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Differences in Korean learners' acquisition of causative expressions: focus on learners' proficiency level

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Abstract

This study examines the learning patterns of intermediate and advanced Korean learners in the acquisition of causative expressions according to their proficiency and the causative sentence type. We measured their grammatical knowledge using three types of grammaticality judgment tasks (GJTs) and self-paced reading tasks (SPRTs) differing in time limit and modality. We included the GJT *A'* score and reading time (RT) for SPRTs' target and spillover regions. The results showed that intermediate learners' accuracy for morphological and lexical causatives was lower than that for syntactic causatives, while advanced learners' accuracy for lexical causatives was lower than that for syntactic and morphological causatives. Learners showed a lower accuracy for timed written and aural GJTs than untimed GJT. In SPRT, learners took twice as long to process the target regions as native speakers and even longer to process spillover regions. Advanced learners had a longer RT. Learners had a low correct rate for causative suffix substitution and adjectival root questions, substitution questions on causative markers, and substitution questions on causee case postpositions in morphological, syntactic, and lexical causatives. Learners showed confusion with active sentences in lexical causatives. This study has implications for understanding causative expression acquisition for learners' proficiency levels.

Keywords: Second language acquisition, Causative voice, Self-paced reading task, Grammaticality judgment task, Grammatical knowledge, Explicit knowledge, Implicit knowledge

Introduction

Korean causative expressions fall under an advanced grammatical category that learners find difficult to acquire (Choi, 2008; Kang & Cho, 2003; Lee et al., 2010; Park, 2019); even advanced learners make errors when using these expressions. Korean causative sentences can be divided into morphological causative sentences using causative verbs, syntactic causative sentences based on a syntactic composition (e.g., "*-key hata*"), and lexical causative sentences based on lexical elements (e.g., "*sikhita*"). In Korean, different types of sentences can be transformed into causative sentences by adding the marker of the causative expressions: adjectival, intransitive, and transitive sentences. The existence

of a variety of causative sentences increases the difficulty of learning Korean causative expressions.

In this context, this study explores the variance in the acquisition patterns of grammatical knowledge on causative expressions in intermediate and advanced learners of Korean, depending on their proficiency and causative sentence type. To this end, the study employs grammaticality judgment tasks (GJTs) and self-paced reading tasks (SPRTs) in an experiment involving 68 Korean learners (30 intermediate and 38 advanced) and 31 Korean native speakers (control group). The study uses GJT and SPRT as research tools to examine learners' acquisition patterns of grammatical knowledge. In second language acquisition research, GJT is widely used to measure learners' grammatical competence. However, differing views exist on the nature of the knowledge it measures. Studies have reported that the nature of knowledge measured by GJT varies depending on the variables, such as the presence of time limit, modality, and grammaticality (e.g., Bowels, 2011; Ellis, 2005; Gutiérrez, 2013; Kim & Nam, 2017; Vafaee et al., 2017; Zhang, 2015). SPRT is a psycholinguistic methodology used to measure learners' sentence processing or knowledge and to measure automated knowledge or implicit knowledge (Marsden et al., 2018). Therefore, this study examines Korean learners' acquisition of grammatical knowledge from various angles using several measurement tasks. It also presents educational implications that can be applied to Korean causative expression education by developing three types of GJTs: timed aural GJT (AGJT), written GJT (WGJT), and untimed written GJT (UGJT). In AGJT, WGJT, and UGJT, the sentences are presented as auditory stimulus, visual stimulus, and visual stimuli, respectively.

Based on the above discussions, the study presents the following research questions:

(i) How do the patterns of acquiring grammatical knowledge on causative expressions differ among Korean learners based on the learners' proficiency?

(ii) How does the acquisition of grammatical knowledge on causative expressions differ among Korean learners based on the type of causative sentences?

(iii) What educational implications can be derived from the analysis of Korean learners' acquisition patterns of grammatical knowledge related to causative expressions?

Theoretical considerations

Korean causative expressions

The causative is a type of grammatical voice found not only in Korean but also in other languages. "The causative construction is a linguistic expression that denotes a complex situation consisting of two component events—(i) the causing event in which the causer does or initiates something and (ii) the caused event in which the causee carries out an action or undergoes a change of condition or state as a result of the causer's action" (Comrie, 1989, p.158). Therefore, a non-causative sentence can be converted into a causative one by introducing a causer as a new subject noun phrase; in such sentences, the predicate realizes the causative expression. Before the addition of the marker of the causative expression, the basic sentence is called the active sentence in school grammar

(Koh & Koo, 2018; Koo, Park, Lee, Lee, & Hwang, 2018). The Korean causative sentence can have the following correlates: adjectival, transitive, and intransitive sentences.

Depending on the method of construction, the Korean causative sentence can be divided into morphological, syntactic, and lexical causative sentences. The morphological causative sentence has a causative verb as a predicate, which is derived from the derivative suffix. The syntactic causative sentence is based on a syntactic composition, and the lexical causative sentence is based on a lexical element. First, the morphological causative is realized through a causative verb predicate that combines the adjective, intransitive verb, and transitive verb root with the causative suffixes "*-i/hi/li/ki-*," "*-u/ku/chu-*." Studies have presented restricted causative derivations, not the exact derivation conditions (Koh & Koo, 2018; Yeon, 2011). They have also failed to clarify the substitution conditions for the suffixes "*-i/hi/li/ki-*" and "*-u/ku/chu-*" (Koh & Koo, 2018, 385). Some Korean textbooks have not included the causative suffixes "*-ku-*' and '*-chu-*" because of their low productivity (Choi, 2008).

Second, in the representative example of syntactic causative, the "*-key hata*" composition has been combined to the predicate stem; it has also been realized through "*-key mantulta*," "*-tolok hata*," "*-tolok mantulta*." These syntactic compositions can be combined with predicates that are not capable of undergoing causative derivation, resulting in causative sentences.

Finally, lexical causatives have been excluded from grammatical causative discussions because reducing them to productive grammar rules is difficult. However, it is argued that "(-)*sikhita*"—which is used as a causative suffix for Chinese word roots—should be treated as an important way to construct the Korean causative (e.g., Kim, 2019; Min, 2009). Given the purpose of Korean language education to enhance the actual communication skills of Korean learners, lexical causatives can serve as important educational content.

From the perspective of Korean language education, based on the studies analyzing the error patterns in Korean learners, it is necessary to examine areas posing difficulties to learners in actually acquiring the knowledge of causative sentences. The frequent causative expression errors in learners include affix-related errors (emerging from confusions associated with the right choice of causative suffix to the choice of verb) (Choi, 2008; Jun, 2016). The learners also commit errors in combining the causee case postpositions, which emerges from an improper understanding of the construction method of causative sentences (Choi, 2008; Jin, 2012; Jun, 2016; Kim, 2010). The other errors include the avoidance of formal causatives, the generalization of syntactic and lexical causatives (Choi, 2008; Jin & Lee, 2020; Lin, 2016), and the omission of the causative marker (Jun, 2016).

In view of these learning errors and difficulties, this study includes lexical causatives, along with morphological and syntactic causatives. Morphological and syntactic causatives have been important in the studies on Korean causative expressions. This study also presents causative sentences originating from different sentences, including adjectival, intransitive, and transitive sentences, as experimental stimuli. Through this, the study broadly observes Korean learners' grammatical acquisition of causative

Table 1 Features of implicit and explicit knowledge (Ellis, 2005)

Characteristics	Implicit knowledge	Explicit knowledge
Awareness	Intuitive awareness of linguistic norms	Conscious awareness of linguistic norms
Type of knowledge	Procedural knowledge of rules and fragments	Declarative knowledge of grammatical rules and fragments
Systematicity	Variable but systematic knowledge	Anomalous and inconsistent knowledge
Accessibility	Access to knowledge by means of automatic processing	Access to knowledge by means of controlled processing
Use of L2 knowledge	Access to knowledge during fluent performance	Access to knowledge during planning difficulty
Self-report	Nonverbalizable	Verbalizable
Learnability	Potentially only within critical period	Any age

L2—second language

expressions in various causative sentences. Drawing from previous studies, this study conducts experiments with non-grammatical sentences based on the various types of causative expression errors of Korean learners.

Second language learners' acquisition of grammatical knowledge

In the early days of SLA research, Bialystok (1978) proposed the concepts of implicit knowledge and explicit knowledge. Explicit knowledge refers to conscious and declarative knowledge that learners have about the formal aspects of the target language such as grammar, and implicit knowledge is unconscious and internalized knowledge related to the fluency or automatic processing of the target language. Ellis (2005) presents seven features to distinguish between explicit and implicit knowledge (see Table 1).

In their measurement of implicit and explicit knowledge, Ellis and Roever (2021) chose three important features—recognition, accessibility, and self-report. Implicit knowledge is non-linguistic knowledge that learners can access during natural language use through automatic processing, without subjective recognition.

As grammatical knowledge encountered in second language learning situations, including classrooms, is usually expressed as explicit knowledge (Bialystok, 1978), converting it into implicit knowledge for fluent use is an important task for second language learning. Studies, such as Krashen (1982, 1989), have presented negative views of the possibility of transference between explicit and implicit knowledge. They point out a qualitative difference between consciously "learned" and unconsciously "acquired" knowledge. However, studies, such as Ellis (1993), have argued that explicit knowledge can be indirectly transferred to implicit knowledge. While DeKeyser (2003) distinguishes between explicit and implicit knowledge, the study also views explicit knowledge as amenable to being made procedural and automated. Opinions are divided on the possibility of transference between explicit and implicit knowledge. However, there are converging views that learners have two types of knowledge with different functions and that implicit knowledge is the one related to fluent language use.

Since it is not possible to directly investigate how knowledge is represented and what types of knowledge are used when learners perform tasks, it should be inferred through the investigation of linguistic behavior (Ellis & Roever, 2021). In this context, factor analysis studies have been conducted on what types of tasks measure implicit knowledge and explicit knowledge. Among the various knowledge measurement tools, this study will focus on GJT and SPRT. In GJT, learners read or listen to sentences in the target language and determine whether the sentence is grammatically correct. As described in the introduction, the more the tasks are timed, the more the sentences are presented with auditory stimuli, and the more grammatical the questions, the more likely they are to access the learner's implicit knowledge. Conversely, the less the tasks are timed, the more the sentences are presented with visual stimuli, and the less grammatical the questions, the more likely they are to access explicit knowledge (Ellis & Roever, 2021). In Loewen (2009), timed GJT seems to limit the ability of L2 learners to access explicit knowledge when making judgments, while ungrammatical sentences in untimed GJT seem to encourage learners to access explicit L2 knowledge. Regarding grammaticality of the questions, however, there was no consensus among researchers, with some saying that ungrammaticality elicits explicit knowledge (Ellis, 2005; Gutiérrez, 2013; Kim & Lee, 2018; Loewen, 2009; Vafaee et al., 2017) while others saying that ungrammaticality elicits implicit knowledge in aural GJT (Kim & Nam, 2017).

Some researchers argue that the GJT tool is forcing learners to focus on linguistic form, making it difficult to access implicit knowledge. In a factor analysis study by Kim and Nam (2017), it was suggested that time limited GJT and aural GJT may be classified as tools for measuring "automated explicit knowledge" as well as implicit knowledge. However, although automated explicit knowledge differs by definition from implicit knowledge in that it should pay attention to linguistic forms (Suzuki & DeKeyser, 2017), it is skeptical about whether it is practically possible to distinguish between these two types of knowledge (Ellis & Roever, 2021). Even though GJT does not provide a pure measure of implicit or explicit linguistic knowledge, many studies commonly agree that various design features of GJT can be manipulated so that L2 learners are more likely to draw on their different types of knowledge.

SPRT has been recognized as a tool for measuring implicit knowledge, while there is much controversy over the type of knowledge GJT measures depending on the test variables. SPRT is used to measure the reading time (RT) for each region in a text while learners read one unit of a sentence (e.g., word, phrase, and clause) at a time according to their reading speed. SPRT also identifies grammatical sensitivity through reading delays in the RT of target and spillover regions. In SPRT, tasks such as grammaticality judgment or comprehension questions are inserted between sentences to help participants focus on reading the sentences. Comprehension questions help participants focus on meaning, and thereby prevent distractions from the linguistic form. Several second language acquisition studies have also used SPRT to measure implicit and non-explicit knowledge. This use is attributed to the fact that SPRT can observe the occurrence of automated processing, owing to its feature of recording RTs in real time (Marsden et al., 2018).

In Kim et al. (2022), a correlation analysis was performed between three types of GJT scores and SPRT reaction time with different variables of time limit and modality. As a result, the correlation between timed aural GJT score and SPRT reading time was the highest, and the correlation between untimed written GJT score and SPRT reading time was the lowest. Timed written GJT showed an intermediate correlation value. It can be interpreted that timed aural GJT is close to a tool for measuring implicit knowledge, while untimed written GJT measures explicit knowledge. Timed written GJT is located in the middle of the two tasks.

In this context, this study designs an experiment using three types of GJTs with different time variables (timed vs. untimed) and modalities (aural vs. written) and using SPRT. This provides a multidimensional perspective when confirming Korean learners' grammatical acquisition of causative expressions. The interpretation of data collected through these tasks in relation to the tasks' features can provide an understanding of the features of Korean learners' knowledge of causative expression from different viewpoints. This study conducts experiments using GJT and SPRT from such a perspective. Based on the results, it presents educational implications that contribute to the teaching of Korean causative expressions in the education field.

Research method

Research participants

The experiment involved 31 Korean native speakers, 30 Korean intermediate learners, and 38 Korean advanced learners. The participants resided in Korea and were aged 18 years and above. The intermediate learners were assigned a test of proficiency in Korean (TOPIK) level of 3 or 4, and advanced learners were assigned a TOPIK level of 5 or 6.[1] Korean native speakers were undergraduate or graduate students who never stayed abroad for more than a year before the age of 18, and their native language, including that of their parents, was Korean. This study was approved by the Ethical Committee of the Institutional Review Board of Seoul National University (Seoul, Korea; SNU IRB No. 2001/002–006), and informed consent were obtained from all 99 participants before they take part in the study.

Table 2 presents the information on the participants.

Table 2 Experiment participant information

Group	Proficiency (TOPIK rating)	N	Total
Intermediate	3	5	30
	4	25	
Advanced	5	15	38
	6	23	
Native		31	31

TOPIK—test of proficiency in Korean

[1] The participants in this study had diverse native languages, with 27 Chinese, 6 Mongolian, 5 Cantonese, 5 Russian, 5 Myanmar, 5 Vietnamese, 5 Japanese, 2 Kazakh, 2 Persian, 1 French, 1 Thai, 1 Uzbek, 1 Turkish, 1 English, and 1 Indonesian/English. Although Chinese learners accounted for a relatively high proportion of the participants, the difference between them and learners from other language backgrounds was not significant ($p = .570 > .05$). Therefore, the learners' native language was not considered as a variable in this study.

Table 3 Comparison of the four experimental tools

	SPRT	AGJT	WGJT	UGJT
Modality	Written	Aural	Written	Aural
Timing	Untimed	Timed	Timed	Untimed
Measurement	The RT for target and spillover regions	Grammatical judgment accuracy	Grammatical judgment accuracy	Grammatical judgment accuracy

AGJT—time aural grammaticality judgment task; RT—reading time; SPRT—self-paced reading task; UGJT—untimed written grammaticality judgment task; WGJT—written grammaticality judgment task

Research tools

As described above, this study designed an experiment using SPRT and three types of GJTs to identify the acquisition patterns of Korean learners' knowledge of causative expression grammar from various angles.

In SPRT, a part of a sentence appears underlined on the screen. This task uses a moving window method. In this method, whenever a participant pressed a key, the previous text was covered, and the participant viewed the subsequent words through a window. A sentence was divided into seven regions and one region was presented at a time; the causative marker (the target grammar item) was presented in the fourth region. When the target region was presented at the end of the sentence, the reading delay in the spillover regions after the target region could not be identified. Hence, a sentence stimulus was created to connect to the subsequent clause, by attaching the connective ending "*-ko*" to the causative's marker. To allow the participants to focus on the meaning of the sentence when performing the task, comprehension questions were presented for 50% of all the sentences. These questions were to be answered with "right" or "wrong." In SPRT, the length of the sentences was set to 21 syllables.

GJT consisted of AGJT, WGJT, and UGJT, depending on whether there was a time limit (timed vs. untimed) and the modality of the stimuli (aural vs. written). The participants were instructed to judge the grammaticality of the sentence as "right" or "wrong," after listening to or reading the sentence. The length of the sentence stimulus presented in GJT was 21 ± 1 syllables. Table 3 summarizes the features of each experimental tool.

Grammatical structure of causative expressions

Regarding the composition of the experiment questions, the following grammatical structures were included, based on the features of the Korean causative expressions examined in Sect. "Korean Causative Expressions".

(1) Morphological causatives

a. Causative marker: "*-i/hi/li/ki-*', '*-u/chu-*"[2]
b. Root types: adjectives and intransitive and transitive verbs
c. Error types: Substitution of causative marker, confusion with active sentences, and substitution of post-positional particle

[2] Causative derivation is often taught with individual terms because learning its rules perfectly is difficult (Song, 2019). The morphological causative "*-ku-*" is used less frequently and is not listed in the vocabulary search of the National Institute of Korean Language's Center for Teaching and Learning Korean. The study concluded that the learners did not have enough opportunities to encounter the morphological causative. Thus, it was excluded from the questions.

Table 4 Number of questions by task

Type of items	Grammaticality	AGJT	WGJT	UGJT	SPRT
Target items	Grammatical	28	28	28	28
	Ungrammatical	28	28	28	28
Fillers	Grammatical	28	28	28	28
	Ungrammatical	28	28	28	28
Total		112	112	112	112

AGJT—time aural grammaticality judgment task; SPRT—self-paced reading task; UGJT—untimed written grammaticality judgment task; WGJT—written grammaticality judgment task

(2) Syntactic causatives

a. Causative marker: "*-key hata*," "*-key mantulta*," "*-tolok hata*," "*-tolok mantulta*"
b. Stem type: Adjectives and intransitive verbs and transitive verbs
c. Error types: Substitution of causative marker, confusion with active sentences, and substitution of post-positional particles

(3) Lexical causatives

a. Causative marker: "*-sikhita*"
b. Root types: Root noun of "*-hata* (intransitive verb/transitive verb)"
c. Error types: Substitution of causative marker and substitution of post-positional particles

In each task, the target questions comprised 28 correct and incorrect sentences, which included all three types of causatives. To prevent participants from recognizing the target items, fillers were included in 28 correct sentences and 28 incorrect sentences, which were not related to causative sentences. Therefore, the participants had 112 sentences per task. Four tasks were composed of different sentences to prevent learning effects. Table 4 summarizes the number of questions by task.

Both SPRT and GJT presented the questions in a random order. When creating the sentence stimuli, the vocabulary level was limited to elementary and intermediate vocabulary. To this end, the study used the vocabulary content search function of the National Institute of Korean Language's Center for Teaching and Learning Korean.

Research procedure

The participants performed four types of tasks sequentially in the following order: SPRT, AGJT, WGJT, and UGJT. The order was organized so that the participants would start with tasks that are less likely to focus on form (SPRT) and gradually move on to tasks that are likely to focus on form. The participants completed the four tasks at one time. Each task took between 10 and 20 min, depending on the participants, who were provided with as much rest as they wanted between tasks. Consequently, it took 60 to 90 min for participants to complete all four tasks. Before performing each task, the researcher informed the participants about the task; the participants had time to understand how the task was performed through four practice questions.

Table 5 Data coding method

Variables	Levels	Coding
Group	3	Group 1: Intermediate learners Group 2: Advanced learners Group 3: Native speakers
Type of causative	3	Type 1: Morphological causative Type 2: Syntactic causative Type 3: Lexical causative
(*A'* score) Type of GJT	3	GJT 1: AGJT GJT 2: WGJT GJT 3: UGJT
(RT) SPRT region	2	Region 1: Target region Region 2: Spillover region
(RT) SPRT grammaticality	2	Grammaticality 1: Ungrammatical Grammaticality 2: Grammatical

AGJT—time aural grammaticality judgment task; GJT—grammaticality judgment task; RT—reading time; UGJT—untimed written grammaticality judgment task; WGJT—written grammaticality judgment task

As SPRT requires the measurement of reading time and AGJT and WGJT require real-time stimulus presentation, the research presented stimuli and collected responses using PsychoPy 3.2.0. In UGJT, the research presented stimuli and collected responses using Excel sheets.

In SPRT, the participants read the stimuli sentences by pressing the space button on the keyboard. The participants pressed "right (a)" or "wrong (l)" as a response to comprehension questions, depending on whether the content matched the previously read sentence. In AGJT, the participants were instructed to listen to the stimulus sentence, judge the grammaticality of the sentence within 12 s, and respond either with "right (a)" or "wrong (l)." If a participant failed to respond to a question within time, the participant was presented with the next set of questions. In WGJT, the stimulus sentence was presented visually, and the participants were instructed to judge the grammaticality of the sentence and respond with either "right (a)" or "wrong (l)." As in AGJT, if the participant failed to respond on time, the participant was presented with the next set of questions. In UGJT, the participants read the sentences in Excel sheets; no time limit was given. They pressed "O" if the sentence was grammatically correct and "X" if it was incorrect.

Data analysis

The judgment responses and reading time data were entered into an Excel spreadsheet. To analyze the collected data, coding was performed on the group, type of causative expression, GJT type, SPRT region, and grammaticality of the SPRT sentence. Table 5 presents the coding method.

In SPRT, an outlier removal process was performed twice to remove outliers in which the RT was too fast or too slow (Jegerski, 2013). First, based on an absolute criterion, observations of 100 ms or less or 6000 ms or more were removed. Second, the mean and standard deviation of RT by group and question were obtained and values with a standard deviation of ± 3 were considered outliers; hence, they were removed or replaced.[3]

[3] When removing or replacing outliers in SPRT, several methods were used, depending on the researcher. The outliers arising from processing too quickly were removed, given the likelihood that they were not read properly. However, the outliers arising from processing too slowly may reflect an actual delay in processing the sentence. Instead of removing these outliers, they can be replaced with limits, such as "standard deviation of $+3$" (Jegerski, 2013). This study used the aforementioned method to process the outliers.

As GJT elicits a dichotomous judgment of right or wrong, learners could answer by chance even without having the required grammatical knowledge. Therefore, this study used the value obtained by converting the GJT correct rate to the *A'* score, based on the signal detection theory (Snodgrass & Corwin, 1988). This prevented the distortion of results by the probability of accidentally correct answers. This score was calculated by distinguishing the cases of detecting incorrect sentences as incorrect (hit) from the cases of detecting correct sentences as incorrect (false alarm) and by giving them weights.[4]

In the statistical analysis, descriptive statistics and inferential statistics (the linear mixed-effects models, LMMs) were conducted. LMMs are useful to analyze the data collected according to multi-stage sampling or repeated measures design, which are likely to have correlations across the conditions because of the same participants or participants who have some association with each other (Meteyard & Davies, 2020). As the experiments in this study are also designed as repeated measures, LMMs that can deal with random effects by subjects and questions were adopted. LMMs were specifically used to identify the fixed effects and coefficients of variables such as group, causative sentence type, GJT type, SPRT region, and SPRT grammaticality for the dependent variable GJT *A'* score and SPRT RT. SPSS 26 was used for the statistical testing, with 95% reliability and a significance level (α) of 0.05.

Results

Before describing the results in detail, the study measured the internal reliability of the research tools used in this study—AGJT, WGJT, UGJT, and SPRT (target region RT). Cronbach's α of the research tools AGJT, WGJT, UGJT, and SPRT were 0.876, 0.898, 0.896, and 969, respectively, with all the research tools securing a high reliability of 0.8 or higher.

Results of GJTs

For the three types of GJTs with different modalities and time limits, Table 6 presents the descriptive statistics values and Fig. 1 presents diagrams examining the mean of *A'* scores by group and by causative type.

Next, statistical analyses were conducted using the LMM to identify the influence of the group, causative type, and GJT type on the GJT *A'* score, according to the proficiency. Table 7 and Fig. 2 show the fixed effect of variables on the dependent variable GJT *A'* score.

The effect of group ($p = 0.000$), causative type ($p = 0.000$), and GJT type ($p = 0.000$) is significant, and an interaction effect was found between group*causative type ($p = 0.036$), group*GJT type ($p = 0.010$), and group*causative*GJT type ($p = 0.046$). The thicker the line in the diagram, the better the predictive power for GJT *A'* score. Table 8 shows the fixed coefficients that estimate the effect on the target variable.

The fixed coefficients are significant for group 1 (intermediate learner), group 2 (advanced learner), and causative type 2 (syntactic causative). Concerning the interaction

[4] HIT = (#wrong + 0.5)/(#incorrect sentence + 1), FA = (#wrong + 0.5)/(#correct sentence + 1),
A' = If HIT ≥ FA, (0.5 + ((HIT-FA)*(1 + HIT-FA))/(4*HIT*(1-FA)) or.
If HIT < FA, (0.5—((FA-HIT)*(1 + FA-HIT))/(4*FA*(1-HIT)).

Table 6 GJT *A'* score descriptive statistics

Task type	Causative type	Group	N	Mean	SD
AGJT	Morphological causative	Intermediate	30	0.55	0.17
		Advanced	38	0.63	0.19
		Native	31	0.88	0.08
	Syntactic causative	Intermediate	30	0.50	0.16
		Advanced	38	0.69	0.17
		Native	31	0.92	0.06
	Lexical causative	Intermediate	30	0.55	0.17
		Advanced	38	0.61	0.17
		Native	31	0.73	0.16
WGJT	Morphological causative	Intermediate	30	0.55	0.14
		Advanced	38	0.69	0.16
		Native	31	0.90	0.08
	Syntactic causative	Intermediate	30	0.62	0.18
		Advanced	38	0.77	0.15
		Native	31	0.95	0.03
	Lexical causative	Intermediate	30	0.52	0.18
		Advanced	38	0.59	0.21
		Native	31	0.84	0.11
UGJT	Morphological causative	Intermediate	30	0.61	0.17
		Advanced	38	0.71	0.21
		Native	31	0.88	0.13
	Syntactic causative	Intermediate	30	0.69	0.14
		Advanced	38	0.74	0.18
		Native	31	0.89	0.17
	Lexical causative	Intermediate	30	0.62	0.21
		Advanced	38	0.71	0.19
		Native	31	0.80	0.15

AGJT—time aural grammaticality judgment task; GJT—grammaticality judgment task; UGJT—untimed written grammaticality judgment task; WGJT—written grammaticality judgment task

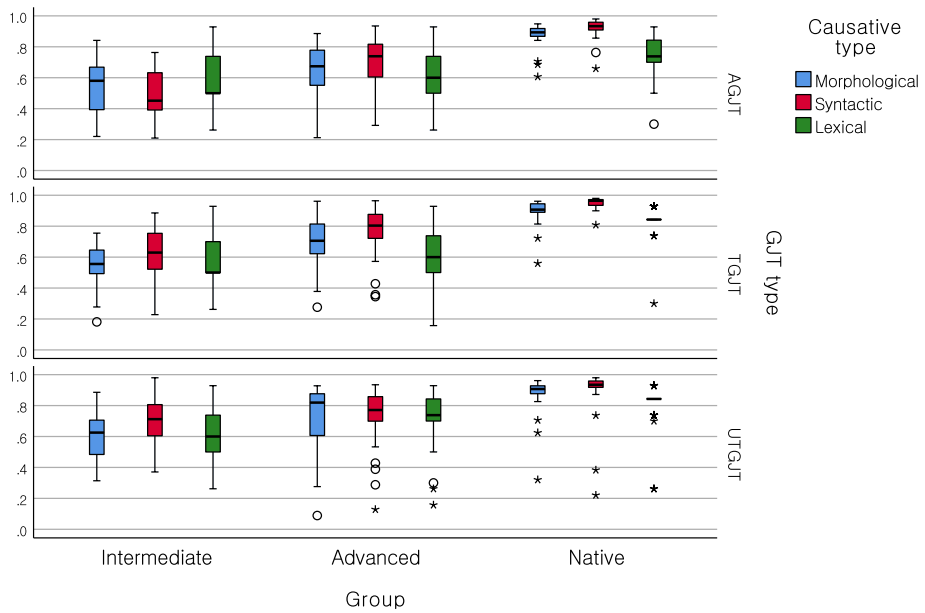

Fig. 1 GJT *A'* scores by group per causative type and GJT type

Table 7 Fixed effects of variables on the GJT scores

Variables	F-value	df1	df2	p-value
Group	221.614	2	864	.000***
Causative type	22.172	2	864	.000***
GJT type	11.528	2	864	.000***
Group * Causative type	2.582	4	864	.036**
Group * GJT type	3.318	4	864	.010**
Causative type * GJT type	1.406	4	864	.230
Group * Causative type * GJT type	1.977	8	864	.046*

***p < 0.01, **p < 0.05, *p < 0.1

GJT—grammaticality judgment task

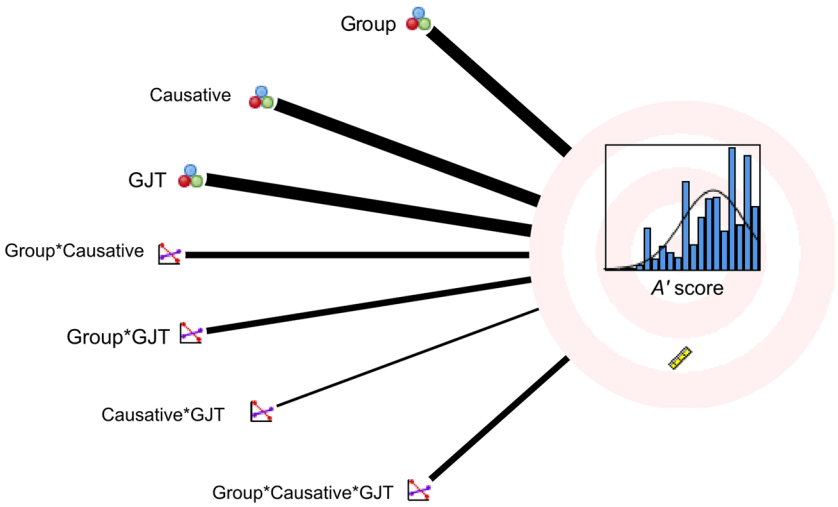

Fig. 2 Fixed effects of variables on the GJT scores

effect, the results are significant for some of the group*GJT types and group*causative type*GJT type. Given the sign (±) of the coefficients, the scores for intermediate learners (−0.178) and advanced learners (−0.083) are lower than those of native learners, and the participants have relatively high scores for syntactic causatives (0.099). In the interaction in group*GJT type, the WGJT scores for intermediate learners (−0.139) and advanced learners (−0.167) are low. In the interaction in group*causative type*GJT type, intermediate learners show a low score for syntactic causatives (−0.209) in AGJT. Tables 9 and 10 present a comparison of the estimate marginal mean for the group and the causative type, respectively.

Figures 3 and 4 visualize the estimate marginal mean of the GJT A' score for the group*causative type and the group*GJT type in their interaction effects, respectively.

For the group, the results are significant for the estimate marginal mean of the intermediate learner–advanced learner (p = 0.000), intermediate learner–native speaker (p = 0.000), and advanced learner–native speaker (p = 0.000). The mean difference value confirms that the higher the proficiency, the higher is the GJT score. For the causative type, the results are significant for the estimate marginal mean of the morphological causative–syntactic causative (p = 0.000), morphological causative–lexical causative (p = 0.000), and syntactic–causative–lexical causative (p = 0.000). The mean difference

Table 8 Fixed coefficients of variables for GJT scores

	Estimate	Std. Error	t-value	p-value	95% confidence interval	
					Lower	Upper
Intercept	.796	.0289	27.485	.000***	.739	.852
Group 1 (Intermediate)	− .178	.0413	− 4.307	.000***	− .259	− .097
Group 2 (Advanced)	− .083	.0390	− 2.128	.034**	− .160	− .006
Causative type 1 (Morphological)	.080	.0409	1.950	.052*	− .001	.160
Causative type 2 (Syntactic)	.099	.0409	2.418	.016**	.019	.179
GJT 1 (AGJT)	− .065	.0409	− 1.576	.115	− .145	.016
GJT 2 (WGJT)	.042	.0409	1.036	.301	− .038	.123
Group 1*Causative type 1	− .092	.0584	− 1.579	.115	− .207	.022
Group 1*Causative type 2	− .029	.0584	− .494	.622	− .143	.086
Group 2*Causative type 1	− .078	.0552	− 1.416	.157	− .186	.030
Group 2*Causative type 2	− .075	.0552	− 1.366	.172	− .184	.033
Group 1*GJT 1	.001	.0584	.018	.986	− .114	.116
Group 1*GJT 2	− .139	.0584	− 2.385	.017**	− .254	− .025
Group 2*GJT 1	− .036	.0552	− .657	.511	− .144	.072
Group 2*GJT 2	− .167	.0552	− 3.036	.002***	− .276	− .059
Causative type 1*GJT 1	.065	.0579	1.127	.260	− .048	.179
Causative type 1*GJT 2	− .021	.0579	− .355	.723	− .134	.093
Causative type 2*GJT 1	.088	.0579	1.526	.127	− .025	.202
Causative type 2*GJT 2	.013	.0579	.228	.820	− .100	.127
Group 1* Causative type 1*GJT 1	− .058	.0825	− .700	.484	− .220	.104
Group 1* Causative type 1*GJT 2	.066	.0825	.799	.425	− .096	.228
Group 1* Causative type 2*GJT 1	− .209	.0825	− 2.534	.011**	− .371	− .047
Group 1* Causative type 2*GJT 2	.012	.0825	.142	.887	− .150	.174
Group 2* Causative type 1*GJT 1	− .045	.0780	− .576	.565	− .198	.108
Group 2* Causative type 1*GJT 2	.123	.0780	1.578	.115	− .030	.276
Group 2* Causative type 2*GJT 1	− .032	.0780	− .409	.682	− .185	.121
Group 2* Causative type 2*GJT 2	.143	.0780	1.830	.068*	− .010	.296

***p < 0.01, **p < 0.05, *p < 0.1

AGJT—time aural grammaticality judgment task; GJT—grammaticality judgment task; WGJT—written grammaticality judgment task

Table 9 Comparison of the estimate marginal mean of the GJT *A'* score per group

						95% confidence interval	
(I) Group	(J) Group	Mean difference (I-J)	Std. Error	df	p-value	Lower	Upper
1	2	− .104*	.013	864	.000***	− .136	− .073
	3	− .285*	.014	864	.000***	− .318	− .252
2	1	.104*	.013	864	.000***	.073	.136
	3	− .181*	.013	864	.000***	− .212	− .150
3	1	.285*	.014	864	.000***	.252	.318
	2	.181*	.013	864	.000***	.150	.212

Multiple comparison correction: Bonferroni

***p < 0.01, **p < 0.05, *p < 0.1

Table 10 Comparison of the estimate marginal mean of the GJT *A'* score per causative type

(I) Group	(J) Group	Mean difference (I-J)	Std. Error	df	p-value	95% confidence interval	
						Lower	Upper
1	2	−0.041*	.013	864	.000***	−.136	−.073
	3	.048*	.014	864	.000***	−.318	−.252
2	1	.041*	.013	864	.000***	.073	.136
	3	.088*	.013	864	.000***	−.212	−.150
3	1	−.048*	.014	864	.000***	.252	.318
	2	−.088*	.013	864	.000***	.150	.212

Multiple comparison correction: Bonferroni

***p < 0.01, **p < 0.05, *p < 0.1

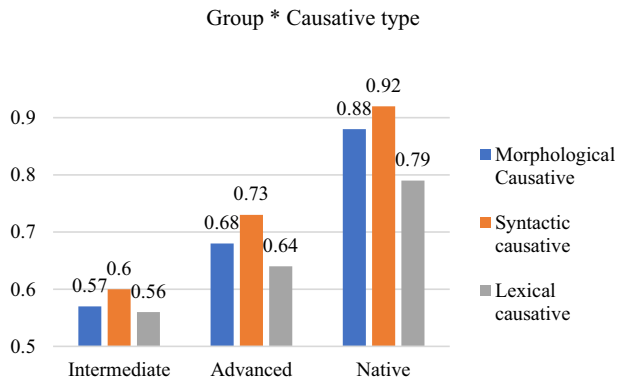

Fig. 3 Estimate marginal mean of the GJT *A'* score per group*causative type

value shows that the GJT scores are the highest and lowest for syntactic and lexical causatives, respectively. The diagram shows that this tendency appears in all three groups. Based on the diagram, in group*GJT interaction, the native speaker and learner groups show different patterns for WGJT. Among all GJTs, the native speakers score the highest in WGJT, whereas the learners score the highest in UGJT.

Concerning the correct rate for questions on each causative type, in incorrect sentences, the intermediate learners show a correct rate for morphological causatives, with the confusion with active sentences (43.70%) > substitution of causative suffixes (36.67%) > error in causative case postpositions (31.11%). For correct sentences, the correct rate is transitive verb (79.26%) > intransitive verb (78.89%) > adjectives (68.8%). For incorrect sentences, advanced learners show a correct rate in the order confusion with active sentences (57.60%) > errors in causee case postpositions (54.38%) > substitution of causee suffixes (48.90%). For correct sentences, the correct rate is adjectives (79.82%) > intransitive verbs (79.64%) > transitive verb verbs (74.85%).

For syntactic causatives, intermediate learners show a correct rate in the order confusion with active sentences (41.85%) > substitution of causative marker (39.26%). For correct sentences, the correct rate is adjectives (78.88%) > intransitive verb (73.14%) > adjectives (68.44%). Advanced learners show a correct rate for incorrect sentences in the order confusion with active sentences (67.83%) > substitution of causative

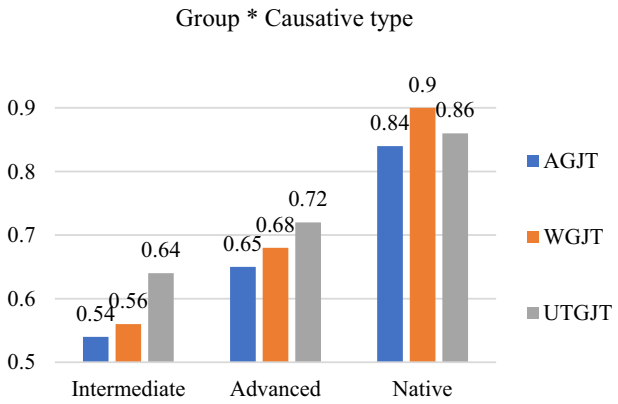

Fig. 4 Estimate marginal mean of the GJT *A'* score per group*GJT type

marker (51.17%). For correct sentences, the correct rate is adjectives (83.33%) > intransitive verb (76.60%) > and transitive verbs (75.58%).

For lexical causatives, intermediate learners show a correct rate for incorrect sentences in the order errors in causative case postpositions (33.34%) > substitution of causative marker (31.67%) > confusion with active sentences (30.00%). For correct sentences, the correct rate is transitive verbs (85.56%) > intransitive verbs (80.00%). Advanced learners show a correct rate for incorrect sentences in the order substitution of causative marker (54.60%) > error in causee case postpositions (44.73%) > confusion with active sentences (35.53%). For correct sentences, the correct rate is transitive verb (85.08%) > intransitive verb (82.45%).

SPRT results

Table 11 and Fig. 5 show the mean RT of the target and spillover regions per group, causative type, and grammaticality for SPRT.

Table 11 Mean RT descriptive statistics for SPRT region (unit: ms)

Region	Sentence type	Group	N	Mean	SD
Target Region	Morphological causative (Ungrammatical)	Intermediate	30	821.76	335.43
		Advanced	38	994.62	391.22
		Native	31	429.20	154.48
	Morphological causative (Grammatical)	Intermediate	30	893.36	408.74
		Advanced	38	985.14	366.13
		Native	31	459.85	181.72
	Syntactic causative (Ungrammatical)	Intermediate	30	867.84	413.31
		Advanced	38	976.48	368.35
		Native	31	407.31	164.88
	Syntactic causative (Grammatical)	Intermediate	30	1022.74	402.66
		Advanced	38	1134.48	420.33
		Native	31	420.69	178.23

Table 11 (continued)

Region	Sentence type	Group	N	Mean	SD
	Lexical causative (Ungrammatical)	Intermediate	30	961.10	442.46
		Advanced	38	1205.47	544.51
		Native	31	434.83	217.98
	Lexical causative (Grammatical)	Intermediate	30	1096.67	621.24
		Advanced	38	1092.75	538.82
		Native	31	385.26	167.79
Spillover region	Morphological causative (Ungrammatical)	Intermediate	30	854.29	342.04
		Advanced	38	860.49	270.64
		Native	31	532.74	279.33
	Morphological causative (Grammatical)	Intermediate	30	850.42	369.18
		Advanced	38	856.49	294.52
		Native	31	474.43	175.99
	Syntactic causative (Ungrammatical)	Intermediate	30	790.38	306.21
		Advanced	38	913.36	281.38
		Native	31	513.68	294.01
	Syntactic causative (Grammatical)	Intermediate	30	800.75	288.13
		Advanced	38	841.66	246.14
		Native	31	545.34	327.64
	Lexical causative (Ungrammatical)	Intermediate	30	800.81	402.72
		Advanced	38	887.41	344.88
		Native	31	600.46	415.00
	Lexical causative (Grammatical)	Intermediate	30	779.95	355.81
		Advanced	38	812.17	275.19
		Native	31	491.92	317.33

Note: RT—reading time; SPRT—self-paced reading task

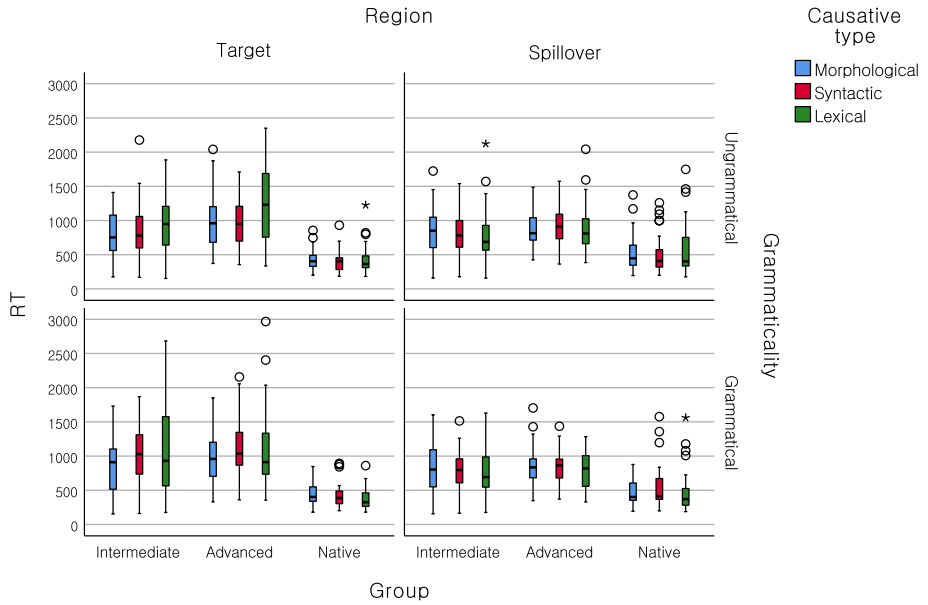

Fig. 5 RT by region per group, grammaticality, and causative type

Table 12 Fixed effects of variables on RT

Variables	F-value	df1	df2	p-value
Group	218.952	2	1152	.000***
Causative type	1.616	2	1152	.199
Grammaticality	.063	1	1152	.802
Region	14.198	1	1152	.000***
Group * Causative type	.391	4	1152	.815
Group * Grammaticality	1.609	2	1152	.201
Causative type * Grammaticality	1.552	2	1152	.212
Group * Causative type * Grammaticality	.299	4	1152	.879
Group * Region	20.812	2	1152	.000***
Region * Grammaticality	3.564	1	1152	.059*
Group * Region * Grammaticality	.350	2	1152	.705
Group * Causative type * Region * Grammaticality	1.353	12	1152	.183

RT—reading time

* ** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

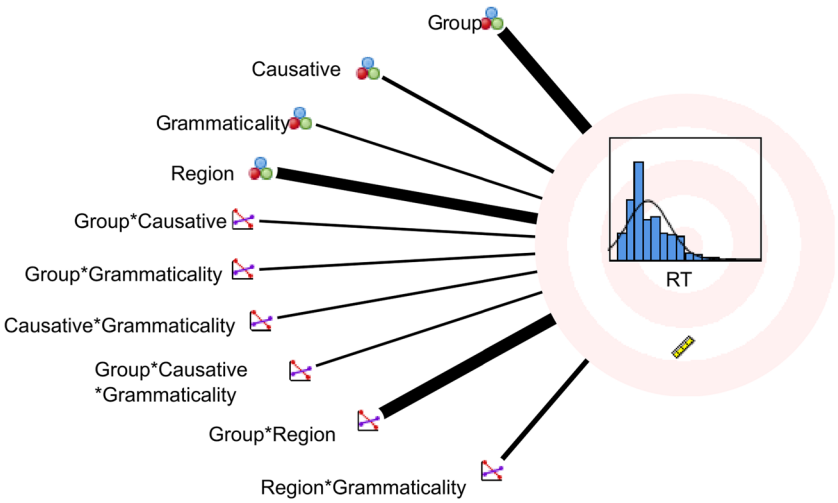

Fig. 6 Fixed effects of variables on RT

Statistical analysis was done using the LMM to identify the influence of group, causative type, and grammaticality on RT, according to proficiency. Table 12 and Fig. 6 show the fixed effect of variables on the dependent variable RT.

Based on group ($p = 0.000$) and region ($p = 0.000$), the results show an effect. The results also show an interaction effect for group*region ($p = 0.000$). The thicker the lines visualizing the fixed effects, the better the predictive power for RT. Figure 7 depicts the fixed coefficient estimating the effect of each variable on the target variable.

The following fixed coefficients are statistically significant: group 1 (288.036, $p = 0.001$), group 2 (320.253, $p = 0.000$), group 1*region 1 (423.379, $p = 0.001$), group 2* region 1 (387.239, $p = 0.001$), and group 2*causative type 2*region 1*grammaticality 1 (-254.934, $p = 0.025$). A thicker line indicates stronger influence on the target variable. A blue line indicates that the estimated coefficient is positive, while a red line indicates that the estimated coefficient is negative.

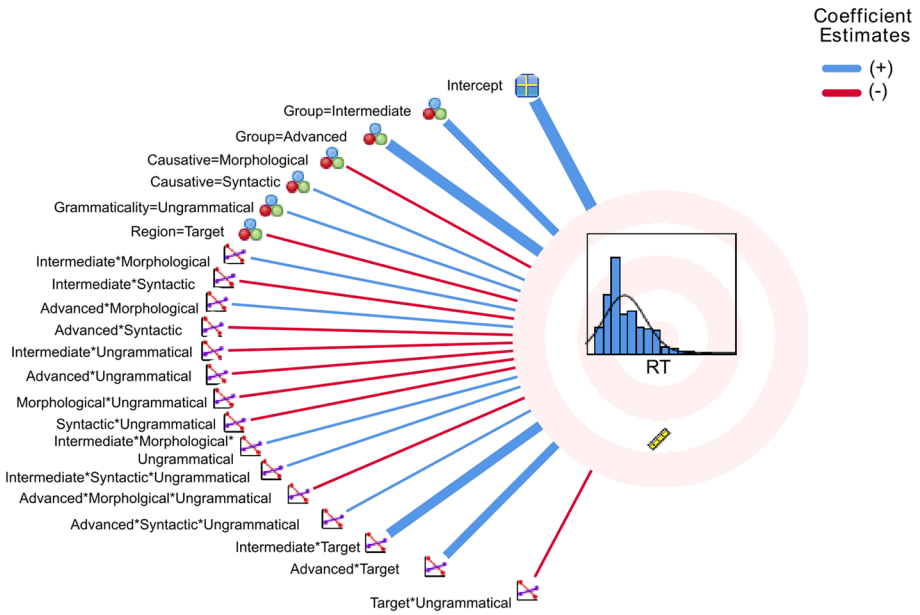

Fig. 7 Fixed coefficients of variables for RT

Table 13 Comparison of RT estimate marginal mean by group

						95% confidence interval	
(I) Group	**(J) Group**	**Mean difference (I-J)**	**Std. Error**	**df**	**p-value**	**Lower**	**Upper**
1	2	− 85.038*	25.052	1166	.002***	− 145.098	− 24.978
	3	403.697*	26.270	1166	.000***	340.717	466.678
2	1	85.038*	25.052	1166	.002***	24.978	145.098
	3	488.735*	24.825	1166	.000***	429.219	548.252
3	1	− 403.697*	26.270	1166	.000***	− 466.678	− 340.717
	2	− 488.735*	24.825	1166	.000***	− 548.252	− 429.219

Multiple comparison correction: Bonferroni. RT—reading time

***p < 0.01, **p < 0.05, *p < 0.1

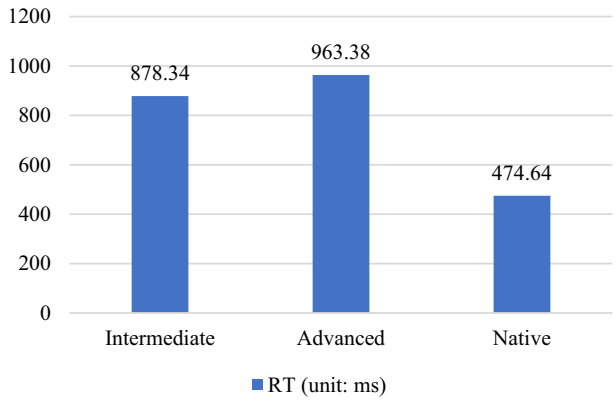

Fig. 8 RT estimate marginal mean by group

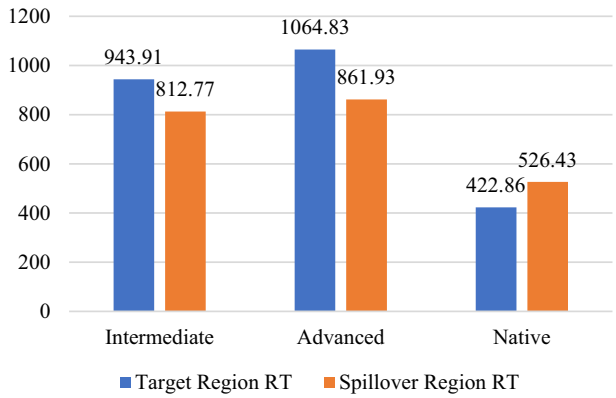

Fig. 9 RT estimate marginal mean by group*region

To examine the differences between groups, the estimate marginal mean of RT by group is compared (see Table 13).

Regarding the significant fixed effects, Figs. 8 and 9 show the RT estimate marginal mean for group and group*region, respectively. The fixed coefficients and estimate marginal mean confirm that the RT of the native speakers is the shortest and that the RT of advanced learners is longer than that of intermediate learners. The RT by group*region shows that the RT of intermediate and advanced learners, unlike native speakers, is longer for the target than the spillover region.

The experimental results of GJT and SPRT are summarized in Tables 14 and 15, respectively. The underlined items are those with a statistically significant fixed coefficient.

Table 14 Summary of the GJT results

Variables	A' score
Group	Native speakers > Advanced learners > Intermediate learners
Causative type	Syntactic > Morphological > Lexical
Group * GJT type	Intermediate learners: 1. UGJT 2. WGJT 3. AGJT Advanced learners: 1. UGJT 2. WGJT 3. AGJT Native speakers: 1. WGJT 2. UGJT 3. AGJT
Group * Causative type * GJT type	Intermediate learners—AGJT: Lexical (0.55) = Morphological (0.55) > Syntactic (0.50) Intermediate learners—WGJT: Syntactic (0.62) > Morphological (0.55) > Lexical (0.52) Intermediate learners—UGJT: Syntactic (0.69) > Lexical (0.62) > Morphological (0.61) Advanced learners—AGJT: Syntactic (0.69) > Morphological (0.63) > Lexical (0.61) Advanced learners—WGJT: Syntactic (0.77) > Morphological (0.69) > Lexical (0.59) Advanced learners—UGJT: Syntactic (0.74) > Morphological (0.71) = Lexical (0.71) Native speakers—AGJT: Syntactic (0.92) > Morphological (0.88) > Lexical (0.73) Native speakers—AGJT: Syntactic (0.95) > Morphological (0.90) > Lexical (0.84) Native speakers—AGJT: Syntactic (0.89) > Morphological (0.88) > Lexical (0.80)

AGJT—time aural grammaticality judgment task; UGJT—untimed written grammaticality judgment task; WGJT—written grammaticality judgment task

Table 15 Summary of the SPRT results

Variables	RT
Group	Advanced learners > Intermediate learners > Native speakers
Group * Region	Intermediate learners: Target region > Spill-over region
	Advanced learners: Target region > Spill-over region
	Native speakers: Spill-over region > Target region

RT—reading time; SPRT—self-paced reading task

Discussion

This section interprets the results described above and derives educational implications for teaching Korean causative expressions. First, native speakers had the highest GJT scores, while intermediate learners had the lowest. The results show a significant difference between the groups, indicating that the learners did not acquire as much knowledge of causative expressions as native speakers. Based on the causative type, GJT scores were the highest for syntactic causatives, and the lowest for lexical causatives. This is consistent with previous findings that Korean learners use syntactic causatives with higher productivity more frequently (Choi, 2008; Jin & Lee, 2020). Korean learners who do not acquire sufficient morphological causative expressions tend to avoid the use of causatives. They overuse syntactic compositions, such as "*-key hata,*" as predicates. This use may lead to grammatical errors and, in turn, produce unnatural sentences. Morphological and lexical causatives have low GJT scores. This can be attributed to a lack of opportunities in teaching and learning or to grammatical difficulty itself.

The score by GJT type produced notable findings in relation to the WGJT scores. Specifically, the WGJT scores of advanced and intermediate learners are lower than those of native speakers. Learners performed well in the following order: UGJT > WGJT > AGJT, while native speakers performed well in the following order: WGJT > UGJT > AGJT. Learners' scores are low for GJT, which has a time limit like WGJT and AGJT. These scores can be attributed to the fact that sufficient implicit knowledge could not be formed to judge grammaticality automatically within a short time.

Next, RT in SPRT was fastest among native speakers, with intermediate learners having a faster RT than advanced learners. In line with previous studies, this study finds that native speakers process non-grammatical sentences quickly without taking a long time (O'Reily, 2018; Roberts & Liszka, 2013). Regarding grammaticality, learners show little sensitivity. However, the RT of learners is longer in target and spillover regions. Overall, advanced learners achieve a higher accuracy in GJTs than intermediate learners. However, based on the SPRT results, this is attributed to the long processing time. In other words, the results indicate that even advanced learners have difficulty in learning causatives.

For syntactic and morphological causatives, the level of knowledge acquisition in advanced learners is higher than that in intermediate learners but lower than that in native speakers. The SPRT results show that advanced learners take a longer time than intermediate learners. Advanced learners also take more time than native speakers. This finding implies that they are highly sensitive to syntactic and morphological causative

expressions, but their grammatical knowledge is yet to reach the stage of internalization and automation. Therefore, it is necessary to enhance the implicit knowledge of syntactic and morphological causatives and to practice automation. In lexical causatives, the knowledge acquisition level of advanced learners is slightly higher than that of the intermediate learners, though no significant difference exists. The SPRT results show that the advanced learners take a slightly longer time than intermediate learners, but they take twice as long as native speakers. Although they have some sensitivity to lexical causative expressions, they need both explicit and implicit learning.

Regarding intermediate learners, the level of knowledge acquisition of syntactic causatives is higher than that of morphological and lexical causatives. Overall, however, their knowledge acquisition level is lower than that of advanced learners and native speakers. In particular, they scored low in AGJT. This finding implies that the knowledge of syntactic causative expressions is not sufficiently internalized and automated in intermediate learners. They spend about twice as much time as native speakers in SPRT. This shows their need for both explicit and implicit learning. For morphological and lexical causatives, they show a lower level of knowledge acquisition than that for syntactic causatives. They also spend about twice as much time as native speakers in SPRT. This shows their need for both explicit and implicit learning seems.

Regarding the characteristic tendencies of each learner group's correct rate for causative type, both intermediate and advanced learners show a low correct rate for the substitution of causative suffixes in morphological causatives. This suggests the need for vocabulary learning focusing on different causatives. Specifically, teaching the correct use of causatives used daily is needed, such as "*mek-i-ta*" and "*noph-i-ta*," "*mek-i-ta* (1363)," and "*noph-i-ta* (2213)," combined with the suffix "*-i-*," are more frequently used than "*nuc-chu-ta*(379)" and "*nac-chu-ta*(676)," combined with the suffix "*-chu-*" (Kang, 2009). These causatives are encountered daily. Nevertheless, the study identified that the correct rate for "*-i-*" affiliated causatives is low. Hence, teaching causatives at the level of vocabulary education is necessary, along with causatives' derivation rules, focusing on errors frequently produced by learners, such as the substitution of "*-i-*" with "*-hi/ki-*" and "*-hi-*" with "*-i/ki-*."

In addition, intermediate learners show a low correct rate for questions in which adjectives are used as roots among morphological causatives. This implies the need to consider the types of predicates in active sentences, in causative expression education. In the grammaticality judgment test conducted by Lee et al. (2010), a significant difference was found in the correct rate between causatives with transitive verbs as roots, and causatives with adjectives and intransitive verbs as roots. This finding shows that the acquisition pattern of causatives is different for each predicate type. Therefore, in the field of Korean teaching, providing causative education by diversifying the predicate types in active sentences is necessary, including adjectives and intransitive and transitive verbs. Particularly, the predicate types in active sentences are closely related to the substitution of causee case postpositions in causative sentences and are essential for using causative sentences properly.

Concerning syntactic causatives, both intermediate and advanced learners had a low correct rate for substitution questions on causative markers. Therefore, teaching when

morphological and syntactic causatives should be used is necessary—to understand the difference between these two causative expressions. Finally, in lexical causatives, both intermediate and advanced learners experienced confusion regarding active sentences and had low correct rates for substitution questions on causee case postpositions. Although "*sikhita*" can be combined with a descriptive noun and used as a causative expression, it will not have a causative meaning when used as having the same argument structure as "*-hata*" (Yoo, 2012). In addition, as with "*kongbu-lul sikhita* (study-ACC CAUSATIVE)," there are cases in which the descriptive noun is separated and used as an object, and "*sikhita*" is separated and used as a verb (Kim, 2019). Considering this feature of "*sikhita*," strengthening the teaching on the sentence structure of lexical causatives is necessary. This can help Korean learners to complete sentences using the correct case sign, when using "*sikhita*" as a causative expression describing a causative event with a causative subject.

Conclusion

This study identifies how acquisition patterns of causative expressions differ in intermediate and advanced learners of Korean as a second language, depending on their proficiency and causative type sentence types. The study's findings present significant implications for teaching Korean causative expressions. The results showed that, in GJT, higher proficiency is associated with higher accuracy. Regarding intermediate learners, accuracy is lower for morphological and lexical causatives than that for syntactic causatives. For advanced learners, accuracy is lower for lexical causatives than that for syntactic and morphological causatives. Learners' accuracy is lower for timed WGJT and AGJT than that for UGJT, which indicates that acquisition levels are lower for implicit than explicit knowledge. In SPRT, both intermediate and advanced learners take almost twice as long as native speakers to process the target regions and take more time to process the target than regions. Advanced learners show a longer RT than intermediate learners. This finding indicates that advanced learners have a higher level of knowledge acquisition than intermediate learners, but they have not yet reached the stage of automated and internalized processing. Based on these results, the study reconfirms that Korean causative expressions are difficult grammatical categories that cannot be easily acquired even by advanced learners.

This study is significant in that it takes a multidimensional approach when measuring learners' acquisition of various Korean causative expressions, such as derivative, syntactic, and lexical causatives. It also uses three types of GJTs with different time limits and modalities and SPRT, which reflects real-time sentence processing. These measures are significant in that they determined the need for causative expression education, by considering each learner's proficiency level. Nonetheless, this study also has a limitation. It did not identify how the various native languages and educational backgrounds of Korean learners affected the acquisition of causative expressions. This remains a task for future research. This work also calls for studies examining whether the causative expression teaching methods presented in this study can reduce causative expression errors in learners.

Abbreviations

AGJT	Timed aural grammaticality judgment task
GJT	Grammaticality judgment tasks
LMM	Linear mixed model
RT	Reading time
SPRT	Self-paced reading tasks
TOPIK	Test of proficiency in Korean
UGJT	Untimed written grammaticality judgment task
WGJT	Timed written grammaticality judgment task

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Availability of data and materials
The datasets generated and/or analysed during the current study are not publicly available because the participants gave consent to use of their data only for the purpose of the research, but are available from the corresponding author on reasonable request.

Declarations

Ethical approval and consent to participate.
This study was approved by the Ethical Committee of the Institutional Review Board of Seoul National University (Seoul, Korea; SNU IRB No. 2001/002-006), and informed consent were obtained from all 99 participants before they take part in the study.

Competing interests
The authors declare that they have no competing interests.

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