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Effects of Task Complexity on L2 Writing Processes and Linguistic Complexity: A Keystroke Logging Study

Jookyoung Jung
(Korea University)

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The influence of task complexity on second language (L2) writing performance has been researched near-exclusively in relation to the linguistic complexity of the learners' written products, while only limited attention has been paid to the online writing processes. In order to fill this gap, the present study focused on the effects of task demands on writing processes as reflected in keystrokes. Forty-four L1 Korean speakers were randomly assigned to either simple or complex condition, and asked to write an argumentative essay. For the simple condition, content support was provided, whereas no such additional information was provided for the complex condition. During the writing task, participants' entire keystroke loggings were recorded, and analyzed in terms of fluency, pausing, and revision behaviors. The lexical and syntactic complexity of the written products was also analyzed and compared between the two task conditions. The results indicated that greater task demands significantly increased the number of pauses and revisions, having negative influence on fluency. Also, lexical rarity and phrasal complexity decreased under the complex condition. The results are discussed with respect to fuller understanding of the task-based approach to L2 writing.

Keywords: task complexity, second language writing, writing process, keystroke logging, linguistic complexity

1. INTRODUCTION

Task-based language teaching (henceforth, TBLT) has received increasing attention from researchers for the past few decades. The underlying theoretical rationale of this pedagogical approach is that tasks can serve as a platform for learners to engage in meaning-oriented activities wherein the target language (TL) is used to achieve a communicative objective (Bygate, Skehan, & Swain, 2001), and thereby enjoy natural opportunities for developing their interlanguage (IL) system. Premised on this assumption,

researchers have proposed diverse criteria regarding how to grade and sequence tasks so that they can have maximal efficacy on second language (L2) development, considering a wide range of task-related factors such as task input, conditions, processes, and outcomes (Ellis, 2003; Long, 1985; Robinson, 2011; Skehan, 2009). In particular, Skehan's (2009) *Limited Capacity Model* and Robinson's (2011) *Cognition Hypothesis* have exerted a considerable amount of influence on TBLT studies, engendering a number of empirical studies on the concept of cognitive complexity of pedagogic tasks. Drawing upon Levelt's (1999) model of speech production, both frameworks predict how various task features may have differential bearings on learners' limited attentional capacity, as reflected in linguistic complexity, accuracy, and fluency of oral production.

The problem inherent in the previous TBLT studies, however, lies in the absence of theoretical framework that can be applied to different language skills, such as writing. Thus far, even though both Limited Capacity Model and Cognition Hypothesis make predictions only to learners' speech production, these models have been directly applied to L2 writing tasks (e.g., Kormos & Trebits, 2012; Kuiken & Vedder, 2011). However, as aptly pinpointed by researchers (Gilabert, Machón, & Vasylets, 2016; Révész, Kourtali, & Mazgutova, 2017), the cognitive process of writing fundamentally differs from that of speech production. Most notably, writing is substantially free from temporal constraints, allowing writers to use more time for planning and revising. That said, a theoretical model unique to writing skills are required so that future studies can better address the influence of cognitive demands on L2 writing performance and thereby have more robust theoretical and pedagogical values.

Another gap in the TBLT literature is that the effects of task complexity on L2 writing has predominantly been investigated in terms of linguistic complexity of linguistic products, rather than online processes (Révész, Sachs, & Haman, 2014; Révész et al., 2017). Indeed, the scope of TBLT needs to be expanded to learners' internal processes, such as noticing or online input processing, using innovative research methodologies such as stimulated recall protocols, eye-tracking technology, or keystroke-logging programs. This warrants particular attention from researchers given that, for theoretical, methodological, and pedagogical advancement of the field of TBLT, task complexity manipulations must be empirically validated via independent evidence that demonstrates the causal cognitive processes triggered by the differential task demands (Norris, 2010; Révész, 2014). In order to fill these gaps in the literature, the present study explored whether task demands affected L2 writing processes, as reflected in the keystroke logging files, and linguistic complexity of the written products.

2. LITERATURE REVIEW

2.1. Task Complexity and L2 Writing

From an attentional capacity perspective, it is important to understand how various task features may impose differential cognitive demands on learners' attentional resources, which can be manifested by their cognitive processes and linguistic outcomes. Skehan, based on VanPatten's (1990) information processing view, proposed Limited Capacity Model and predicts that cognitively demanding tasks put pressure on learners' limited attention and trigger competition among different aspects of oral performance, namely linguistic complexity, accuracy, and fluency. More specifically, performing more demanding tasks will lead learners to prioritize either form (complexity and accuracy) or meaning (fluency). Additionally, within form, attention may be directed to either using challenging language (complexity) or avoiding attention-demanding structures in favor of more accurate language.

Robinson, on the other hand, based on a *Multiple Attentional Resources Model* (Wickens, 2007), put forward Cognition Hypothesis and claims that tasks can become more demanding along either developmental (i.e., resource-directing) or performative (i.e., resource-dispersing) dimensions. Along the resource-directing dimension, cognitive and conceptual need to formulate complex content has the effect of driving learners' attention towards lexical and grammatical encoding, which results in greater complexity and accuracy while negatively affecting fluency. By contrast, a task can also become more demanding along the resource-dispersing dimension, steering learners' attention towards the consolidation of, and faster access to, the existing interlanguage (IL) system, resulting in a trade-off between linguistic complexity and accuracy.

As mentioned earlier, both Skehan's Limited Capacity Model and Robinson's Cognition Hypothesis have extended to written mode (e.g., Ishikawa, 2007; Kormos & Trebits, 2012; Kuiken & Vedder, 2005, 2008; 2011; Révész, et al., 2017; Tavakoli, 2014), regardless of fundamental differences in the underlying processes involved speech versus written production. An issue frequently raised here is plannability in the written mode, whereby learners are inevitably allowed with more time to prepare and adjust their production. For instance, in Kuiken and Vedder's (2011) study that compared task effects on L2 speaking and writing performance, linguistic complexity was affected negatively in the oral mode but positively in the written mode as task complexity increased. In Ishikawa's (2007) study, again, complex task led to significantly more complex language structures in written narrative discourse, which contradicts the findings from studies on oral production wherein linguistic complexity tends to be negatively affected by increased task demand. It appears that, in the case of written tasks, learners are able to stop their grapho-motoric progress in order to retrieve information from long-term memory or engage in a planning process, and hence linguistic and cognitive

resources can be stored and used for longer, resulting in enhanced linguistic complexity of written production (Kormos, 2011). Neither Skehan nor Robinson, however, makes clear predictions about task effects on written tasks, which underscores the need to include a wider spectrum of task modes in empirical studies on task complexity (Gilabert et al., 2016).

Against this background, as suggested by Révész et al. (2017), Kellogg's (1996) model of writing was called for as a theoretical framework in order to better predict and explain the influence of task complexity on learners' writing performance. This model was determined as an ideal conceptual framework considering that it is based on *Cognitive Load Theory* (Sweller, 1988) and views writing as a dynamic process that constantly reacts to cognitive loads imposed by the writing task on learners' working memory and central executive functioning. According to Kellogg, writing subsumes three serial, but recursive, stages, namely, planning, execution, and monitoring. Planning involves activating relevant ideas from long-term memory at a conceptual level, which resonates with orthographic, lexical, and grammatical encoding. Planning stage is followed by sentence generation, which involves motoric processes in the form of handwriting or typing. The written products from this stage are subjected to revision that includes reading and evaluating the quality of the draft and making modifications. Kellogg further claimed that these processes operate in tandem while the working memory capacity, especially central executive function, uniquely constrained by the task features.

When applied to TBLT, Révész et al.'s (2017) made explicit predictions as to how increased task complexity may influence writing process and written product. That is, when learners are under greater pressure, such as the need for expressing more complex ideas or lack of conceptual support, their writing processes will be slowed down due to additional cognitive demands placed on their limited attentional resources. This will also be reflected in longer, and more frequent pauses during writing, especially between larger linguistic units such as clauses or sentences (Schilperoord, 1996). In addition, when the writing task becomes more demanding, learners may have less opportunity for revising their drafts, resulting in less linguistically complex texts. In order to test the accountability of their predictions, accumulation of more empirical findings seem imperative, and the present study is one of such attempts to confirm their hypotheses.

2.2. Task Complexity and Online Writing Process

Although it is hard to find research into the effects of cognitive demands on L2 writing processes, Spelman Miller's (2000) study provides some useful insights regarding the relationship between task complexity and L2 writing behaviors. The study explored whether longer pause length and locations would be associated with more attention paid to planning and revisions during computer-based writing tasks, and whether writing behaviors would

differ between writing in L1 and L2. Pause locations were further categorized into character, word, phrase, clause, and sentence levels. In this study, ten L1 and eleven L2 writers of English produced descriptive and evaluative essays, while their keystroke loggings were recorded with a keystroke logging software program, JEdit (Severinson Eklundh & Kollberg, 1996). The evaluative essay was presumed to place a greater amount of cognitive load on the participants, provided that it necessitated critical evaluation of diverse perspectives. The analysis of pausological features of the writing processes revealed that participants paused longer between sentences and more frequently between noun and verb phrases. However, there were no significant differences in the overall writing patterns, both in terms of fluency and pausing, between the descriptive and evaluative writing tasks.

Ong and Zhang (2010) focused on writing fluency, as measured by the mean number of words produced per minutes, in addition to linguistic complexity of the written texts. The independent variables were the amount of planning time, provision of supporting ideas and macro-structure, and availability of draft during revision. They found that more planning time allowed to the participants led to increased fluency and the provision of helpful ideas and organization guidelines resulted in greater lexical complexity. The availability of the draft, however, did not have any significant influence on either the quality of the texts or writing fluency. In a similar vein, Ong (2014), using retrospective questionnaires, found that L2 writers who received assistance with supporting ideas and text structure were less able to engage in metacognitive processes, in comparison to those who had to write without such help.

One of the most influential and relevant studies to the present research is Révész et al.'s (2017) recent investigation on the effects of absence or presence of conceptual support on L2 learners' writing processes and linguistic complexity of their written texts. Their study was one of the first attempts made to investigate how task complexity affects L2 writing processes by analyzing task performers' keystrokes, based on a theoretical framework specifically designed for writing. In their study, seventy-three L2 speakers of English were assigned to either simple or complex condition and wrote an argumentative essay. For those under the simple condition, helpful ideas that could be included in the essay were provided in order to reduce cognitive demands of the task. The entire writing processes were recorded using a keystroke logging program, *Inputlog*, and analyzed in terms of writing fluency, pausing frequency and length, and revision behaviors. The researchers also assessed lexical and syntactic complexity of the written texts produced by the participants. The results indicated that learners who did not receive content support engaged in more frequent pauses and revisions and produced lexically less sophisticated texts. Based on the findings, they suggested that reducing cognitive demands of writing task through provision of relevant ideas would help learners to pay more attention to linguistic aspects during writing.

The theoretical implication of their research lies in the fact that they proposed Kellogg's (1996) model of writing as the theoretical framework, and made a series of explicit

predictions as to the effects of task complexity on L2 writing performance, in terms of both process and product. Motivated by this theoretical and methodological agenda claimed by Révész et al. (2017), the present study attempted to fill the gaps in the TBLT literature, namely, the need for a conceptual framework to be called upon when investigating the influence of task complexity on L2 writing performance and lack of empirical evidence as to online L2 writing processes. In this regard, the purpose of this study can be viewed as twofold: (a) validating accountability and applicability of Kellogg's model in task-based approaches to L2 writing studies and (b) testing the predictions advanced in Révész et al.'s seminal research into the impact of task complexity on L2 writing processes. In order to achieve these dual goals, this study reports a partial replication study of Révész et al. (2017), by addressing the following research questions:

1. To what extent do the cognitive demands of an English writing task affect Korean undergraduate students' writing process as reflected in their keystroke-logging files?
2. To what extent do the cognitive demands of an English writing task affect linguistic complexity of Korean undergraduate students' written products?

3. METHODOLOGY

3.1. Participants

This study examined the impact of task complexity on Korean speakers' L2 English writing processes and linguistic complexity of their written products. The participants were forty-four undergraduate students (22 male and 22 female) enrolled in a university in Korea. Their L1 was Korean and their average age was 23.37 years (*SD* = 2.00). The average onset age of English education was 8.23 years (*SD* = 1.97). A majority of the participants majored in Linguistics-related studies, such as English for international communication, English language, French language, German language, Russian language, to name a few. The average TOEIC score was 945.91 (*SD* = 33.81), and hence their English level was assumed as C1 or C2 (i.e., advanced) according to the Common European Framework of Reference levels (Educational Testing Services, 2017).

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3.2. Writing Task

The writing task of this study was selected and adapted from topics for IELTS Writing Task II. The participants were provided with the following task prompt:

> Being able to speak a foreign language is an advantage these days. Some people think that children should start learning a foreign language at primary school, while others think children should begin in secondary school. What is your opinion?

The participants were instructed to choose one of the two choices suggested in the prompt, and write an argumentative essay. As done in previous studies on the impact of task complexity on L2 writing processes (Ong, 2014; Ong & Zhang, 2010; Révész et al., 2017), those assigned for the simple condition further received conceptual supporting ideas that could be utilized in their essays. The content support was assumed to decrease task complexity by allowing participants to save their mental resources from generating ideas at the planning stage and thereby direct the surplus attention to linguistic aspects during writing processes. Those under the complex condition had to pay attention to not only linguistic processing but also conceptual processing due to the absence of content support, resulting in increased level of task complexity.

More specifically, the following topics were included in the content support: (a) the benefits of learning a foreign language at an earlier age; (b) the increased need for early foreign language education; (c) dangers in learning a foreign language at an earlier age; and (d) the reasons why early foreign language education is unnecessary. For each of these four topics, three concrete ideas were provided, and the participants were allowed to freely choose which to include in their essays (see Appendix A). Considering the relatively high English proficiency of the participants of this study, the word limit for the writing task was set at 300-350 words within 45 minutes. During the entire writing session, the keystroke logging software Inputlog 7.0.0.11 (Leijten & Van Waes, 2013) recorded the participants' writing processes comprehensively (see Figure 1).

FIGURE 1

Sample keystroke log-file

<Text>_378_[T_271_[_267_[_9_[_5_[_4_[_3_[_2_[h_1_[·]_1_e]_2_쏘]_3_씨]_4_Thje]_5_Th_6_[e·]_6_ere·have·been·much·d_7_[a]_7_ebate·w_8_[h]_8_ht]_9_As·the·world·]_267_As·the·_269_[world·ha]_269_boundaries·between·countries·are·collap]_271_Learning·a·Foreign·Language_375_[·]_375_:·Primary·School·vs·Secondary·School_377_[_379_[In_373_[·]_373_a·society·where·boundaries·between·countries·have·_273_[kn]_273_no·meaning,·l_275_[L]_275_earning·a·_10_[F]_10_for_11_[i]_11_eign·language·has·become·a·nec_12_[i]_12_es_13_[i]_13_sity_281_[_279_[·in_277_[·the·c_14_[u]_14_urrent·soci_15_[eyt]_15_ety.·_16_[However,·some·peopl]_16_]_277_]_279_.]_281_.·TThe·benefits_18_[·that·_17_[it·pro]_17_this·ability·fo]_18_·of·_19_[p]_19_being_20_[·provided·a·forei]_20_·able·to·speak·a·secondary·language·_21_[is·]_21_are·uncountable.·_22_[Howver,·]_22_However,·there·h_284_[av]_284_se·beenmuch··controvers_283_[y·_25_[o_24_[_23_[n·whethe]_23_·]_24_n·]_25_o]_283_·onn_326_[·whether·children·should·start·learning·a·_28_[secondary·langu_26_[g]_26_age·]_28_fore_30_[i]_30_gn·lan_53_[ug]_53_guage·in·primary·or·secondary·s_27_[h]_27_chool]_326_what·age·_328_[they·]_

3.3. Questionnaires

Participants were asked to answer a background questionnaire and a post-task questionnaire. The background questionnaire was to collect demographic information about participants, such as their age, native language, onset age of English education, and TOEIC scores. Immediately after the task completion, a post-writing questionnaire, comprised with 7 Likert-scale items, asked participants to provide their perceived level of task difficulty, which was to be used for validating the task complexity manipulation of the current study (Révész, Michel, & Gilabert, 2016). The items included: (a) *I thought this task was difficulty*; (b) *I felt frustrated doing this task*; (c) *I did poorly on this task*; (d) *I invested a large amount of mental effort to complete the task*; (e) *I struggled during this task*; (f) *This task was stressful for me*; and (g) *I thought this task was demanding*. All questionnaires were administered in Korean.

3.4. Data Collection Procedure

The data were collected over an hour as groups in a computer-laboratory at a university. All participants first answered the background questionnaire and listened to task instruction delivered by the researcher. Then, they had 45 minutes to complete the writing task. Upon the task completion, the essays written by the participants were collected and the post-writing questionnaire was administered in order to estimate the level of the task complexity perceived by the participants manipulation. After the participants left the computer laboratory, the keystroke-logging files were collected from all computers.

3.5. Data Analysis

Program R version 3.3.0 (R Development Core Team, 2016) was used for statistical analysis of the data, such as computing reliability of questionnaire items (Cronbach's alpha), descriptive statistics of the data, and independent-sample t-tests. The level of significance for this study was set at alpha level of $p < .05$. For *t*-tests, Cohen's *d* was calculated to examine effect sizes. As suggested by Plonsky and Oswald (2014), the benchmarks were .40 for small, .70 for medium and 1.00 for large effect sizes. The detailed information regarding indices for writing processes and linguistic complexity is presented in the following sections.

3.5.1. Online writing process

As in Révész et al. (2017), the keystroke logging data collected during the writing task were analyzed in terms of writing fluency, pausing, and revision behaviors. For fluency, the length of time divided by the number of total number of words and characters (minute per word/character) as well as the total number of words and characters divided by P-burst, (words/characters per P-burst) were calculated. Following Spelman Miller et al. (2008), the threshold for pausing was set at 2000ms. Pausing behaviors were analyzed in terms of the length and frequency of pausing during the writing process. More specifically, pausing indices included measures such as the average length and number of pause between words, sentences, and paragraphs (Wengelin, 2006). Lastly, revision behaviors were investigated by means of the ratio of the number of words/characters in the final text out of the total typed during the entire task performance.

3.5.2. Linguistic complexity of written texts

The participants' written products were analyzed in relation to the lexical and syntactic complexity. Following Révész et al. (2017), lexical complexity incorporated qualities such as rarity, variability, and disparity. First, measures for lexical rarity, i.e., frequency of words, included proportion of K1 (the most frequent thousand words), K2 (the second most frequent thousand words), and off-list words contained in the written texts. These values were computed using Cobb's (2016) Vocabprofiler. Next, lexical variability, i.e., type-token ratio, was analyzed using measures such as D formula (Malvern & Richards, 1997) and MTLD (McCarthy & Jarvis, 2010), using McNamara, Louwerse, Cai, and Graesser's (2005) Coh-Metrix 3.0. Finally, lexical diversity, i.e., the degree of semantic relatedness among words, was assessed by means of a latent semantic analysis (LSA) index, which was also extracted with Coh-Metrix.

Syntactic complexity of the written texts was analyzed in terms of overall complexity, subordination complexity, phrasal complexity, and syntactic sophistication. The overall complexity and subordination complexity was assessed via the ratios of words and clauses in relation to t-units, which were calculated using SynLex (Lu, 2010). In addition, phrasal complexity and syntactic sophistication were analyzed by computing the number of modifiers per noun phrase and syntactic structure similarity of each text, which were computed using Coh-Metrix.

4. RESULTS

4.1. Validation of Task Complexity Manipulation

Prior to answering the research questions, the task complexity manipulation conducted in the present study was tested using the amount of time taken to complete the task and perceived level of task difficulty (for descriptive statistics, see Table 1). Firstly, the time taken to complete the writing task was recorded for each of the participants. An independent-sample t-test indicated that it took significantly longer for the participants to complete the writing task under the complex condition, $t(42) = 3.021$, $p = .004$, Cohen's $d = .921$.

In addition, as described in the earlier section, in order to infer the effects of task complexity on the amount of cognitive demands placed on the participants, seven Likert-scale questionnaire items were administered after task completion. The Cronbach's alpha for the seven items was .78. In order to see if there was significant difference between the simple and complex conditions in participants' ratings of perceived task difficulty, independent-sample *t*-tests were conducted. The results revealed that participants perceived the complex version significantly more demanding in comparison to the simple version, $t(42) = 2.449$, $p = .019$, Cohen's $d = .753$. The effect sizes, as evaluated with Cohen's *d*s, were large ($d > .70$). In short, the task complexity manipulation conducted in the current study via presence or absence of supporting ideas was empirically validated.

TABLE 1

Descriptive Statistics for Time to Task Completion and Perceived Task Difficulty

		Time to Task Completion			Perceived Task Difficulty		
Condition	*N*	*M*	*SD*	95% *CI*	*M*	*SD*	95% *CI*
Simple	22	37.720	7.856	[34.441, 41.003]	31.440	6.953	[28.543, 34.345]
Complex	22	44.737	7.325	[41.682, 47.806]	36.368	6.130	[33.811, 38.938]
Total	44	40.750	8.322	[37.274, 44.237]	33.568	6.986	[30.653, 36.497]

Note. Maximum value for perceived task difficulty = 49

4.2. Effects of Task Complexity on L2 Writing Process

The mean length of the participants' writings was 381 for the complex and 398 for the simple condition, indicating that those provided with conceptual support were able to produce longer texts. In addition, it took 44.74 minutes overall for the complex group to complete the writing task, whereas those in the simple condition spent 37.72 minutes on

average (for comparison, see Appendix B). The descriptive statistics for the online writing processes are displayed in Table 2. As presented, it took significantly longer for the participants to produce words/characters when assigned in the complex version, Word: $t(42) = 2.468$, $p = .018$, Cohen's $d = .735$; Characters: $t(42) = 2.771$, $p = .008$, Cohen's $d = .714$. In addition, the average number of pauses was greater between words and sentences under the complex condition, Word: $t(42) = 2.691$, $p = .010$, Cohen's $d = .800$; Characters: $t(42) = 2.083$, $p = .043$, Cohen's $d = .607$. Effect sizes were evaluated as large ($d > .70$), except for the number of pauses per character ($.40 < d \leq .70$). Lastly, the ratio of words contained in the finalized texts out of total typed during the task was larger for the simple condition. That is, the results indicated that when the participants were not provided with conceptual support, they were less fluent in producing words and characters, while making more frequent pauses both between words and sentences. Also, the participants assigned in the complex condition appeared to engage in more extensive revisions while writing, as reflected in the smaller amount of words left in the final texts out of those during the entire writing process.

4.3. Effects of Task Complexity on Linguistic Complexity

Table 3 presents the descriptive and inferential statistics for the lexical and syntactic complexity of the written products. Firstly, the proportion of K1 words seemed significantly greater under the complex condition, $t(42) = 3.150$, $p = .003$, Cohen's $d = .958$, whereas that for K2 words was larger under the simple condition, $t(42) = -2.649$, $p = .011$, Cohen's $d = .795$. Significant differences were also found for the ratio of words to t-units and the number of modifiers per noun phrase. To be more specific, the values were significantly greater under the simple condition, Overall complexity: $t(42) = -2.915$, $p = .006$, Cohen's $d = .877$; Phrasal complexity: $t(42) = -3.213$, $p = .003$, Cohen's $d = 1.004$. Effects sizes were large for all the cases where significant differences were observed ($d > .70$). In other words, the participants under the complex condition relied more heavily on more frequent words (larger proportion of K1), while those under the simple condition were able to retrieve less frequent words (larger proportion of K2). Plus, when provided with conceptual support, they could include a larger number of modifiers in noun phrases, making their texts syntactically more complex.

TABLE 2

Descriptive and Inferential Statistics for Writing Fluency, Pausing, and Revision Behaviors

Index	Simple				Complex			*t*	*p*
	N	*M*	*SD*	95% *CI*	*M*	*SD*	95% *CI*		
Fluency									
Minute/ word	22	0.099	0.034	[0.085, 0.113]	0.124	0.034	[0.110, 0.138]	2.468	.018
Minute/ character	22	0.019	0.007	[0.016, 0.022]	0.024	0.007	[0.021, 0.027]	2.771	.008
Words/ P-burst	22	3.518	1.362	[2.949, 4.087]	3.057	2.225	[2.217, 3.987]	- .181	.857
Characters/ P-burst	22	18.658	7.321	[15.599, 21.717]	15.463	10.696	[10.994, 19.932]	- .481	.633
Pausing									
Pause length/ word	22	5.468	1.308	[4.921, 6.015]	5.426	1.250	[4.904, 5.948]	- .388	.700
Pause length/ sentence	22	7.040	1.518	[6.406, 7.674]	6.966	1.954	[6.149, 7.783]	- .107	.915
Pause length/ paragraph	22	3.521	2.098	[2.644, 4.398]	3.782	1.320	[2.965, 4.599]	- .142	.888
Pause number/ word	22	57.280	15.307	[50.884, 63.676]	72.211	21.516	[63.220, 81.202]	2.691	.010
Pause number/ sentence	22	4.720	1.208	[4.215, 5.225]	5.842	2.316	[4.874, 6.810]	2.083	.043*
Pause number/ paragraph	22	2.000	1.041	[1.565, 2.435]	2.368	1.012	[1.945, 2.791]	1.177	.246
Revision									
Words in text out of total typed	22	0.774	0.096	[0.734, 0.814]	0.690	0.051	[0.669, 0.711]	2.876	.006
Characters in text out of total typed	22	0.587	0.092	[0.549, 0.625]	0.520	0.047	[0.500, 0.540]	1.661	.104

TABLE 3

Descriptive and Inferential Statistics for Lexical and Syntactic Complexity of Written Texts

Index	Simple				Complex				*t*	*p*
	N	*M*	*SD*	95% *CI*	*M*	*SD*	95% *CI*			
Lexical Complexity										
Proportion of K1	22	77.983	3.389	[76.564, 79.396]	81.236	3.398		[79.810, 82.650]	3.150	.003
Proportion of K2	22	12.871	1.944	[12.058, 13.682]	11.174	2.308		[10.206, 12.134]	-2.649	.011
Proportion of off-list words	22	2.304	1.760	[1.492, 3.116]	2.431	1.840		[1.662, 3.200]	.233	.817
D formula	22	82.305	18.098	[74.742, 89.868]	74.018	15.883		[67.381, 80.655]	-1.585	.121
MTLD	22	82.754	17.802	[75.315, 90.193]	73.693	17.670		[66.309, 81.077]	-1.678	.101
LSA	22	0.277	0.067	[0.249, 0.305]	0.277	0.067		[0.249, 0.305]	- .311	.757
Syntactic Complexity										
Ratio of words to t-units	22	19.671	2.360	[18.685, 20.657]	17.404	2.794		[16.236, 18.571]	-2.915	.006
Ratio of clauses to t-units	22	1.847	0.230	[1.751, 1.943]	1.807	0.250		[1.703, 1.911]	- .551	.584
Number of modifiers/ NP	22	0.913	0.143	[0.853, 0.973]	0.793	0.090		[0.755, 0.831]	-3.213	.003
Syntactic structure similarity	22	0.111	0.096	[0.071, 0.151]	0.100	0.016		[0.093, 0.107]	-. 504	.617

5. DISCUSSION

In this study, it was investigated whether task complexity affected Korean undergraduate students' cognitive processes while writing an English argumentative essay and the linguistic complexity of their written texts. Following previous research (Ong, 2014; Ong & Zhang, 2010; Révész et al., 2017), task complexity was manipulated by providing conceptual support only to the participants assigned in the simple task condition. The results indicated that it took significantly longer for the participants to complete the given task when there was no content support, and they perceived the writing task significantly more difficult when assigned in the complex condition. In other words, the task complexity manipulation conducted in this study was empirically validated, which allows further discussions on the findings of this study.

5.1. Task Complexity and L2 Writing Process

The participants' writing processes were recorded with a keystroke-logging program, Inputlog, and analyzed in terms of writing fluency, pausing length and frequency, and revision behaviors. The results showed that the participants paused more frequently between words and sentences when they were not provided with conceptual support. This finding fits neatly into the slowed down writing speed under the complex condition. That is, the participants under the complex condition might have had to allocate their attention to planning processes, i.e., generating and organizing ideas, as manifested by the increased number of pauses. Similar results were found in Ong (2014) and Révész et al. (2017) in which provision of conceptual support significantly reduced frequency of pausing behaviors. Interestingly, task effects were not detected in the duration of pausing. Révész et al. (2017) suggest that, as in the case of speaking fluency (De Jong, Steinel, Florijn, Schoonen, & Hulstijn, 2013), the length of pauses may be more susceptible to the individual learners' writing style, while relatively resistant to task complexity. In other words, pause frequency is sensitive to task demands, whereas pause length is more closely tied to linguistic demands put on the writer, reflecting his or her lexical and syntactic maturity.

Next, when the participants were not provided with content support, fluency, as measured by minutes per word/characters, decreased. This seems to indicate that the participants under the complex condition struggled more due to the greater need to spare out their limited attentional resources to planning processes, resulting in slowed down pace of writing. However, in Ong and Zhang (2010) and Révész et al. (2017), the provision of ideas and macro-structure did not have an impact on writing fluency. One possible explanation of conflicting findings could be the extensive amount of information provided

to the simple group in this study. For example, when compared with Révész et al.'s (2017) study in which keywords were used as content support, the supporting ideas of this study were all in full sentences, containing more concrete and detailed information. Perhaps this might have lessened the burden put on the simple group at the planning stage, which was manifested in more fluent writing performance. In this regards, futures studies may need to incorporate multiple degrees of task complexity, as done in Kim's (2012) study where simple, + complex, and ++ complex tasks were designed, in order to arrive at a more nuanced understanding of the effects of varying levels of task complexity on L2 task performance.

What seems also noteworthy in this study was that the participants in the complex group made more revisions at word level, as evinced by the smaller number of words left in the final draft out of the total words typed. It appears that the participants under the complex condition might have had to keep revising their drafts more frequently when there was no supporting information or guidelines as in the simple condition. This finding again runs counter to Révész et al.'s (2017) finding that showed less revision below word level for the complex condition. They explained that increased demands on planning due to lack of content support might have left little resources to be distributed to monitoring and revising processes, resulting in significantly less lexical revisions. In their study, this speculation was corroborated by stimulated recalls collected immediately after task completion. Again, the different amounts of conceptual support between Révész et al. (2017). and the present study may explain the contrasting findings. That is, in this study, the supporting ideas were all in full sentences, which could have helped those under the simple condition to establish relatively solid outline before beginning writing and thus less need to reorganize or change their drafts at later stages. By contrast, when there was no such provision of conceptual support, the participants might have had to engage in recursive writing processes, traversing across planning, execution, and revision stages to a greater extent.

5.2. Task Complexity and Linguistic Complexity

The participants' written texts were analyzed in terms of lexical rarity, variability, and disparity, as well as the level of subordination complexity, phrasal complexity, and syntactic sophistication. As found in Ong and Zhang (2010), Kormos (2011), and Révész et al. (2017), when heavier demands were placed on the planning stage, the participants relied more heavily on K1 words, but less on K2 words. That is, lexical complexity of the written products significantly decreased when there was no content support, as the participants had more difficulty in retrieving less frequent words during writing. In addition, overall complexity, as measured by the number of words to t-units, and phrasal complexity, as measured by the number of modifies per noun phrase, decreased

significantly for the complex condition. Similar trend was also found in Révész et al.'s (2017) research for the overall complexity. In Kormos's (2011) study, however, increased task complexity did not make a significant impact on syntactic complexity. In her study, the two tasks were in different types, i.e., describing a series of coherent pictures versus narrating a story based on unrelated pictures. It seems noteworthy that when performing the supposedly simple task, i.e., describing a coherent comic strip, learners could have been forced to narrate a given story with their limited L2 resources. In contrast, in the supposedly complex task i.e., inventing a story with six unrelated pictures, the learners could have enjoyed the room for adjusting their story to their existing L2 means. In other words, the two tasks were entirely different in nature (describing vs. creating), making cognitive demands on the learners in unique ways, which renders it very difficult to estimate the relative demands imposed on learners by each. She also admits that both task types might have provided similar opportunities for the participants to demonstrate their L2 linguistic competence in writing. Having said that, in order to spell out the exact influence induced by task complexity on learners' task performance, it seems crucial to control the task type while manipulating only the level of task complexity.

6. CONCLUSION

The present study casts some valuable implications. Most importantly, Kellogg's (1996) model of writing was shown to serve as a viable theoretical framework for predicting and explaining the influence of task demands on learners' writing processes. Given that task effects on L2 writing performance has mainly been approached with respect to the quality of the written texts, Kellogg's model, together with the availability of keystroke logging programs such as Inputlog, will inspire and invite more research into the L2 writing processes under varying levels of task demands. The results of this study also provide pedagogical implications. That is, when it comes to L2 classrooms where developing L2 competence and improving writing skills are simultaneously highlighted, provision of content support may help learners to spare their limited attentional resources and thereby better attend to linguistic features during writing (Révész et al., 2017). In addition, the amount of conceptual support (e.g., illustrations, keywords, or full sentences) may need to be carefully selected and adjusted by the instructor considering the students' L2 proficiency and writing skills.

There are several methodological limitations of this study. Firstly, only one task type and one way of task manipulation were included in this study, placing limitations in the scope of generalizability of the findings. In future studies, diverse task types along with various ways of task manipulation will generate more useful insights into the task effects

on L2 writing processes and products. Plus, unlike Révész et al.'s (2017) study in which data triangulation was possible due to multiple data collection methods such as stimulated recall protocols, this study did not involve participants' verbal reports on their task performance due to practical limitations including restricted time allowed for data collection. That said, it would be desirable for future research to include additional data sources so that fuller understanding of the task effects on L2 writing processes. Last but not least, the number of the participants was forty-four, which appeared relatively small for answering the research questions through statistical analysis.

Regardless of the aforementioned limitations, the current study made a valuable attempt to extend the theoretical, methodological, and pedagogical understanding of the task-based approach to L2 writing processes, which has long been unattended by researchers. Given the dearth of empirical explorations into this topic, further research will be necessary to examine how differential task demands affect L2 learners' writing performance, especially at the online processing level.

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APPENDIX A

Task instruction for simple condition

(300-350 words, 45 minutes)

Following a discussion about Language at school, you have been asked to write an essay giving your opinions on the topic:

'Being able to speak a foreign language is an advantage these days. Some people think that children should start learning a foreign language at primary school, while others think children should begin in secondary school. What is your opinion?'

In your essay, please address the issues below. You do not have to use all the examples suggested in the bullet points. Please select some of them and expand on those.

If you agree with early foreign language education, include the following information:

- What are the benefits of learning a foreign language at an earlier age? For example,
  - Children can develop natural interest in learning another language.
  - Children can learn another language relatively easily.
  - The resulting outcome of learning is likely to be successful.

- What is early education of a foreign language necessary? For example,
  - Children can expand their knowledge more effectively.
  - Children can enjoy cultural contents and events in different languages.
  - Children can socialize with people with different linguistic and cultural backgrounds.

If you disagree with early foreign language education, include the following information:

- What are the dangers in learning a foreign language at an earlier age? For example,
  - Children may lose interest in learning another language.
  - Children may be confused and show delayed linguistic development.
  - Early foreign language education often requires high costs.

- Why is early foreign language education unnecessary? For example:
  - Full development in the first language should be prioritized.
  - It is not that all children must be able to speak a foreign language.
  - Rapid development in the translating technology has weakened the need to learn a foreign language.

APPENDIX B

Text samples for simple and complex conditions

[Simple condition]

Nowadays, being able to speak a foreign language is regarded as a necessary skill that is required to get employed. Many countries include a foreign language subject in their regular education course, and some students even attend private academy to learn a second language. Although the majority of people agree that foreign language education for children is significant, they are not in a complete agreement about the appropriate time the education should begin. While some argue that children should start learning a foreign language at primary school, others assert that the education should begin at secondary school when children are more mature. Though both sides have their own logical arguments, I support the former stance, that students should start learning their second language at primary school due to the following reasons.

First of all, it is easier to learn a foreign language in an early age. Primary school students who have not yet finished developing the language structure of their mother tongue, tend to experience less difficulties when learning a new language. This is possible because the structure of the second language does not collide with that of mother tongue. Adults, who normally have complete knowledge about their mother tongue, find it much challenging to absorb new language. Hence, if one is planning to learn a foreing language some day, it is recommended that one starts as early as possible.

Secondly, if children learns a foreing language in an early age, it is easier for them to expand their knowledge more effectively. Educational materials, as well as a number of entertainment programs does not exist in a single language. Resources come from diverse countries, and thus, if a child is monolingual, it clearly restricts the variety of knowledge they can gain access to. Since it is obvious that children will gain a broader view of the world and more diverse aspects if they are exposed to more contents, an earlier language education is a necessity.

To sum up, children should start learning a foreign language at primary school because it hels them to learn the language more easily, and allows them to gain more accessibility to educational contents from a more variety of countries. Though children are not that old in secondary school too, it would be more beneficial for the students if they started learning at a younger age. (390 words, 35 minutes)

[Complex condition]

In this global world, being able to speak foreign language is an advantage. Therefore, learning foreign language in childhood is a trend, especially in Korea. Also, there are many studies that support the early foreign language education.

According to a study, speed of learning language is specially better at childhood than in other ages. In that reason, some people argue that their children should start learning a foreign language at primary school. However, I think too early learning language is burden to the children. The education competition already overheated in Korea, and learing a foreign language means the children should go to one more academy. Generally, in that age, playing with friends is more natural than going to academies.

Furthermore, at primary school, children should learn Hanguel first. Speaking a foreign language has no meaning if they can not speak Hanguel. However, if learn a foreign language too early, they will confuse between Hanguel and the other language. Consequently, they will fail with not only learing a foreing language but also Hangeul. So I think it is better to learn a foreign language in secondary school, at least.

In addition. I do not think being able to speak a foreign language will be a benefit to children when thew grow up. The children's parents might have some advantage by learning English or other languages, but the world that their children will live is so different from where they lived. The technology will progress faster, and our children may not feel the necessity to learn foreign languages. For example, the tlanslator with AI was devised and although we did not learn Arabic, we can communication easily with Arabian.

For these three reason, I think learnign a foreign languages at primary school is not good idea for children. Instead of learning a foreign language in that age, learning what children prefer and playing freely are more important. Their parents have to let their child learn what they love, so they love learning. If their children do not want to learn a foreign language, but parents put them to a academy forcefully, learning become fearful to them. Not only children but also their parents do not want this situation. Therefore, early foreign language education is not helpful. (374 words, 45 minutes)

Application levels: Tertiary

Jookyoung Jung
Center for English Language Education, Korea University
145 Anam-ro, Anam-dong, Seongbuk-gu, Seoul, 02841
Phone: 02-3290-1678
Email: chosenfew@korea.ac.kr

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