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Research Article

Interactions Among Declarative and Procedural Memory Systems, Different Linguistic Structures, and the Efficacy of Different Corrective Feedback Types

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ABSTRACT

This study investigated the interactions among different cognitive abilities, linguistic structures, and the efficacy of different corrective feedback (CF) types. The cognitive abilities examined were declarative and procedural memory. The target linguistic structures were English regular and irregular past tense forms. In terms of the relationships between English past tense forms and the two memory systems, the declarative and procedural (D/P) model (Ullman, 2020) posits that regular past tense forms are learned in procedural memory while irregular past tense forms are learned in declarative memory. However, these relationships have not been investigated for second language learners. The participants were divided into recast, explicit correction, metalinguistic prompt groups. Second language learning was measured using an untimed grammaticality judgment task (UGJT) and an elicited imitation task (EIT). The results showed that procedural memory significantly predicted the UGJT posttest scores for regular past tense forms in the metalinguistic prompt group, while declarative memory significantly predicted the EIT posttest scores for irregular past tense forms in the recast group. These results were consistent with the predictions of the D/P model that the learning of regular past tense forms is related to procedural memory, whereas that of irregular past tense forms is related to declarative memory, although relationships were not observed for all the treatment groups.

Keywords: corrective feedback, declarative memory, procedural memory, the past tense

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INTRODUCTION

The effects of corrective feedback (CF) on second language (L2) learning have been widely reported (e.g., Li, 2010; Lyster & Saito, 2010; Mackey & Goo, 2007). However, research has shown that these effects are moderated by learner internal variables such as cognitive abilities or aptitude (e.g., Fu & Li, 2021; Granena & Yilmaz, 2019; Li, 2013, 2015; Li et al., 2019; Sheen, 2007; Yilmaz, 2013; Yilmaz & Granena, 2016, 2019) and/or learner external variables such as linguistic structures (Yalcin & Spada, 2016; Yang & Lyster, 2010). Aptitude refers to "cognitive and perceptual abilities that facilitate L2 acquisition" (Kourtali & Révész, 2020, p. 183). Several researchers have recently begun to consider declarative and procedural memories (Buffington & Morgan-Short, 2019; Fu & Li, 2021) as language aptitudes. Declarative memory is "a memory system that supports the acquisition of facts and personal experiences" (Buffington & Morgan-Short, 2019, p. 216), while procedural memory is "a type of implicit memory system that supports the acquisition of cognitive and motor skills as well as habits" (Buffington & Morgan-Short, 2019, p. 217). Most previous studies have investigated the associations between the two memory systems and L2 development under implicit, explicit, and/or incidental learning conditions (Hamrick, 2015; Morgan-Short et al., 2014; Suzuki, 2018; Tagarelli et al., 2016). However, these studies were laboratory studies, and CF was not provided during classroom interactions. Recently, however, such a study was conducted by Fu and Li (2021). They showed that procedural memory was significantly associated with the efficacy of immediate CF, while declarative memory was significantly associated with that of delayed CF.

As the provision of different types of CF requires different processing on the part of the learner, different aptitudes or cognitive abilities would be called upon according to each type of feedback (e.g., Li, 2013, 2015; Yilmaz & Granena, 2021). In addition, different aptitudes may be required to develop different linguistic structures (Yalcin & Spada, 2016). The current study targeted regular and irregular past tense forms as the learning of these two forms is considered to involve different learning processes (Yang & Lyster, 2010) and may require differential cognitive abilities. Ullman (2020) proposed the declarative/procedural (D/P) model and insisted that the regular past tense form may rely on rule-based learning and be related to procedural memory, whereas the irregular past tense form may rely on item-based learning and be related to declarative memory. DeKeyser (2012) argues that exploring the interaction between treatment, aptitude, and linguistic structures reveals the black box of L2 learning processes. This study aimed to investigate the relatively unexplored associations of declarative and procedural memory with the effects of three different types of feedback (recasts, explicit correction, and metalinguistic prompts) on L2 learning of different linguistic structures (i.e., regular and irregular past tense forms).

LITERATURE REVIEW

Corrective Feedback Types

CF "refers to responses to learners' errors, and it is an important aspect of interaction that has been found to lead to learning gains" (Li, 2017, p. 46). Lyster and Saito (2010) classified CF into three types: recasts, explicit correction, and prompts. Recasts refer to "the teacher's reformulation of all or part of a student's utterance minus the error" (Lyster & Ranta, 1997, p. 46). Explicit correction is "the explicit provision of correct form" and it "clearly indicates that what the student had said was incorrect" (Lyster & Ranta, 1997, p. 46). The provision of explicit correction can accompany metalinguistic explanations (Sheen & Ellis, 2011). Unlike recasts and explicit correction, various types of CF such as elicitation, repetition, clarification requests, and metalinguistic prompt/feedback can be included in prompts. The common characteristics among them is that "they withhold correct forms and instead provide clues to prompt students to retrieve these correct forms from their existing knowledge" (Lyster & Saito, 2010, p. 268). The current study only deals with metalinguistic prompts/feedback and the terms metalinguistic prompts and metalinguistic feedback are used interchangeably. Since recasts and explicit correction provide correct target forms, they are categorized into input-providing feedback. In contrast, as metalinguistic prompts do not provide correct target forms and, instead, elicit those forms from learners, they are classified into output-prompting feedback (Ellis & Shintani, 2013). Furthermore, these feedback types can be classified into implicit or explicit feedback. Implicit feedback refers to "feedback that does not overtly correct the learner error; rather it signals to the learner indirectly that his utterance may contain an error" (Nassaji, 2015, p.

56). In contrast, explicit feedback "indicates clearly to the learner that his or her utterance is erroneous" (Nassaji, 2015, p. 56). Recasts are frequently categorized into implicit feedback, while explicit correction and metalinguistic prompts are categorized into explicit feedback. However, "the issue of implicit and explicit is relative and a matter of degree" (Nassaji, 2015, p. 57). For instance, although recasts are considered a relatively implicit type of feedback, they can be more explicit if they are partial, interrogative, and/or intensive. Moreover, the degree of explicitness may vary depending on the linguistic structures. For instance, if recasts target irregular past tense forms, the feedback may be more explicit than the feedback targeting regular past tense forms, as the former is more noticeable owing to the saliency of the structure (Yang & Lyster, 2010).

Theoretically, the effectiveness of input-providing feedback such as recasts and explicit correction is supported by the noticing hypothesis (Sheen, 2007). Schmidt (1995, 2001) argued that noticing facilitates L2 development. As both recasts and explicit correction contain the correct target form or positive evidence, the learner may be able to notice the gap between their erroneous utterances and the target forms more easily compared to those who receive CF without the correct form. Moreover, as these two types of feedback are categorized as input-providing feedback, the input hypothesis (Krashen, 1981), that states that input is indispensable for L2 learning, may be related to learning under these two feedback conditions. Conversely, metalinguistic prompts are supported by the skill acquisition theory (Lyster & Sato, 2013). DeKeyser (2015) states that initial declarative knowledge is proceduralized when used during communicative activities. As metalinguistic prompts provide metalinguistic declarative knowledge, and opportunities to apply this knowledge in subsequent production, this feedback may encourage more proceduralization (Lyster & Sato, 2013) than input-providing feedback.

Declarative Memory, Procedural Memory and L2 Learning

The D/P model proposed by Ullman (2020) is "motivated by basic principles of evolution and biology" (p. 155). Ullman argued that declarative memory relies "on medial temporal lobe and its associated circuitry" (p. 130) while procedural memory relies on "the basal ganglia and their associated circuitry" (p. 132). The D/P model is theoretically powerful and "generates a wide range of behavioral and neurocognitive predictions" (Ullman, 2020, p. 155) for L2 learning. The model posits that when one attempts to memorize the meanings of L2 words, declarative memory supports memorization. Moreover, Ullman (2015, p. 141) postulates that procedural memory "may be expected to underlie the learning and processing of sequences and rules in both first and second language", and that it plays an important role in predicting "output of a linguistic rule." Regarding linguistic structures, the D/P model postulates that regular and irregular past tense forms are learned in procedural and declarative memory systems, respectively.

Recently, researchers have begun to investigate the relationship between declarative and procedural memories, and L2 learning. Although most of the past studies have not focused on the association between declarative and procedural memory and the effects of different feedback types on L2 learning, they found that individual differences in the two types of memory affect L2 learning (Faretta-Stutenberg & Morgan-Short, 2018; Hamrick, 2015; Hamrick et al., 2018; Morgan-Short et al., 2014; Suzuki, 2018; Tagarelli et al., 2016). Hamrick et al. (2018) conducted meta-analyses and showed that grammar learning was associated with declarative memory for L2 learners with less L2 experience, while it was related to procedural memory for those with more L2 experience. Furthermore, research has suggested that learning in implicit conditions is generally related to procedural memory, while that in explicit conditions is related to declarative memory. For instance, Faretta-Stutenberg and Morgan-Short (2018) showed that procedural memory was related to L2 learning for learners who studied abroad, but not for those who studied L2 at their university. As the former learners were in a more implicit learning condition, Faretta-Stutenberg and Morgan-Short (2018) argued that "the role of procedural memory may be enhanced under less explicit, more exposure-based contexts" (p. 24). However, Suzuki (2018) found a significant relationship between procedural learning ability and the early stages of the automatization of L2 morphology even in explicit conditions. To the best of my knowledge, only one study has investigated the associations between effects of CF provided in classrooms and the two types of memory (Fu & Li, 2021). Fu and Li (2021) focused on the timing of CF and

explored whether the benefits of immediate and delayed CF were associated with these two types of memory. The CF employed in their study was corrective recast (Doughty & Varela, 1998). The feedback consisted of "two moves: an output-prompting move aiming at eliciting a self-correction, followed by an input-providing move if a self-repair is not provided or is not successful" (Fu & Li, 2021, p. 9). The target structure was the English past tense. The results showed that procedural memory was significantly predictive of the efficacy of immediate CF, whereas declarative memory was significantly predictive of the efficacy of delayed CF.

Although Fu and Li (2021) did not distinguish between regular and irregular past tense forms, the effects of declarative and procedural memory on language learning may also differ based on linguistic structures. Lum and Kidd (2012) investigated the relationships between the two types of memory, and the learning of regular and irregular past tense forms and vocabulary for first language (L1) children. According to the D/P model, declarative and procedural memory systems are related to the learning of irregular and regular past tense forms, respectively. The learning of the former form requires item-based learning, while that of the latter requires rule-based learning. The results showed that neither declarative nor procedural memory was associated with the correct production of irregular or regular past tense forms, but that declarative memory was related to vocabulary sizes. The authors argued that the age of the participants may be relevant to the non-significant results between the two types of memory and the past tense. However, these relationships have not yet been explored for L2 learners.

Purposes of the Current Study

The current study is part of a larger study that investigated the relationships between the benefits of different types of CF and L2 learning (Sato, 2021). The study reported here aims to examine whether effects of different types of CF (recasts, explicit correction, and metalinguistic prompts) on different linguistic structures (regular and irregular past tense) are moderated by declarative and procedural memories. Different feedback types require differential processing on the part of the learner, and hence the learner would rely on different cognitive abilities. The inclusion of the three different types of CF would better clarify the process associated with L2 development. For instance, comparing the three CF types would reveal more clearly which dimension (implicitness/explicitness or input-providing/output-prompting) is more related to which cognitive ability than when comparing only two types. In this regard, Ellis (2021) pointed out that most previous studies confounded the explicit/implicit dimension with the input-providing/output-prompting dimension. Moreover, research suggests that different linguistic structures may call for different cognitive abilities/aptitude (Ullman, 2015; Yalcin & Spada, 2016). For instance, the D/P model predicts that regular and irregular past tense are learned in different memory systems. Therefore, this study aimed to examine the interactions among CF types, cognitive abilities, and linguistic structures. The following research questions were formulated:

1. Are declarative and procedural memories associated with L2 learning of the regular past tense when L2 learners receive recasts, explicit correction, or metalinguistic prompts during interactions?
2. Are declarative and procedural memories associated with L2 learning of the irregular past tense when L2 learners receive recasts, explicit correction, or metalinguistic prompts during interaction?
3. If such an association is found, does the relationship differ depending on the linguistic structure?

As the D/P model posits that declarative memory and procedural memory are related to irregular and regular past tense forms respectively, such relations may be observed in this study. Learning in procedural memory requires the creation/updating of representations after incorrect predictions (Ullman, 2020). As metalinguistic prompts require additional output opportunities for practice, a positive relation between procedural memory and metalinguistic prompts would be expected, particularly for regular past tense forms. Conversely, for irregular past tense forms, recast and explicit correction include correct target forms, and learners who receive such feedback would easily learn the forms. Thus, a relationship between declarative memory and irregular past tense forms would be found under these feedback conditions.

METHOD

Participants

This study included 92 Japanese learners of English as a foreign language (EFL). They were university freshmen, and their age ranged from 19 to 20 years. They had been learning EFL for over six years. Based on the scores of the TOEIC (Test of English for International Communication) Bridge test, the learners' proficiency levels were assumed to be upper beginner to lower intermediate. Three classes that were assumed to possess relatively similar L2 proficiency were chosen and assigned to the recast, explicit correction, metalinguistic prompt groups. The three CF groups received feedback during tasks designed to elicit the past tense. All the groups completed a pretest, immediate posttest, and delayed posttest. As the participants' duration of L2 learning before the study was over six years, they possessed partial knowledge of past tense forms. Data from participants whose pretest scores on the grammaticality judgement test (GJT) were >90% were excluded from the analyses to observe the effects of CF on L2 development. Moreover, data from participants who did not take the aptitude tests were not included in the analysis. One-way analyses of variance (ANOVAs) were separately computed on the pretest scores of GJT and elicited imitation test (EIT) for regular and irregular past tense forms to confirm that there were no significant group differences in terms of prior knowledge of the target structures. The results of ANOVAs showed that there were no significant differences among the groups in GJT scores for the regular past tense form, F (2, 89) = 2.06, p = .13, partial η^2 = .04 and the irregular past tense form, F (2, 89) = 0.42, p = .66, partial η^2 = .01. Moreover, ANOVAs did not detect significant group differences in EIT scores for the regular past tense form, F (2, 89) = 0.89, p = .41, partial η^2 = .02 and the irregular past tense form, F (2, 89) = 2.13, p = .13, partial η^2 = 05.

Linguistic Target

The target linguistic structures in this study were English regular and irregular past tense forms. Regular past tense forms are constructed by the following simple rule: add *-ed* to the end of the base form of a regular verb. However, in terms of irregular past tense forms, there is no clear rule. English regular and irregular past tense forms were selected as the target structures for two reasons. First, even learners in the later stages of second language acquisition have difficulty in gaining full control of these structures (Ellis et al., 2006). Thus, although the learners in this study possessed partial knowledge of the structures, effects of feedback on the structures would be observed. Moreover, the interactions among the benefits of CF, cognitive abilities, and linguistic structures can be examined by using different linguistic structures. In particular, the prediction of the D/P model can be investigated by using regular and irregular past tense forms. As the D/P model posits that declarative memory supports the learning of irregular past tense forms, while procedural memory supports that of regular past tense forms, the use of these structures would reveal whether different linguistic structures call for different cognitive abilities.

Treatment Tasks

Picture-cued narrative tasks were used to elicit the target structures. Researchers who explore the effects of CF on the development of past tense forms frequently adopt such tasks (Ellis, 2007; Ellis et al., 2006; Yang & Lyster, 2010). As a story for this task, one of the Japanese famous folk tales, *Momotaro*, was selected. Participants were shown pictures of the story on a computer screen and asked to describe the scenes. Several unfamiliar verbs related to the scenes were listed in these pictures. In addition, several sentences related to the scenes were included in the pictures to reduce the burden imposed on the participants.

First, the participants practiced describing the scenes in pairs. Subsequently, several participants chosen by the teacher described the scenes in class. When they made an ill-formed utterance about past tense forms, the teacher provided CF. The story of *Momotaro* was divided into two parts, and the first and second halves were used during the first and second weeks, respectively. The task took approximately 30 minutes to complete.

Corrective Feedback Types

During the treatment tasks, participants in recasts, explicit correction, and metalinguistic prompts groups received CF when they uttered ill-formed past tense forms. The recasts were full and declarative (Zhao & Ellis, 2022). An example of this is as follows.

Learner: The man go to a forest.

Researcher: Oh, the man went to a forest.

Explicit correction included a clear indication that the learner's utterance was problematic, the correct target form, and metalinguistic information, as shown below.

Learner: The woman pick up the peach.

Researcher: No. You need to use the past tense. So, the woman picked up the peach.

Metalinguistic prompts consisted of metalinguistic information and opportunities for learners to modify their erroneous utterances. Unlike explicit correction, the feedback did not contain correct forms, as demonstrated below.

Learner: They arrive on the island.

Researcher: You need to use the past tense. So…

Learner: They arrived on the island.

Assessment Tests

Untimed Grammaticality Judgment Task. The participants read grammatical or ungrammatical sentences shown on a computer screen and indicated whether the sentence was grammatical under no time pressure (e.g., Miki played badminton yesterday). For ungrammatical sentences, participants were required to correct the errors. The test included 16 sentences for the target structures and eight distractor sentences. Half of the sentences were grammatical, and the other half were ungrammatical. The target sentences consisted of nine sentences for regular past tense forms and seven for irregular past tense forms. If the learner judged grammatical sentences to be grammatical, one point was awarded. For ungrammatical sentences, a point was awarded if the learner judged them to be incorrect and provided a correction for the ungrammatical part. The reliabilities of the pretest, immediate posttest, and delayed posttests were α = .68, .72, and .77, respectively. The UGJT has been used to measure mainly learners' explicit or declarative knowledge (Ellis, 2005, 2009; Zhao & Ellis, 2022) and has been validated as such a measure (Bowles, 2011; Ellis, 2005, 2009; Zhang, 2015).

Elicited Imitation Task. In the EIT, participants listened to a sentence (e.g., Last week, I took a bus to come to school.) and indicated on their answer sheet whether it was true of their personal life. This oriented their attention to meaning, rather than to form (Erlam, 2009). Subsequently, they had to reproduce the sentence in correct English within six seconds. A time limit was set to encourage the use of the learners' procedural knowledge. A limit of six seconds was defined based on the participants' performances in the preliminary study. Participants' reproductions were audio recorded. The test included 12 sentences for the target structures and six distractor sentences. Half of the sentences were grammatical, and half were ungrammatical. There were six target items each for the regular and irregular past tense forms. For grammatical items, one point was awarded if the learner correctly repeated the target structure. For ungrammatical items, a point was awarded if the learner corrected the erroneous part. The reliabilities of the pretest, immediate posttest, and delayed posttests were α = .68, .70, and .67, respectively. The EIT has been validated as a measure of implicit knowledge (Bowles, 2011; Ellis, 2005, 2009; Zhang, 2015). However, several researchers have considered it as a measure of procedural or automatized explicit (procedural) knowledge (Suzuki & DeKeyser, 2015; Zhao & Ellis, 2022). As the participants in this study possessed explicit or declarative knowledge of the target structures, and the measure may not have prevented learners from consciously accessing the knowledge, what was measured using the EIT was considered to be their procedural knowledge.

Three versions of the two types of tests were developed for the pretest and the two posttests. The test items were the same but ordered differently.

Aptitude Tests

L2 researchers have frequently used the LLAMA_B (Meara, 2005) and a serial reaction time (SRT) task (Nissen & Bullemer, 1987) to measure declarative and procedural memory, respectively. These two measures were used in this study.

LLAMA_B. To measure the participants' declarative memory, LLAMA_B, a subcomponent of the LLAMA test, was used. LLAMA_B is a vocabulary-learning task. In the training session, participants memorized the names of 20 characters shown on the screen for two minutes. When they clicked on the characters on the screen, their names appeared. After the training session, the participants completed a test that required them to choose the correct character to match the provided name. The software automatically computed the scores.

Serial Reaction Time Task. This test measures the participants' procedural memory. The participants were shown four circles arranged horizontally on the computer screen, of which one circle was colored, and were asked to press the key corresponding to it as fast and accurately as possible. The colored circle appeared pseudo-randomly in the first and last (sixth) blocks, while in the second to fifth blocks, the circle appeared in a set order of 12 sequences. There were six blocks of 60 trials. The mean RT difference between the fifth (last patterned sequence) and sixth (last random sequence) blocks was regarded as the participants' procedural memory ability, factoring out practice effects (Hamrick, 2015).

Procedure

Data were collected over six weeks. During the first week, all groups completed the pretests (UGJT and EIT) and aptitude tests (LLAMA_B and SRT task). In the second and third weeks, all participants performed the first and second tasks, respectively. Participants received feedback during the task. Each task lasted approximately 30 minutes. In the third week, all groups underwent the immediate posttest. Three weeks later, they completed the delayed posttest.

Analysis

The dataset for this study was collected as part of a larger study examining the relationship between different CF types and L2 development (Sato, 2021, 2022, 2023). Multiple regression analyses were conducted separately for regular and irregular past tense forms to examine the research questions. The dependent variables were the immediate and delayed posttest scores of the GJT or EIT. The predictor variables were aptitude test scores for LLAMA_B and SRT tasks. Furthermore, the participants' pretest scores on the GJT or EIT were included as a predictor variable, as previous studies found that pretest scores significantly explained posttest scores (Fu & Li, 2021; Li et al., 2019; Yalcin & Spada, 2016). In the regression analyses, the data did not violate the assumptions of independence of errors, and multicollinearity was not detected.

RESULTS

For regular past tense forms, the numbers of CF received by the recast, explicit correction, and metalinguistic prompt groups were five, four, and four, respectively, while for irregular past tense forms, the numbers were five, six, and five, respectively. Thus, all the CF groups received a comparable amount of feedback for regular, χ^2 (2) = 0.154, $p < .05$, and irregular past tense forms, χ^2 (2) = 0.125, $p < .05$. Table 1 presents the descriptive statistics for LLAMA_B and SRT task. One-way ANOVAs showed that there were no significant group differences in LLAMA_B scores, F (2, 89) = 0.41, $p = .67$, partial $\eta^2 = .01$; or the SRT scores, F (2, 89) = 0.08, $p = .92$, partial $\eta^2 = .00$. In terms of the effect size, .01, .06, and .14 were considered small, medium and large, respectively (Mizumoto & Takeuchi, 2008).

Table 1. *Descriptive Statistics for LLAMA_B and the SRT Task*

		LLAMA_B		SRT	
Group	*n*	*M*	*SD*	*M*	*SD*
Recast	32	57	16.4	71.6	57
Explicit correction	30	57.8	22.2	66.6	36
Metalinguistic prompts	30	53.3	23	68	54

Note. SRT = serial reaction time task.

Regular Past Tense

Descriptive statistics of the GJT and EIT scores for the pretest, immediate posttest, and delayed posttest are presented in Tables 2 and 3, respectively. Repeated measures ANOVAs showed that the participants improved their GJT and EIT scores after the treatment, F (2, 182) = 40.1, p = .00, partial η^2 = .31, and F (2, 182) = 18.4, p = .00, partial η^2 = .17, respectively. The large effect sizes showed that the treatment was effective in learning regular past tense forms. As the focus of this study was on the relationship between language aptitude and the effects of different CF types, no group comparisons were conducted (Sato, 2021).

Table 2. *Descriptive Statistics for the Untimed Grammaticality Judgment Test for Regular Past Tense*

		Pretest		Immediate posttest		Delayed posttest	
Group	*n*	*M* (%)	*SD*	*M* (%)	*SD*	*M* (%)	*SD*
Recast	32	67.7	15.8	80.2	11.9	81.3	11.4
Explicit correction	30	75.2	10.8	87	10.1	82.2	15.3
Metalinguistic prompts	30	68.9	18.8	77	17.7	75.2	17.9

Table 3. *Descriptive Statistics for the Elicited Imitation Task for Regular Past Tense*

		Pretest		Immediate posttest		Delayed posttest	
Group	*n*	*M* (%)	*SD*	*M* (%)	*SD*	*M* (%)	*SD*
Recast	32	27.9	21.8	41.7	24.7	31.3	21.9
Explicit correction	30	22.8	22.5	29.4	25.4	28.3	20.1
Metalinguistic prompts	30	20.6	22.2	33.3	23.2	37.8	21

Multiple regression analyses were performed to answer research question 1. Tables 4 and 5 present summaries of the multiple regression analyses for the UGJT and EIT for regular past tense form. In general, pretest scores were significantly related to posttest scores irrespective of the CF type or L2 outcome measure, in line with previous studies (Fu & Li, 2021; Li et al., 2019; Yalcin & Spada, 2016). Regarding the effects of cognitive abilities, declarative memory scores measured using the LLAMA_B were not significantly related to the post-test scores of any of the groups. Procedural memory scores measured using the SRT were significant predictors of only the UGJT immediate posttest scores of the metalinguistic prompt group. These results are in line with the D/P model, in that only procedural memory was related to the learning of regular past tense forms. In addition, the results revealed an interaction between the two types of memory and the three feedback conditions.

Irregular Past Tense

The descriptive statistics of the GJT and EIT scores for the irregular past tense forms are displayed in Tables 6 and 7, respectively. A repeated measures ANOVA confirmed that all the groups improved their GJT and EIT scores after they received the treatment, F (2, 182) = 32.0, p = .00, partial η^2 = .26; and F (2, 182) = 24.2, p = .00, partial η^2 = .21, respectively. The large effect sizes showed that the three types of CF were beneficial for learning irregular past tense forms.

Table 4. *Summary of Multiple Regression Analyses for Untimed Grammaticality Judgement Task for Regular Past Tense*

		LLAMA_B		SRT		Pretest		
Group	Timing	β	*p*	β	*p*	β	*p*	R^2
Recasts	IP	.01	.07	-.19	.31	.31	.10	.05
	DP	-.08	.63	-.09	.58	.54*	.00	.22
Explicit correction	IP	.14	.42	.00	.97	.49*	.01	.14
	DP	.00	.98	.05	.79	.55*	.03	.24
Metalinguistic prompt	IP	.06	.60	.33*	.00	.72*	.00	.77
	DP	.07	.64	.26	.06	.66*	.00	.60

Note. IP = immediate posttest; DP = delayed posttest; SRT = serial reaction time task; R^2 = adjusted R^2; * = $p < .05$.

Table 5. *Summary of Multiple Regression Analyses for Elicited Imitation Task for Regular Past Tense*

		LLAMA_B		SRT		Pretest		
Group	Timing	β	*p*	β	*p*	β	*p*	R^2
Recasts	IP	-.09	.49	.15	.28	.70*	.00	.46
	DP	.00	.96	.07	.66	.59*	.00	.29
Explicit correction	IP	-.09	.57	.09	.53	.76*	.00	.47
	DP	.03	.84	-.05	.75	.64*	.00	.37
Metalinguistic prompt	IP	.13	.37	-.07	.65	.73*	.00	.52
	DP	.20	.19	-.11	.46	.71*	.00	.54

Note. IP = immediate posttest; DP = delayed posttest; SRT = serial reaction time task; R^2 = adjusted R^2; * = $p < .05$.

Table 6. *Descriptive Statistics for the Untimed Grammaticality Judgment Test for Irregular Past Tense*

		Pretest		Immediate posttest		Delayed posttest	
Group	*n*	*M* (%)	*SD*	*M* (%)	*SD*	*M* (%)	*SD*
Recast	32	71.9	14.3	82.6	11.3	80.8	13.4
Explicit correction	30	71	12.1	84.8	11.8	80.5	13.3
Metalinguistic prompts	30	68.6	16.9	77.1	20.4	78.1	17.1

Table 7. *Descriptive Statistics for the Elicited Imitation Task for Irregular Past Tense*

		Pretest		Immediate posttest		Delayed posttest	
Group	*n*	*M* (%)	*SD*	*M* (%)	*SD*	*M* (%)	*SD*
Recast	32	16.1	17.2	31.8	25.5	25.5	23.2
Explicit correction	30	8.3	15.6	19.4	19.6	18.9	18.4
Metalinguistic prompts	30	10.1	14.3	21.1	23.1	23.3	26.1

Table 8. *Summary of Multiple Regression Analyses for Untimed Grammaticality Judgement Task for Irregular Past Tense*

		LLAMA_B		SRT		Pretest		
Group	Timing	β	*p*	β	*p*	β	*p*	R^2
Recasts	IP	.38*	.03*	-.05	.75	.22	.21	.12
	DP	.17	.32	.00	.99	.41*	.02	.17
Explicit correction	IP	-.06	.76	-.13	.49	.45*	.03	.12
	DP	-.09	.63	.17	.34	.35	.08	.12
Metalinguistic prompt	IP	.13	.48	.00	.98	.56*	.00	.30
	DP	.25	.15	.06	.75	.47*	.01	.34

Note. IP = immediate posttest; DP = delayed posttest; SRT = serial reaction time task; R^2 = adjusted R^2; * = $p < .05$.

Table 9. *Summary of Multiple Regression Analyses for Elicited Imitation Task for Irregular Past Tense*

		LLAMA_B		SRT		Pretest		
Group	Timing	β	*p*	β	*p*	β	*p*	R^2
Recasts	IP	.16	.31	.07	.64	.56*	.00	.30
	DP	.09	.57	.06	.72	.57*	.00	.27
Explicit correction	IP	.07	.71	-.06	.76	.40*	.04	.09
	DP	.19	.22	.09	.56	.64*	.00	.37
Metalinguistic prompt	IP	.06	.75	.04	.82	.45*	.01	.14
	DP	.26	.14	-.03	.86	.54*	.00	.33

Note. IP = immediate posttest; DP = delayed posttest; SRT = serial reaction time task; R^2 = adjusted R^2; * = $p < .05$.

Multiple regression analyses were conducted to explore research question 2. Tables 8 and 9 summarize the multiple regression analyses. In line with the results of the regular past tense form, pretest scores were generally significantly associated with posttest scores irrespective of the CF type and outcome test. Declarative memory (LLAMA_B) scores were significantly related only to the UGJT immediate posttest scores of the recast group. However, procedural

memory (SRT) scores were not a significant predictor of the UGJT and EIT posttest scores irrespective of the type of CF. These results are in line with the D/P model in that declarative memory was only associated with the learning of irregular past tense forms. Moreover, the results demonstrated an interaction between the two cognitive abilities and three CF types.

DISCUSSION

The present study sought to examine whether declarative and procedural memories were differentially related to the effectiveness of different CF types (recasts, explicit correction, and metalinguistic prompts) in the development of different linguistic structures (regular and irregular past tense forms). The results indicated that these cognitive abilities were differentially associated with the effects of different CF types. Furthermore, the relationship patterns differed according to the linguistic structures. The following section discusses the major findings for the regular and irregular past tense forms.

Regular Past Tense

Declarative memory was not related to the efficacy of any CF for the regular past tense, regardless of the L2 outcome measure. This may be partly consistent with the prediction of the D/P model, which posits that the regular past tense form is learned in the procedural memory system. Although the simple rule of regular past tense formation (add *-ed* to the stem of verbs) could be learned declaratively, the relationship between declarative memory and learning of declarative knowledge was not observed for the CF groups. This may be because the L2 learners may not have needed to draw on their declarative memory as the rule of the regular past tense is simple.

The efficacy of metalinguistic prompts was related to procedural memory, which may be partly consistent with the prediction of the D/P model that the procedural memory system supports the learning of regular past tense forms. As only the metalinguistic prompt group was pushed to modify their erroneous output based on metalinguistic information, this may have facilitated the proceduralization process (Lyster & Sato, 2013), and the learners' procedural memory may have moderated the process. Although most previous studies have shown a positive relationship between procedural memory and L2 development under implicit conditions, one study (Suzuki, 2018) found a positive relationship even under explicit learning conditions. Suzuki (2018) insisted that procedural memory was associated with the early stages of automatization. As the pretest scores showed, the learners in this study were considered to be in the early stages of automatization as they possessed some declarative, but little procedural knowledge. Thus, procedural memory may be associated with early stage L2 development if learners are provided with practice opportunities or pushed to modify their output. In terms of this, Fu and Li (2021) provided corrective recasts, which included an output-prompting move and showed a significant association between procedural memory and the effectiveness of the feedback. Although a significant relationship was found only between procedural memory and declarative knowledge, these results are in line with those of previous studies (Faretta-Stutenberg & Morgan-Short, 2018; Hamrick, 2015; Morgan-Short et al., 2014) that used GJTs as outcome measures and reported a significant relationship between procedural memory and L2 learning. However, the treatment time was relatively short in this study. Considering that procedural knowledge develops gradually, a significant relationship may have been found between procedural memory and procedural knowledge had the learners been provided with more practice opportunities.

Irregular Past Tense

Declarative memory was associated with the benefits of recasts. There are no clear rules for constructing irregular past tense forms, unlike regular forms (add *-ed* to the end of the verb); thus, the learners would have needed to memorize the forms. This result is partly consistent with the prediction of the D/P model (Ullman, 2015) that irregular past tense forms are learned in the declarative memory system, while regular past tense forms are learned in the procedural memory system. As the recast group received the correct forms during their interaction with the teacher, learners with high declarative memory may have been able to store more irregular past tense forms. Conversely, such positive relationships were not observed in the other groups, although they performed better on the posttests after treatment. Notably, although the explicit correction group also received the correct forms, their declarative memory

was not significantly associated with the benefits of feedback. Although the reason for this is unclear, explicitly providing the correct forms/instructions may be related to neutralizing individual differences in cognitive ability (Li et al., 2019). However, for the generalization of these results, further studies are required.

Regarding procedural memory, no significant relationship was found between procedural memory and L2 development for any group. This is consistent with the prediction of the D/P model that irregular past tense forms are learned in the declarative memory system. As there is no clear rule to construct irregular past tense forms, this sequence learning or rule learning ability may not be necessary for learning irregular past tense forms.

CONCLUSION

This study examined whether declarative and procedural memories moderated the effects of recasts, explicit correction, and metalinguistic prompts on the development of English past tense forms. The results demonstrated the interactions between cognitive abilities, CF types, and linguistic structures. Declarative memory was significantly associated with the benefits of recasts of the irregular past tense forms. Since the recasts contained correct forms, learners under the recast condition may have learned the form declaratively. Procedural memory was related to the development of regular past tense forms under the metalinguistic prompt condition. Therefore, additional practice opportunities to apply the rules of regular past tense forms in communication may require this type of memory. The D/P model predicts that the declarative and procedural memory systems support the learning of irregular and regular past tense forms, respectively. The results of this study were essentially in line with the predictions of the D/P model, in that declarative and procedural memories were only significantly and positively associated with the learning of irregular and regular past tense forms, respectively. However, as discussed above, such relationships patterns were not always observed in any group. Therefore, further studies are necessary to support the D/P model.

This study has several limitations. First, treatment duration was short. Thus, proceduralization of the target structures may not have been substantial. Second, only one measure was employed for each cognitive ability. Therefore, future studies should employ multiple measures to generalize the results. Third, although the EIT and UGJT were employed as procedural and declarative knowledge measures respectively, there would not be a pure measure to tap into different linguistic knowledge separately (Ellis, 2009). Thus, the use of multiple measures for each knowledge type is recommended for future research. Fourth, as the participants possessed partial knowledge of the target structure, the relationship found in this study may not be applicable to learners with no knowledge of the structure. Employing a novel structure for the participants may generate different relationship patterns.

However, this study was the first to investigate the prediction of the D/P model under different feedback conditions for L2 learners and revealed complicated relations between linguistic structures, cognitive abilities, and instructional treatments. Further studies examining these interactions are necessary to generalize the results.

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Authors' Contributions

The author alone contributed to all stages of the research.

Ethics Approval & Consent to Participate

All participants provided written informed consent prior to enrollment and data collection in this study.

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