Furthermore, investigations on individual differences in grammatical knowledge of L1 speakers with different demographic backgrounds (Dąbrowska, 2019) are also noteworthy, as this line of research may potentially allow us to distinguish "core" grammar in which L1 speakers show little variation.

While the aforementioned future directions concern individual difference factors, the nature of L2 grammatical knowledge should be elucidated more carefully, whether it is explicit versus implicit or declarative versus procedural (automatic), depending on how researchers theorize them. Rigorous behavioral psycholinguistic investigations using real-time processing tasks reviewed in this chapter are promising, and neural measures of L2 grammar knowledge can also be utilized, such as electroencephalogram (EEG) and functional magnetic resonance imaging (fMRI) (Morgan-Short et al., 2015; Suzuki et al., 2022).

Furthermore, more serious consideration should be given to types of grammatical structures investigated. Because grammatical structures are not equal in their

complexity/difficulty of form, function, and meaning, different psychological processes are involved in the acquisition of different structures. To date, several potentially useful grammatical features (categories) have been proposed, such as salience (DeKeyser, 2000; DeKeyser et al., 2017) and item-rule distinctions (Flege et al., 1999). As a case in point, DeKeyser et al. (2017) found that the acquisition of less salient structures is severely constrained by AO, suggesting that adults fail to learn them due to their diminished ability to learn non-salient features implicitly. It is crucial to delve into the complexity of L2 grammar learning with this type of theoretical guidance. Investigating the roles of individual difference factors in L2 grammar learning needs more specificity; for instance, which components of explicit and implicit learning aptitudeplay important roles in learningwhat types of grammatical structures (see Li & DeKeyser, 2021). Identifying theoretically-motivated grammatical categories prevents us from overgeneralizing the findings related to one specific grammatical structure to others, and yet still allows us to generalize the findings to some universal linguistic features.

REFERENCES

Abrahamsson, N., & Hyltenstam, K. (2008). The robustness of aptitude effects in near-native second language acquisition. *Studies in Second Language Acquisition, 30*(4), 481-509. https://doi.org/10.1017/S027226310808073X

Ando, J., Fukunaga, N., Kurahashi, J., Suto, T., Nakano, T., & Kage, M. (1992). A comparative study on the two EFL teaching methods: The communicative and the grammatical approach. *Japanese Journal of Educational Psychology, 40*, 247-256.

Benson, S., & DeKeyser, R. (2019). Effects of written corrective feedback and language aptitude on verb tense accuracy. *Language Teaching Research, 23*(6), 702-726. https://doi.org/10.1177/1362168818770921

Brooks, P. J., Kempe, V., & Sionov, A. (2006). The role of learner and input variables in learning inflectional morphology. *Applied Psycholinguistics, 27*(2), 185-209. https://doi.org/10.1017/S0142716406060243

Buffington, J., & Morgan-Short, K. (2019). Declarative and procedural memroy as individual differences in second language aptitude. In Z. Wen, P. Skehan, A. Biedroń, S. Li, & R. L. Sparks (Eds.), *Language aptitude: Advancing theory, testing, research and practice* (pp. 215-237). Routledge.

Carroll, J. B., & Sapon, S. M. (1959). *Modern language aptitude test: MLAT*. Psychological Corporation.

Cronbach, L. J., & Snow, R. E. (1977). *Aptitudes and instructional methods: A handbook for research on interactions*. Irvington Pub.

Dąbrowska, E. (2019). Experience, aptitude, and individual differences in linguistic attainment: A comparison of native and nonnative speakers. *Language Learning, 69*(S1), 72-100. https://doi.org/10.1111/lang.12323

DeKeyser, R. M. (2000). The robustness of critical period effects in second language acquisition. *Studies in Second Language Acquisition, 22*(4), 499-534. https://doi.org/10.1017/S0272263100004022

DeKeyser, R. M. (2005). What makes learning second language grammar difficult? A review of issues. *Language Learning, 55*(S1), 1-25. https://doi.org/10.1111/j.0023-8333.2005.00294.x

DeKeyser, R. M. (2012a). Age effects in second language learning. In S. Gass & A. Mackey (Eds.), *The Routledge handbook of second language acquisition* (pp. 442-458). Routledge.

DeKeyser, R. M. (2012b). Interactions between individual differences, treatments, and structures in SLA. *Language Learning, 62*(s2), 189-200. https://doi.org/10.1111/j.1467-9922.2012.00712.x

DeKeyser, R. M. (2019). Introduction to the special issue of aptitude-treatment interaction in second language learning. *Journal of Second Language Studies, 2*(2), 165-168. https://doi.org/10.1075/jsls.00007.int

DeKeyser, R. M., Alfi-Shabtay, I., & Ravid, D. (2010). Cross-linguistic evidence for the nature of age effects in second language acquisition. *Applied Psycholinguistics, 31*(3), 413-438. https://doi.org/10.1017/S0142716410000056

DeKeyser, R. M., Alfi-Shabtay, I., Ravid, D., & Shi, M. (2017). The role of salience in the acquisition of Hebrew as a second language: Interaction with age of acquisition. In S. Gass, P. Spinner, & J. Behney (Eds.), *Salience in second language acquisition* (pp. 131-146). Routledge.

Ellis, R. (2009). Measuring implicit and explicit knolwedge of a second language. In R. Ellis, S. Loewen, C. Elder, R. Erlam, J. Philp, & H. Reinders (Eds.), *Implicit and explicit knowledge in second language learning, testing and teaching* (pp. 31-64). Multilingual Matters.

Erlam, R. (2005). Language aptitude and its relationship to instructional effectiveness in second language acquisition. *Language Teaching Research, 9*(2), 147-172. https://doi.org/10.1191/1362168805lr161oa

Ferris, D. R., & Kurzer, K. (2019). Does error feedback help L2 writers? Latest evidence on the efficacy of written corrective feedback. In K. Hyland & F. Hyland (Eds.), *Feedback in second language writing: Contexts and* (pp. 106-124). Cambridge University Press.

Flege, J. E., Yeni-Komshian, G. H., & Liu, S. (1999). Age constraints on second-language acquisition. *Journal of Memory and Language, 41*(1), 78-104.

Fu, M., & Li, S. (2019). The associations between individual differences in working memory and the effectiveness of immediate and delayed corrective feedback. *Journal of Second Language Studies, 2*(2), 233-257. https://doi.org/https://doi.org/10.1075/jsls.19002.fu

Godfroid, A. (2016). The effects of implicit instruction on implicit and explicit knowledge development. *Studies in Second Language Acquisition, 38*(2), 177-215. https://doi.org/10.1017/S0272263115000388

Godfroid, A., Loewen, S., Jung, S., Park, J., Gass, S., & Ellis, R. (2015). Timed and untimed grammaticality judgements measure distinct types of knowledge. *Studies in Second Language Acquisition, 37*(s2), 269-297. https://doi.org/10.1017/S0272263114000850

Granena, G. (2012). *Age differences and cognitive aptitudes for implicit and explicit learning in ultimate second language attainment* [Unpublished doctoral dissertation, University of Maryland]. College Park, MD.

Granena, G. (2019). Cognitive aptitudes and L2 speaking proficiency: Links between LLAMA and Hi-LAB. *Studies in Second Language Acquisition, 41*(2), 313-336. https://doi.org/10.1017/S0272263118000256

Granena, G., & Long, M. H. (2013). *Sensitive periods, language aptitude, and ultimate L2 attainment* (Vol. 35). John Benjamins Publishing.

Granena, G., & Yilmaz, Y. (2019). Corrective feedback and the role of implicit sequence-learning ability in L2 online performance. *Language Learning, 69*(S1), 127-156. https://doi.org/10.1111/lang.12319

Harley, B., & Hart, D. (1997). Language aptitude and second language proficiency in classroom learners of different starting ages. *Studies in Second Language Acquisition, 19*(3), 379-400. https://doi.org/10.1017/S0272263197003045

Harley, B., & Hart, D. (2002). Age, aptitude and second language learning on a bilingual exchange. In P. Robinson (Ed.), *Individual differences and instructed language learning* (pp. 301-330). John Benjamins.

Hartshorne, J. K., Tenenbaum, J. B., & Pinker, S. (2018). A critical period for second language acquisition: Evidence from 2/3 million English speakers. *Cognition, 177*, 263-277. https://doi.org/10.1016/j.cognition.2018.04.007

Hayashi, Y. (2019). Investigating effects of working memory training on foreign language development. *The Modern Language Journal, 103*(3), 665-685. https://doi.org/10.1111/modl.12584

Housen, A., & Simoens, H. (2016). Introduction: Cognitive perspectives on difficulty and complexity in L2 acquisition. *Studies in Second Language Acquisition, 38*(2), 163-175. https://doi.org/10.1017/S0272263116000176

Kachinske, I., & DeKeyser, R. (2019). The interaction between timing of explicit grammar explanation and individual differences in second language acquisition. *Journal of Second Language Studies, 2*(2), 197-232. https://doi.org/10.1075/jsls.19003.kac

Kasprowicz, R., Marsden, E., & Sephton, N. (2019). Investigating distribution of practice effects for the learning of foreign language verb morphology in the young learner classroom. *The Modern Language Journal, 103*(3), 580-606. https://doi.org/10.1111/modl.12586

Kormos, J., & Trebits, A. (2012). The role of task complexity, modality, and aptitude in narrative task performance. *Language Learning, 62*(2), 439-472. https://doi.org/10.1111/j.1467-9922.2012.00695.x

Kourtali, N.-E., & Révész, A. (2020). The roles of recasts, task complexity, and aptitude in child second language development. *Language Learning, 70*(1), 179-218. https://doi.org/10.1111/lang.12374

Larson-Hall, J. (2008). Weighing the benefits of studying a foreign language at a younger starting age in a minimal input situation. *Second Language Research, 24*(1), 35-63. https://doi.org/10.1177/0267658307082981

Li, S. (2013). The interactions between the effects of implicit and explicit feedback and individual differences in language analytic ability and working memory. *The Modern Language Journal, 97*(3), 634-654. https://doi.org/10.1111/j.1540-4781.2013.12030.x

Li, S. (2015). The associations between language aptitude and second language grammar acquisition: A meta-analytic review of five decades of research. *Applied linguistics, 36*(3), 385-408. https://doi.org/10.1093/applin/amu054

Li, S., & DeKeyser, R. M. (2021). Implicit language aptitude: Conceptualizing the construct, validating the measures, and examining the evidence: Introduction to the special issue. *Studies in Second Language Acquisition, 43*(3), 473-497. doi:https://doi.org/10.1017/S0272263121000024

Li, S. (2017). The effects of cognitive aptitudes on the process and product of L2 interaction. In L. Gurzynski-Weiss (Ed.), *Expanding individual difference research in the interaction approach: Investigating learners, instructors, and other interlocutors* (pp. 41-70).

Li, S., Ellis, R., & Zhu, Y. (2019). The associations between cognitive ability and L2 development under five different instructional conditions. *Applied Psycholinguistics, 40*, 693-722. https://doi.org/10.1017/S0142716418000796

Li, S., & Roshan, S. (2019). The associations between working memory and the effects of four different types of written corrective feedback. *Journal of Second Language Writing, 45*, 1-15. https://doi.org/10.1016/j.jslw.2019.03.003

Linck, J. A., Hughes, M. M., Campbell, S. G., Silbert, N. H., Tare, M., Jackson, S. R., Smith, B. K., Bunting, M. F., & Doughty, C. J. (2013). Hi-LAB: A new measure of aptitude for high-level language proficiency. *Language Learning, 63*(3), 530-566. https://doi.org/10.1111/lang.12011

Long, M. H. (2013). Maturational constraints on child and adult SLA. In G. Granena & M. H. Long (Eds.), *Sensitive periods, language aptitude, and ultimate L2*

attainment. John Benjamins. https://www.jbe-platform.com/content/books/9789027272065-01lon

Lyster, R., & Saito, K. (2010). Oral feedback in classroom SLA. *Studies in Second Language Acquisition*, *32*(02), 265-302. https://doi.org/10.1017/s0272263109990520

Morgan-Short, K., Faretta-Stutenberg, M., & Bartlett-Hsu, L. (2015). Contribution of event-related potential research into explicit and implicit second language acquisition. In P. Rebuschat (Ed.), *Investigating implicit and explicit language learning* (pp. 349-386). John Benjamins Publishing Company.

Munoz, C. (2007). Age-related differences and second language learning practice. In R. M. DeKeyser (Ed.), *Practice in a second language: Perspectives from applied linguistics and cognitive psychology* (pp. 229-255). Cambridge University Press.

Ojima, S., Matsuba-Kurita, H., Nakamura, N., Hoshino, T., & Hagiwara, H. (2011). Age and amount of exposure to a foreign language during childhood: Behavioral and ERP data on the semantic comprehension of spoken English by Japanese children. *Neuroscience Research*, *70*(2), 197-205. https://doi.org/10.1016/j.neures.2011.01.018

Pashler, H., McDaniel, M., Rohrer, D., & Bjork, R. (2008). Learning styles concepts and evidence. *Psychological Science in the Public Interest, 9*(3), 105-119. https://doi.org/10.1111/j.1539-6053.2009.01038.x

Qureshi, M. A. (2016). A meta-analysis: Age and second language grammar acquisition. *System, 60*, 147-160. https://doi.org/10.1016/j.system.2016.06.001

Robinson, P. (1997). Individual differences and the fundamental similarity of implicit and explicit adult SLA. *Language Learning*, *47*(1), 45-99. https://doi.org/10.1111/0023-8333.21997002

Roehr-Brackin, K., & Tellier, A. (2019). The role of language-analytic ability in children's instructed second language learning. *Studies in Second Language Acquisition, 41*(5), 1111-1131. https://doi.org/10.1017/S0272263119000214

Rosa González, D. (2011). *The effects of aptitude and motivation on the acquisition of EFL in young learners* Universitat of Barcelona].

Saito, K. (2017). Effects of sound, vocabulary, and grammar learning aptitude on adult second language speech attainment in foreign language classrooms. *Language Learning, 67*(3), 665-693. https://doi.org/10.1111/lang.12244

Sanz, C., Lin, H.-J., Lado, B., Stafford, C. A., & Bowden, H. W. (2016). One size fits all? Learning conditions and working memory capacity in ab initio language development. *Applied linguistics*, *37*(5), 669-692. https://doi.org/10.1093/applin/amu058

Sheen, Y. (2007). The effect of focused written corrective feedback and language aptitude on ESL learners' acquisition of articles. *TESOL Quarterly, 41*(2), 255-283. https://doi.org/10.1002/j.1545-7249.2007.tb00059.x

Shintani, N., & Ellis, R. (2015). Does language analytical ability mediate the effect of written feedback on grammatical accuracy in second language writing? *System, 49*, 110-119. https://doi.org/10.1016/j.system.2015.01.006

Skehan, P. (1998). *A cognitive approach to language learning*. Oxford University Press.

Stefanou, C., & Révész, A. (2015). Direct written corrective feedback, learner differences, and the acquisition of second language article use for generic and specific plural reference. *The Modern Language Journal, 99*(2), 263-282.

https://doi.org/10.1111/modl.12212
Suzuki, Y. (2017). Validity of new measures of implicit knowledge: Distinguishing implicit knowledge from automatized explicit knowledge. *Applied Psycholinguistics, 38*(5), 1229-1261. https://doi.org/10.1017/S014271641700011X
Suzuki, Y. (2019). Individualization of practice distribution in second language grammar learning: A role of metalinguistic rule rehearsal ability and working memory capacity. *Journal of Second Language Studies, 2*(2), 170–197. https://doi.org/10.1075/jsls.18023.suz
Suzuki, Y. (2021). The cognitive approach. In T. Gregersen & S. Mercer (Eds.), *The Routledge handbook of psychology of language learning* (pp.7-21). New York, NY: Routledge.
Suzuki, Y., & DeKeyser, R. M. (2015). Comparing elicited imitation and word monitoring as measures of implicit knowledge. *Language Learning, 65*(4), 860-895. https://doi.org/10.1111/lang.12138
Suzuki, Y., & DeKeyser, R. M. (2017a). Exploratory research on L2 practice distribution: An aptitude x treatment interaction. *Applied Psycholinguistics, 38*(1), 27-56. https://doi.org/10.1017/S0142716416000084
Suzuki, Y., & DeKeyser, R. M. (2017b). The interface of explicit and implicit knowledge in a second language: Insights from individual differences in cognitive aptitudes. *Language Learning, 67*(4), 747-790. https://doi.org/10.1111/lang.12241
Suzuki, Y., Jeong, H., Cui, H., Okamoto, K., Kawashima, R., & Sugiura, M. (2022). An fMRI validation study of the word-monitoring task as a measure of implicit knowledge: Exploring the role of explicit and implicit aptitudes in behavioral and neural processing. *Studies in Second Language Acquisition*. Early View.
Suzuki, Y., Nakata, T., & DeKeyser, R. M. (2019). The desirable difficulty framework as a theoretical foundation for optimizing and researching second language practice. *Modern Language Journal, 103*(3), 713-720. https://doi.org/10.1111/modl.12585
Suzuki, Y., Yokosawa, S., & Aline, D. (2020). The role of working memory in blocked and interleaved grammar practice: Proceduralization of L2 syntax. *Language Teaching Research, Early View*. https://doi.org/10.1177/1362168820913985
Torres, J., Estremera, R., & Mohamed, S. (2019). The contribution of psychosocial and biographical variables to heritage language learners' linguistic knowledge of spanish. *Studies in Second Language Acquisition, 41*(4), 695-719. https://doi.org/10.1017/S0272263119000184
Vafaee, P., Suzuki, Y., & Kachinske, I. (2017). Validating grammaticality judgment tests: Evidence from two new psycholinguistic measures. *Studies in Second Language Acquisition, 39*(1), 59-95. https://doi.org/10.1017/S0272263115000455
Wen, Z., Biedroń, A., & Skehan, P. (2017). Foreign language aptitude theory: Yesterday, today and tomorrow. *Language Teaching, 50*(1), 1-31. https://doi.org/10.1017/S0261444816000276
Wesche, M. (1981). Language aptitude measures in streaming, matching students with methods, and diagnosis of learning problems. In K. C. Diller (Ed.), *Individual differences and universals in language learning aptitude* (pp. 119-154). Newbury House.