Unconscious but Slowly Activated
Grammatical Knowledge of Japanese EFL Learners: A Case of *Tough* Movement

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**Abstract**

Among foreign language teachers and researchers, it has been widely acknowledged that grammatical knowledge of a foreign language comprises two types of mental storage. One of the two, explicit knowledge, is quite likely linked to adjectives such as “slow” and “conscious,” whereas the other, implicit knowledge, is associated with words such as “fast” and “unconscious.” The present study challenges this conventional and popularized view, by addressing the consciousness and speed dimensions of Japanese EFL learners’ (*N* = 24) knowledge about *tough* movement. We conducted a grammaticality judgment task adopting two experimental paradigms: (a) a subjective measure of consciousness known as the *meta-knowledge criterion*, and (b) response time modeling. The participants judged the grammaticality of the stimuli under the two conditions, (a) control and (b) tough movement, and described their mental state during judgments (explainable vs. intuitive) trial by trial. We analyzed the dynamics among the recorded judgment responses, reaction times, and responses on the subjective measure. The results supported the hypothesis that the consciousness and speed dimensions intersect obliquely. This means that unconscious knowledge does not entail faster grammatical performance. Some pedagogical implications, particularly in light of English grammar teaching in Japan, are also discussed.

1. **Introduction**

No one argues that grammatical knowledge of a foreign language is a unitary concept; rather, it is complex. A common strategy to capture this complexity is to set an assumption that
the concept in question comprises multiple subcomponents, and to describe the dynamics of those components. Numerous terms have been created in this manner to refer to the subcomponents of grammatical knowledge, such as explicit vs. implicit, declarative vs. procedural, and non-integrated vs. integrated knowledge (e.g., Jiang, 2007). We adopt the first distinction, which must be the most accepted framework.

Although there must be little difference in defining explicit and implicit knowledge, explicit knowledge is usually defined as the mental storage of linguistic representations. Generally, it is linked to adjectives such as slow and conscious, while implicit knowledge, in contrast, is characterized with words such as fast and unconscious. This type of conceptualization has been widely popularized among foreign language teachers, as well as second language acquisition (SLA) researchers, language testers, and possibly policy makers. However, as some researchers claim, despite the long history of its literature, empirical inquiries into explicit and implicit knowledge have not yet been sufficiently evidenced, particularly with regard to their measurement, since there have been numerous methodological debates (e.g., Ellis, 2005; Gutiérrez, 2013; Rebuschat, 2013).

This article is concerned with the fact that this popularized version of the conceptualization of the two types of knowledge can sometimes misguide us, not only in our theoretical inquiries, but also in teaching practice, language testing, and educational management. In particular, we challenge the relatively implicit, but popular view, of which the point is that implicit knowledge is conjunctively characterized by the two separate types of property as fast ∧ unconscious. Against this view, the conclusion of this article is that this cannot always hold true, and may lead us to a both theoretically and pedagogically ineffective understating of the nature of implicit knowledge. This article claims that two dimensions, speed and consciousness, are obliquely intersected within one’s grammatical knowledge; this means that unconscious knowledge is not always utilized quickly, and conscious knowledge does not necessarily mean knowledge that is slowly activated.

In the next section, we will review the literature on explicit and implicit knowledge from two academic fields—SLA research and current cognitive psychology—in which the two types of knowledge have been defined quite differently. We will then report the psycholinguistic evidence that supports our challenging but simple claim in the latter sections. We adopted a case of Japanese EFL learners’ knowledge of tough movement, in which their performance fitted well to the model that the knowledge in question is utilized unconsciously, but relatively slowly.

2. Literature Review

2.1 Explicit and Implicit Knowledge in Second Language Acquisition

Explicit and implicit grammatical knowledge is one of the most central topics in SLA research (e.g., Ellis, 2005). Although regarding L2 grammatical knowledge as a mixture of explicit and implicit knowledge has prevailed since the dawn of SLA research in the 1970s (e.g.,
Bialystok, 1979), the relationship between the two, technically called interface, and how to differentiate them both theoretically and methodologically, have been continuously debated. Since the 2000s, time-sensitive experimental methods, such as speeded and timed grammaticality judgment tasks (e.g., Loewen, 2009; Tamura & Kusanagi, 2015), elicited imitation (e.g., Erlam, 2006), self-paced reading (e.g., Jiang, 2007), and eye-tracking techniques (e.g., Godfroid et al., 2015) have been introduced to the field of SLA research. In current SLA research, these time-sensitive measures serve the role of measuring implicit knowledge, and other traditional testing techniques are usually regarded as measures of explicit knowledge.

A common basis for the time-oriented view may originate in the traditional discipline of SLA research. That is, the ultimate goal of SLA is to attain native-like language performance. Native speakers do not acquire their L1 as L2 learners do with a vast amount of effort, but exhibit strikingly fast and accurate performance, which L2 learners fail to attain with a few exceptions. SLA researchers have thus repeatedly emphasized the association between the way in which native speakers acquire their L1—naturalistic learning—and native-like language performance. For instance, Krashen, in the strongest version of his model, claimed that acquired knowledge, not learned knowledge, is responsible for real-time and native-like language use, while learned knowledge works only as a monitor (Krashen, 1982). Such analogical reasoning behind the view of the direct connection between rapidly used knowledge, naturally gained knowledge, and native speaker’s performance can often be seen in the literature of SLA research.

Moreover, such a view of implicit knowledge has been reinforced by Rod Ellis and some other researchers who applied a psychometric approach to measuring explicit and implicit knowledge (e.g., Ellis, 2005; Ellis et al. 2009). They use multiple task scores and construct latent variables that measure the two types of knowledge. Although some validation studies have supported this view, some changes have recently been taking place in the field of SLA, influenced by research on implicit learning (e.g., Hama & Leow, 2010). That is, adopting the consciousness criterion as a measure of implicit knowledge has been reevaluated in recent models of explicit and implicit knowledge in SLA research (e.g., Rebuschat, 2013; Suzuki & DeKeyser, 2015). In fact, this is the difference between the prevailing view of explicit and implicit distinction in SLA research and cognitive psychology, which we will review in the next section.

2.2 Explicit and Implicit Knowledge in Cognitive Psychology

Cognitive psychologists have a very different angle toward the conceptualization of explicit and implicit knowledge, perhaps due to the difference of their discipline. Taking the field of artificial grammar learning (AGL) for instance, explicit and implicit distinction is purely a matter of consciousness, or mental state (Dienes, 2007). That is, explicit knowledge is what one can be aware of, and implicit knowledge is what one cannot. The rationale behind this view underlies Higher-Order Thought Theory (e.g., Rosenthal, 2005), which accounts for the general role of consciousness in the human mind. In this view, the term explicit knowledge can be used
interchangeably with conscious knowledge; it can be defined by a condition such as “one knows that he or she knows it.” On the other hand, unconscious knowledge, which is almost equal to implicit knowledge, does not have the property of such a hierarchical mental state. We call this the consciousness dimension. There is a clear contrast whereby SLA researchers focus much more on the performance of explicit and implicit knowledge, while cognitive psychologists focus on the mental states associated with the two.

Cognitive psychologists make use of various methods in order to operationalize the mental states relating to the use of explicit and implicit knowledge, such as (a) retrospection, (b) the think-aloud method, and (c) subjective measures. The final method may be one of the mainstream methods (e.g., Dienes, 2007; Ziori & Dienes, 2006). A typical procedure to address mental state using subjective measures is to ask participants directly about the knowledge source of each judgment in some psychological task. For instance, after judging the grammaticality of a sentence, the experimenter asks the participant whether the judgment was given intuitively or not. If the answer is “intuitive,” this would sometimes indicate an unconscious state. Furthermore, various indices of subjective measures are used; some researchers use categories such as “rule” and “re-correction” for conscious knowledge, and “intuition,” “guess,” and “familiarity” for unconscious knowledge (e.g., Dienes, 2007).

These methods are used under the mathematical assumption that evidence of implicit knowledge is over-chance-rate performance of judgments with the unconscious mental state characterized by some attributes such as “intuitive.” Thus, implicit knowledge can be operationalized as “no relationship” between performance typically given by observational variables such as accuracy, and consciousness given by subjective measures. This is called the zero-correlation criterion, also known as the meta-knowledge criterion (Dienes, 2007).

2.3 The Problem

As we reviewed above, there are clearly two contrasting viewpoints regarding the operationalization of explicit and implicit knowledge. One side basically focuses on the performance of each type of knowledge: explicit knowledge is slowly activated while implicit knowledge promotes fast and accurate grammatical processing like native speakers. The other side views explicit knowledge from the viewpoint of the mental state during linguistic processing: Explicit knowledge is consciously accessed, and thus may be reportable while implicit knowledge is likewise unconsciously accessed.

The problem with which we will be concerned now arises. That is, these two separate dimensions are usually compounded in researchers’ and teaching practitioners’ understanding. Namely, explicit knowledge is treated as a type of knowledge that is conscious “and” slowly activated, whereas implicit knowledge is unconscious “and” utilized quickly. However, it has been quite unclear whether these two dimensions are unitary or not. If the two dimensions are not unitary, but rather oblique, what should we call the type of knowledge that is conscious “and”
utilized quickly, and what about another type that is unconscious “and” utilized slowly? Figure 1 visualizes this question simply.

\[
\begin{array}{|c|c|c|}
\hline
\text{Speed Dimension} & \text{Fast (Implicit)} & \text{Slow (Explicit)} \\
\hline
\text{Conscious Dimension} & ? & \text{No Problem} \\
\hline
\text{Unconscious Dimension} & \text{No Problem} & ? \\
\hline
\end{array}
\]

*Figure 1. Schema representing the main question of the present study.*

If these dimensions are not unitary, it should be inappropriate to discuss explicit and implicit knowledge by taking only one side of the two.

2.4 Tough Movement in English

In order to address the issue of compounding, we examined Japanese EFL learners’ grammatical knowledge about tough movement, yielding a psycholinguistic experiment. Tough movement in English is a syntactic operation, as can be seen in (1). Note that the syntactic subject, *the problem*, is not the theme or experiencer of the copula *is*, rather the patient of and the syntactic object of the embedded non-finite verb, *solve*. In a classical account, the syntactic subject was raised from the position of the object. This operation is called *object-to-subject raising* (e.g., Chomsky, 1981). This type of sentence can also be called a tough construction (e.g., Chomsky, 1981; Rosenbaum, 1967), and one of the non-agentive subject constructions.

(1) The problem is [tough to solve *t*].

It can be inferred that ordinary Japanese EFL learners do not possess sufficiently conscious knowledge about the operation such as the object-to-subject raising, and it is uncommon to instruct Japanese students on this construction because there is no description of tough movement in the Courses of Study and also because *The grammar book* (Celce-Murcia & Larsen-Freeman, 1999), which is for ESL and EFL teachers, did not touch upon tough movement. However, the meaning of the sentences with tough-movement appears straightforward and the tough construction is similar to Japanese topic–comments structures. This leads us to expect that the participants will show evidence of unconscious knowledge about tough movement, but it has been unclear whether the performance on this operation is fast or slow.

2.5 Pedagogical Significance of the Present Study

The present study has the potential to raise some important questions for researchers and practitioners. In one sense, we must reconsider what “acquisition” or “learning” mean because if one acquires unconscious knowledge that can only be used very slowly, it may be the case that
one succeeds in acquiring knowledge very similar to what native speakers of English possess. In contrast, if a learner possesses knowledge that is activated quickly and accurately and that is also conscious, do we consider that learner not yet to have acquired implicit knowledge that native speakers can use very quickly and with a high degree of accuracy?

Thus, the present study, as a pioneering one, can provide some implications for foreign language grammar learning and teaching in that it proposes a rethinking of grammar learning and acquisition, and yields new insights into L2 learners’ grammar knowledge from the speed and consciousness dimensions, which may help teachers diagnose their learners’ knowledge representations.

3. Hypothesis

If the participants exhibited an unconscious state on a subjective measure during grammaticality judgments with relatively higher speed, it would be the case that the popularized unitary conceptualization is true. If not, the speed and consciousness dimensions are obliquely intersected. We call the former scenario the unitary model, and the latter the oblique model. The unitary model is the null hypothesis of the present study. The unitary model can be expressed formally by the logical conjunction, and we also include the negative disjunction of this:

\[ P \land Q \]

\[ \neg P \lor \neg Q \]

where,

\( P \): The performance of tough movement exhibits an unconscious state on a subjective measure. \( Q \): The performance of tough movement exhibits relatively higher speed than the control.

Thus, adopting the law of the excluded middle, the oblique model assumes the exclusive disjunction:

\[ P \lor Q \]

We examine the condition \( P \) by the use of the zero-correlation criterion and the condition \( Q \) performing the generalized linear mixed effect model, of which the response variable is the reaction time of grammaticality judgments.
4. Method

4.1 Participants
The participants in the present study comprised 24 Japanese undergraduate and graduate students. Because Keating and Jegerski (2015) reported that studies on L1 processing tend to have a minimum of 12 participants per condition (p. 27), 24 participants were the minimum requirement of the present study, which examined experimental doublets. The participants’ mean age and TOEIC scores were 22.87 (SD = 1.29, n = 23) and 704.32 (SD = 95.39, n = 22), respectively. Their majors varied greatly, including biology, information technology, engineering, and so on. In order to ensure that the participants were ideally unfamiliar with the rule of tough movement so as to investigate unconscious knowledge of grammar, care was taken not to collect data from learners who major in linguistics, applied linguistics, or other related fields. In addition, post-experimental interviews confirmed that none of the participants were familiar with the correct rule of tough movement in English. Before the experiment, the participants signed a consent form and agreed to participate in the study with the compensation of 1,000 Japanese yen.

4.2 Grammaticality Judgment Task
In order to address the research questions raised in section 3, a computer-based grammaticality judgment task (GJT) was administered in the present study. The computer-based GJT was developed using Hot Soup Processor ver. 3.2, a programming language.

In the experiment, the participants engaged in the computer-based GJT individually. The program first required the participant to type in several blanks for their age, TOEIC score, and English proficiency ratings in the four skills, vocabulary, and grammar. In the GJT session, the participants were asked to read the explanation about the task presented on the screen before the trials. Once the participants fully understood the task, they clicked the start button on the screen.

First, the fixation point appeared on the screen for 1,000ms and disappeared. After the blank screen had been displayed for 500ms, the target sentence appeared on the screen and the participants were required to judge the grammaticality of the sentences by pressing the left arrow key for grammatical and right arrow key for ungrammatical. The reaction time was calculated from the time the target sentence appeared on the screen until the participants pressed either the left or right arrow key. After the participants had made a judgment, the target sentence disappeared and they were required to answer whether the source of their grammaticality judgment was based on their intuition or on a grammar rule that they could explain. If their judgment was based on their knowledge of grammar rules, they were asked to press the right arrow key and if they thought they didn’t know the rules but knew the grammaticality by intuition, they were asked to press the left arrow key. All judgments of grammaticality and the source of those judgments were recorded and used in the analysis. The entire session lasted for approximately 30 minutes.
4.3 Stimuli

The stimuli list included 24 test items that targeted tough movement: 8 items were categorized as grammatical conditions in that they did not include any type of grammatical error (2a). This type of item \( k = 8 \) was originally used to establish a baseline of the performance, but we excluded it from the later analyses since the inter-participant variance was relatively small. The other 16 items were divided into either semantic or syntactic error conditions. The former included semantic related errors of tough movement as can be seen in (2b). In (2b), tough movement can be applied in a syntactic sense, but the derived sentence was difficult to interpret semantically. On the other hand, the latter contained syntactic error and tough movement was unacceptable because the raised constituent in the subject position of the sentence can hardly be replaced in the original position, which is the object position of the infinitive phrase already filled with another NP (2c).

(2a) He said that his wife was difficult to please.
(2b) * The boy told me that his mother was sad to play with.
(2c) * My younger sister was difficult to be an actress.

In order to compare the response toward rather unfamiliar items for the participants and toward the items that targeted the common grammatical errors, we also added 16 control items: 8 grammatical items and 8 ungrammatical items. Those 16 items were developed originally on the basis of the items used in Ellis (2005), and they covered grammatical structures such as third person singular \(-s\) and counterfactual conditionals. Both lists also contained 24 distractors so that the participants did not pay much attention to the target structures.

4.4 Analyses

4.4.1 Meta-Analytic Approach

We first calculated the descriptive statistics of the accuracy and responses on the subjective measure. We then adopted a meta-analytic approach. That is, we arranged the counts into a fourfold table (correct/incorrect by explainable/intuition) for each item. The odds ratio and its 95% confidence interval (CI) using the Wald’s approximation method for each item were calculated. Using the Mantel-Haenszel method, we estimated the pooled odds ratios and their CIs. As the pooled estimates showed non-significance or negative values, this indicates unconsciousness in terms of the zero-correlation criterion. Furthermore, the Woolf’s test was performed to detect heterogeneity. The analyses were conducted using R 3.2.0 (R Core Team, 2014), and an R package \textit{rmeta} (Lumley, 2012). Basically, we compared the pooled odds ratios of the two conditions.

4.4.2 Generalized Linear Mixed-Effect Model

In order to examine the speed dimension, a generalized linear mixed-effects model (GLMM) was performed by \textit{lme4}, an R package (Bates, Maechler, Bolker, & Walker, 2015). We used contrast
coding (Linck & Cunnings, 2015) for the following four linear predictors: grammaticality judgments (-.5 = incorrect, 5 = correct), subjective measures (-.5 = explainable, 5 = intuition), linguistic structures (-.5 = control, 5 = tough movement), and grammaticality (-.5 = ungrammatical, 5 = grammatical). With raw RT (no outliers were excluded) as a response variable, GLMM with crossed-random effects (subject and item) was fitted. The Gamma distribution and log-link function were adopted in order to capture the distribution information of RT data as theoretically accurately as possible and to avoid transformation of RT data, which may result in losing the information that the original data had (Lo & Andrews, 2015). The estimation method was the maximum likelihood estimation.

We started with the maximum model, which included all four linear predictors and random slopes of the predictors and random intercepts by subjects and items. Removing predictors in the step-by-step backward procedure, the best model was selected on the basis of the information criterion.

Before running the response time modeling, we fitted the raw data to ex-Gaussian distribution using the maximum likelihood estimation method (retimes, an R package; Massidda, 2013). We report the parameters of the distribution, μ, σ, and τ, with their 95% nonparametric bootstrap (B = 1,000 with the percentile method) CIs for each and its goodness of fit.

### 5. Results

#### 5.1 Consciousness Dimension

Table 1 summarizes the accuracy, ratio of “explainable” responses, odds ratio, and 95% CI for each item. The tough condition exhibited 15% lower accuracy and 19% lower ratio of “explainable” responses than the control condition.

We then performed the Mantel-Heanszel method to compare the pooled odds ratios between the two conditions. The results demonstrated that, in the control condition, the pooled odds ratio (Mantel-Heanszel odds ratio) was 2.25, 95% CI [1.45, 3.49], and the test for heterogeneity rejected the null hypothesis; \( \chi^2(15) = 13.23, p = .58 \). In the tough movement condition, the odds ratio was 0.63, 95% CI [0.42, 0.94], while the test also rejected the null hypothesis; \( \chi^2(15) = 5.91, p = .98 \). Since the tests for heterogeneity rejected their nulls, we did not conduct a moderator variable analysis. Figure 2 visually represents the forest plot for the analysis. Although the tests for heterogeneity were insignificant, we also conducted the random-effect model analysis as an alternative, but the results were basically equal to the fixed effect model.

Consequently, it was confirmed that the participants’ mental state while judging tough constructions was unconscious in terms of the zero-correlation criterion. Rather, the odds ratio demonstrated a slightly negative tendency (0.63). This means that when the response for a tough movement construction was intuitively given, the response was slightly more likely to be correct, unlike that of the control condition, which showed a greater positive value on the odds ratio. The condition P can thus be judged true.
Table 1

Summary of Accuracy, Response Ratios, and Odds Ratios with 95% CIs

<table>
<thead>
<tr>
<th>Item</th>
<th>A</th>
<th>SM</th>
<th>OR</th>
<th>Lower</th>
<th>Upper</th>
</tr>
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<td>1</td>
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<table>
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<th>Item</th>
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<td>0.40</td>
<td>0.08</td>
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<td>.50</td>
<td>0.63</td>
<td>0.42</td>
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Note. A = Accuracy (% correct); SM = Subjective Measure (% “Explainable” response); OR = odds ratio; Lower = Lower limit of 95% CI; Upper = Upper limit of 95% CI.

Figure 2. Forest plot representing the item odds ratios for the two conditions, where each dot indicates the estimated odds ratio with the line representing its 95% CI, and the size of the boxes and diamonds indicating the weight of effects.
5.2 Speed Dimension

First, the raw RT data were fitted to the ex-Gaussian distribution. Table 2 summarizes the estimated parameters with 95% bootstrap CIs, while Table 3 shows the goodness of fit. As the tables show, the data did not follow the normal distribution but rather the ex-Gaussian distribution, and the two conditions showed almost equal parameter values assuming the latter distribution. The plots in Figure 3 represent the probability distribution functions (PDF) and cumulative distribution functions (CDF) of the two conditions, based on the estimated parameters.

Table 2

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Lower</th>
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<th>Estimate</th>
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<th>Lower</th>
<th>Estimate</th>
<th>Upper</th>
<th>Lower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>4,728</td>
<td>4,168</td>
<td>5,578</td>
<td>1,689</td>
<td>2,190</td>
<td>8,661</td>
<td>7,574</td>
<td>9,672</td>
<td></td>
</tr>
<tr>
<td>Tough</td>
<td>5,181</td>
<td>4,512</td>
<td>5,778</td>
<td>1,947</td>
<td>2,397</td>
<td>8,656</td>
<td>7,605</td>
<td>9,701</td>
<td></td>
</tr>
</tbody>
</table>

Note. Lower = Lower limit of 95% CI; Upper = Upper limit of 95% CI.

Table 3

<table>
<thead>
<tr>
<th></th>
<th>Distribution</th>
<th>AIC</th>
<th>BIC</th>
<th>Log-likelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Gaussian</td>
<td>8,048</td>
<td>8,055</td>
<td>-4,021</td>
</tr>
<tr>
<td></td>
<td>Ex-Gaussian</td>
<td>7,856</td>
<td>7,867</td>
<td>-3,925</td>
</tr>
<tr>
<td>Tough</td>
<td>Gaussian</td>
<td>8,100</td>
<td>8,108</td>
<td>-4,048</td>
</tr>
<tr>
<td></td>
<td>Ex-Gaussian</td>
<td>7,912</td>
<td>7,923</td>
<td>-3,952</td>
</tr>
</tbody>
</table>

Figure 3. Plots illustrating the theoretical probability density functions (PDF) and cumulative distribution functions (CDF) between the two conditions. The dashed lines are for the control condition, and the normal lines for the tough movement condition.
Response time modeling was then conducted. Because the full model including all the main effects of the linear predictors and their interactions with random slopes and intercepts for the participants and the items did not converge, we excluded random slopes of the predictors one by one until the model fully converged. We then removed predictors in the step-by-step backward procedure. The demographic information of the compared models is shown in the Appendix. The results of model comparison revealed that removing predictors from the converged full model did not improve AIC or BIC; therefore, we report the results of this converged full model below.

The converged full model included all the predictors. Surprisingly, however, only the main effect of responses on the subjective measure was certainly significant (estimate = -0.24, \(SE = 0.07\), \(t = -3.08\), \(p = .002\)). This suggests that none of the other predictors (grammaticality judgments, grammaticality of items, and linguistic structures) have much impact on the RT in GJT. That is, although the responses towards tough movements were expected to be faster than the control, there seemed to be no such tendency (estimate = 0.01, \(SE = 0.07\), \(t = 0.11\), \(p = .910\)). Moreover, the grammaticality judgments also failed to predict the RT (estimate = -0.04, \(SE = 0.07\), \(t = -0.55\), \(p = .579\)), indicating that the participants sometimes responded slowly and correctly, but at other times responded quickly and incorrectly. Similarly, the grammaticality of the test items did not influence the RT either (estimate = -0.11, \(SE = 0.08\), \(t = -1.46\), \(p = .146\)).

In addition, interestingly, the responses in which the participants answered that they were able to explain the rule were faster than those judged with intuition. If intuitive and correct responses reflecting implicit knowledge were activated quickly, as the majority of SLA researchers have argued to be the case, the results should have been the very opposite, and the participants should have responded quickly when they used their intuition.

6. Discussion

Clearly, the results of the experiment presented thus far fall into the domain of the oblique model, which assumes the exclusive disjunction, namely:

\[ P \lor Q \]  \hspace{1cm} (v)

The condition P was true because the subjective measure showed the unconscious mental state, and the condition Q was false because the reaction time modeling revealed that the unconscious mental state did not entail faster responses, but rather slower ones. Thus, it can be safely stated here that the popularized view of explicit and implicit knowledge reviewed in the literature section is not universally true. This leads us to conclude, using other words, that unconscious knowledge is not always utilized quickly. That is to say, the two dimensions intersect obliquely.
The oblique model may contradict some of the literature. However, the results can be understood by inference based on certain phenomena that are all established facts in psychology: (a) there is a positive correlation between item difficulty and RT (the easier, the faster) and (b) there is a negative correlation between item difficulty and certainty or subjective measures (the easier, the more certain). Consequently, some difficult items such as tough movement in the present study can be expected to exhibit slower (at least not faster) responses and a higher ratio of intuitive responses. This is caused by the correlation structure among the variables, and grammaticality judgments are simply not an exception to this tendency. Of course, there must be a direct correlation between RT and a subjective measure as the present study reported.

Grammaticality judgment performance is complex, as multiple variables (e.g., accuracy, RT, subjective measures, and numerous others) are concerned, and all observations are complexly nested in experimental conditions, participants, and items. The problem in the popularized view was simply that the studies in explicit and implicit knowledge have ignored such a multi-level complex structure of the variables relating to the behaviors of grammaticality judgment, and roughly assumed that the performance can be explained by one side of the two dimensions. Thus, it is desirable to further examine the structure behind the measurement, rather than discussing the explicit and implicit distinction. However, although the oblique model can be explained and modeled mathematically, the cognitive and neurological mechanisms underlying this continue to remain far from clear. More integrated viewpoints are thus required to address this issue.

With regard to some pedagogical issues, capturing learners’ grammatical knowledge from the viewpoint of explicit and implicit dimensions is not only important for SLA research but is also worthwhile in everyday teaching practice. In particular, practitioners need to carefully consider which dimensions of learners’ grammatical knowledge were measured because whether the learners are conscious of the grammar rule or not, and whether they can respond quickly are not necessarily in parallel. Therefore, arguing what explicit or implicit knowledge is, or what it should be, may not be a fruitful strategy. What is desirable for practitioners is to interpret the speed and consciousness dimensions of grammatical knowledge according to their purposes of instruction and curriculum design to provide optimal decision making.

Neither the results of the present study nor the authors imply that consciousness is the only important dimension. Rather, we believe that understanding the nature more precisely is a small step towards change, but one of the most effective and powerful in pedagogy.

As one would expect, these findings need to be interpreted with numerous caveats. First, since all the participants had studied English for more than six years through their secondary education, which surely provided them with explicit knowledge of most of the grammar features tested in this study, apart from tough movement, one should be careful in extrapolating the case of the participants in this study to junior high or high school students who are supposed not yet to have fully acquired explicit knowledge of English grammar. There would therefore seem to be a
definite need for future research to take into account the developmental aspects of oblique dimensions of grammatical knowledge.

Another aspect is the generalization of the obliqueness of grammatical knowledge that was obtained only through GJT. Since judging the grammaticality and natural use of language—reading, listening, speaking, and writing—are essentially different, we do not insist that the findings be applied to other skills or other tasks. Nonetheless, grammatical knowledge, which GJT is expected to tap into, assumes an important role in the research on explicit and implicit knowledge or even in everyday teaching practice and usual language testing. Future research needs to work towards a generalization of the obliqueness by utilizing other tasks that involve a different process than GJT.

7. Conclusion

Although the aforementioned limitations should be kept in mind, the present study cast doubt upon the widespread view of explicit and implicit knowledge in SLA literature. That is, whether the knowledge is quickly accessible or not and whether the learners are conscious of their knowledge or not are obliquely intersected. Future research should take into account this obliqueness of grammatical knowledge and underlying multivariate latent structures of explicit and implicit knowledge in order to fully reveal the nature of learners’ knowledge representations.

Note

1. For example, Suzuki and DeKeyser (2015) argued that online grammatical processing can be a measure of implicit knowledge. Also, it is supposed that the quickly activated knowledge takes an important role in the online processing, which is implied that implicit knowledge is fast.
2. One anonymous reviewer pointed out that only correct responses should be included in the analysis. However, GLMM with only the correct responses showed the same results, indicating that the type of linguistic structures did not influence RT.

References


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Another aspect is the generalization of the obliqueness of grammatical knowledge that was obtained only through GJT. Since judging the grammaticality and natural use of linguistic structures did not influence RT, the type of linguistic structures did not influence RT.

An important role in the online processing, which is implied that implicit knowledge is fast. The construct validity of grammaticality judgment tests as measures of implicit and explicit knowledge. Studies in Second Language Acquisition, 37, 269–297. doi:10.1017/S0272263114000850


**Appendix**

<table>
<thead>
<tr>
<th>Demographic information of the GLMM models</th>
<th>df</th>
<th>AIC</th>
<th>BIC</th>
<th>Log-lik</th>
</tr>
</thead>
<tbody>
<tr>
<td>rt ~ sub + cond + score + ug + (1 + sub + score</td>
<td>id) + (1 + sub + score</td>
<td>item)</td>
<td>17</td>
<td>15,443</td>
</tr>
<tr>
<td>rt ~ score + sub + (1 + score + sub</td>
<td>id) + (1 + score + sub</td>
<td>item)</td>
<td>16</td>
<td>15,444</td>
</tr>
<tr>
<td>rt ~ sub * cond + ug + (1 + sub + cond</td>
<td>id) + (1 + sub</td>
<td>item)</td>
<td>15</td>
<td>15,459</td>
</tr>
<tr>
<td>rt ~ score + sub + cond + (1 + sub + cond</td>
<td>id) + (1 + sub</td>
<td>item)</td>
<td>14</td>
<td>15,459</td>
</tr>
<tr>
<td>rt ~ sub + cond + ug + (1 + sub + cond</td>
<td>id) + (1 + sub</td>
<td>item)</td>
<td>14</td>
<td>15,457</td>
</tr>
<tr>
<td>rt ~ score + sub + (1 + score + sub</td>
<td>id) + (1 + score</td>
<td>item)</td>
<td>13</td>
<td>15,448</td>
</tr>
<tr>
<td>rt ~ sub * ug + (1 + sub</td>
<td>id) + (1 + sub</td>
<td>item)</td>
<td>11</td>
<td>15,454</td>
</tr>
<tr>
<td>rt ~ score + sub + (1 + sub</td>
<td>id) + (1 + sub</td>
<td>item)</td>
<td>10</td>
<td>15,454</td>
</tr>
<tr>
<td>rt ~ sub + ug + (1 + sub</td>
<td>id) + (1 + sub</td>
<td>item)</td>
<td>10</td>
<td>15,452</td>
</tr>
<tr>
<td>rt ~ sub + (1 + sub</td>
<td>id) + (1 + sub</td>
<td>item)</td>
<td>9</td>
<td>15,452</td>
</tr>
<tr>
<td>rt ~ sub + (1 + sub</td>
<td>id) + (1 + sub</td>
<td>item)</td>
<td>9</td>
<td>15,452</td>
</tr>
</tbody>
</table>

*Note.* Only the models that successfully converged are included in the table. rt = reading time; sub = subjective measure; cond = linguistic structure; score = grammaticality judgments; ug = grammaticality; id = participants; item = test items; Log-lik = Log-likelihood. Other supplemental data related to the present study including the item list, more detailed explanations about the analysis procedures, R source codes, and the demographic information of the participants are all available online at https://goo.gl/NVRiRG