

The Effect of Manipulating Task Complexity Along Resource-Dispersing Dimension on L2 Written Performance from the Perspective of Complexity Theory

Xiaobo Luo¹

¹Office of Academic Affairs, Ningbo Open University, Zhejiang, China

Correspondence: Xiaobo Luo, Office of Academic Affairs, Ningbo Open University, Ningbo, Zhejiang, China.

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Abstract

From the perspective of complexity theory and based on Robinson's Cognition Hypothesis and the Triadic Componential Framework, this paper investigated the effect of manipulating task complexity along resource-dispersing dimension on L2 written performance. The results showed that: 1) Significant interactive effects were found between the two variables (i.e. task structure and planning). 2) Without planning, the accuracy and fluency of written output in tasks without structural constraint were significantly higher, while the syntactic complexity was lower. 3) Planning had no significant effect on accuracy. In macro-structure given task, planning promoted fluency and lexical complexity, but did not affect syntactic complexity. The result only partially supports the Cognition Hypothesis. Combined with previous research, it can be found that written output in tasks is nonlinear, multidimensional and self-adaptive. Researchers and teachers are suggested to fully consider task characteristics and individual differences, and not to take task complexity as the sole criterion when designing writing tasks.

Keywords: task complexity, complexity theory, resource-dispersing, cognition hypothesis, L2 writing

1. Introduction

Writing is a multifactorial, complex, and cyclical cognitive process (Hyland, 2003), and Flower & Hayes (1981), Scardamalia & Bereiter (1987), and Hayes (2012) have proposed several cognitive models of writing which suggest that factors such as task characteristics work together to influence the writer's attentional resource allocation, which in turn affects written output. With the rise of task-based teaching and research, research on task difficulty and task complexity has gradually intensified, and the relationship between task complexity and L2 written performance has gradually become a central topic in the field of second-language acquisition. Related theories include Skehan's (1998) Limited Attentional Capacity Model and Robinson's (2007, 2011) Cognition Hypothesis and the Triadic Componential Framework. Although a large number of empirical studies have been conducted by researchers based on these theories, the effect of manipulating task complexity on learners' language performance is far from conclusive. In recent years, some researchers have advocated the complexity theory as a perspective to explore the relationship between task complexity and L2 performance, arguing that tasks are microenvironments for language learning, and that different task complexity places different demands on learners' cognitive resources, and learners interactively adapt to the cognitive demands of the task by redeploying resources to produce new linguistic features and patterns (Zheng & Liu, 2020). The present study attempts to explore the relationship between task complexity and L2 written performance through the lens of the complexity theory.

2. Review of Related Studies

2.1 The Perspective of Complexity Theory

The application of complexity theory in L2 acquisition was first proposed by Larsen-Freeman (1997), which views language as a complex, dynamic, and systematic whole with self-organization, self-adaptation, and

openness, and advocates a nonlinear, multidimensional view of language development (Zheng, 2019). Language in the framework of complexity theory is a complex dynamic system in which the elements within the system are interconnected and interact, and the language system adapts to the environment through self-organizing behavior under certain external conditions. The cognitive complexity of a task can be viewed as the stimulation of the learner's internal cognitive resources by the task environment, while the language output is the adaptive language behavior of the learner by deploying his or her own cognitive and linguistic resources (Zheng & Liu, 2020). Most of the current research in this area is theoretical, and there are not many relevant empirical studies. Li & Sui (2017) found that the development of spoken language is characterized by complexity, dynamics, and multidimensionality by observing the development trajectories of six English learners' spoken language within one year in terms of complexity, accuracy, and fluency. Zheng & Liu (2020) discovered a deep connection between task complexity and learners' language behavior at a macro level by using a spoken corpus as research material and found that the lexical complexity of learners' spoken language significantly changed with increasing task complexity, and concluded that the spoken vocabulary system is a complex adaptive system that interactively adapts with the cognitive demands of task environment. In L2 writing, Zhang (2021) conducted a correlation analysis of learners' written output under different task conditions and found that the correlation showed a trend from negative to positive over time, arguing that the transition of the correlation between task complexity and second language writing performance is the self-adaptive process of second language writing system.

2.2 Studies Related to Task Complexity

Robinson's Cognition Hypothesis and the Triadic Componential Framework are currently the most influential theories in the field of task complexity research (Xing, 2019). Robinson (2001: 29) defines task complexity as “the result of attentional, memory, reasoning, and other information processing demands imposed by the structure of the task on the language learner”. He divides task complexity into resource-directing and resource-dispersing dimensions. Resource-directing dimension refers to cognitive, conceptual requirements, including few/many elements, here-and-now/there-and-then, +/-reasoning demands, while resource-dispersing dimension refers to procedural and behavioral requirements, including +/-planning, task structure, single/dual task, +/-prior knowledge. He argues that increasing task complexity in the resource-directing dimension leads to higher accuracy and complexity of L2 performance, but affects fluency, while increasing task complexity in the resource-dispersing dimension prevents learners from making full use of their existing L2 knowledge, thus affecting the quality of L2 performance.

The Cognition Hypothesis and the Triadic Componential Framework were originally used to study the effects of task cognitive demands on spoken output, and in recent years, a number of scholars have introduced them to the field of L2 writing. Task complexity along resource-directing dimension in the Triadic Componential Framework has been the focus of researchers. Kuiken et al did a series of studies involving elements (Kuiken et al., 2005; Kuiken & Vedder, 2007; Kuiken & Vedder, 2008) and found that in complex tasks with more elements, there was an increase in learners' linguistic accuracy, but no significant effect on syntactic complexity and lexical complexity. Wang (2013) revealed that lexical complexity did increase in more complex tasks, but there was no significant change in syntactic complexity. Frear & Bitchener (2015) found that more complex vocabulary and more adverbial clauses were used in tasks with more elements. In studies where here-and-now was the main variable, Ishikawa (2007) discovered an increase in accuracy, complexity, and fluency in the linguistic output of L2 writers as the complexity of tasks increased. Rahimpour & Hosseini (2010) found a significant increase in fluency in tasks with higher complexity, with no significant effect on accuracy or complexity. Cho (2015) manipulated task complexity based on two variables, elements and reasoning demands, and found that learners' fluency was higher in tasks with higher complexity, but accuracy and syntactic complexity did not change significantly. Jin et al. (2020), also using elements and reasoning demands as variables, found that there was a competitive relationship with the allocation of attentional resources between language accuracy and complexity, with the higher the difficulty of the task, the greater the proportion of attentional resources allocated to accuracy, while the proportion to complexity became smaller. These findings are not entirely consistent with Robinson's Cognition Hypothesis, and some even appear to be completely contradictory.

The resource-dispersing dimension has been relatively less studied than the resource-directing dimension (Ong & Zhang, 2010), and related studies have focused on prior knowledge and planning (Johnson, 2017). Prior knowledge, also known as topic familiarity, was found by Adams & Nik (2014) to be more diverse in the vocabulary used by writers with less prior knowledge. The findings of Wang et al. (2020) were largely consistent with Adams & Nik. Yang (2014) concluded the opposite, suggesting that subjects with more prior knowledge had higher vocabulary complexity, but no effect on syntactic complexity. In terms of planning, Ellis & Yuan (1999)

found that pre-task planning improved fluency and syntactic complexity in L2 narrative writing, while no planning had a negative effect on fluency, complexity, and accuracy, which is generally consistent with the findings of some researchers (He & Wang, 2003; Ojima, 2006; Abrams & Byrd, 2016). Ong & Zhang (2010), on the other hand, found a negative effect of pre-task planning on fluency and lexical complexity, arguing that writing is different from speaking in that planning can occur throughout the writing process and that too much planning can instead affect written output, a finding that is diametrically opposed to other researchers. Another variable that has received attention from researchers is task structure, which has mostly focused on spoken language and has mostly focused on the internal structure or storyline structure of the task itself. Javad Ahmadian et al. (2015) found that learners produced more complex, accurate, and fluent speech in tasks with a storyline structure and planning, which is consistent with Tavakoli & Skehan's (2005) findings. Ong & Zhang (2010) included task structure in their study of argumentative writing and found a significant increase in lexical complexity in topic, ideas, and macro-structure given tasks, but no significant change in fluency. Other research on task structure in L2 writing is scarce and has largely not been conducted from the perspective of task complexity.

In summary, there is a paucity of research on the task complexity along resource-dispersing dimension, and most of them have focused on oral output or combined with resource-directing variables, failing to analyze the specific effects of this dimension independently on L2 written performance, and the existing studies have adopted an oversimplified perspective, with inconsistent and even contradictory findings. In view of this, this paper intends to investigate the effect of manipulating task complexity along resource-dispersing dimension (i.e. task structure, planning) on L2 written performance from the perspective of complexity theory. Task structure is chosen because it is a variable that has not been sufficiently studied in L2 writing. Moreover writing tasks in large-scale language proficiency tests (e.g. IELTS, CET4 and 6) usually give strict requirements for structure and topic, but there is insufficient empirical support whether such tests can effectively present the real language proficiency of the examinees. The present study aims to fill this gap.

3. Research Methods

3.1 Research Questions

This is an empirical study examining the effects of two resource-dispersing task complexity variables (i.e. task structure and planning) on learners' written production by answering the following questions.

- 1) Does task structure affect accuracy, complexity, and fluency of L2 written output? If so, how?
- 2) Does planning affect accuracy, complexity, and fluency of L2 written output? If so, how?
- 3) Are there interactive effects between task structure and planning?

3.2 Participants

Altogether 54 sophomore non-English majors were invited to participate in the study, 20 boys and 34 girls. All of them had studied English for a comparable number of years, and had received one semester of English writing tutorials prior to this experiment. None of them had any long-term experience of studying or living in an English-speaking country. The participants were randomly divided into two groups of 27 students each. An independent samples t-test of the students' overall scores in English writing classes showed that there was no significant difference in their writing competence.

3.3 Study Design

The independent variables in this study were task structure and planning, with task structure divided into two dimensions: with structural constraint and without structural constraint, and planning divided into: with planning and without planning. Two writing tasks were designed according to the research questions. The genre was argumentative essay and the topics were familiar to the students. Task 1 was taken from the IELTS exam, which specified the structure of the essay, requiring students to write in three parts, each of which specified the writing content. Task 2 was also taken from the IELTS exam, but with the structural constraint removed. Each group of students was required to complete two tasks with a one-week interval, both in class, in 40 minutes, with a word count of 250 words or more, with the first group being asked to take 10 minutes to prepare before writing, and the second group being required to write immediately without planning. Ellis & Yuan (2004), Ong & Zhang (2010), and other researchers have proved that only providing at least 10 minutes of planning has a measurable impact shown on language accuracy, complexity, and fluency.

3.4 Data Collection and Analysis

This study examined students' written output in terms of accuracy, complexity, and fluency. The measures adopted were as follows, which researchers such as Wolfe-Quintero et al. (1998), Wang (2013), and Johnson (2017) believe can objectively and truly reflect learners' ability to express themselves in written language.

(1) Accuracy:

- i. The number of errors in each T-unit (E/T). T-unit, in this research, is defined as a main clause plus any subordinate clauses attached to it, as well as any embedded clauses (Bardovi-Harlig, 1992).
- ii. The percentage of the total number of errors to the total number of words in the written text (E/W). The higher the number of errors is, the less accurate the language is.

(2) Syntactic complexity:

- i. Ratio of S-node per T-unit (S/T). This ratio is obtained by dividing the total number of S-nodes by the total number of T-units in a written text. S-node is indicated by a tensed or un-tensed verb within whatever base unit of analysis is being used.
- ii. The number of words per T-unit (W/T).

(3) Lexical complexity:

Mean segmental type-token ratio (MSTTR). The students' compositions are first divided into 88-word segments (± 5 words) and then Wordsmith is used to calculate the average of the type-token ratio for each segment in a composition.

(4) Fluency:

In this study, fluency is measured by the total number of words produced in a written text (Length).

Approximately 25% of the data are randomly selected and then reassessed by another researcher. The interrater consistency is 0.77 (Pearson's r). All raw data were statistically analyzed using SPSS (20.0) software.

4. Results and Discussion

4.1 The Effect of Task Structure on Language Output

With regard to the first research question, an ANOVA analysis was used and the results are presented in Tables 1 and 2.

Table 1. The effect of task structure in the condition of no planning

Dependent Variables	Measurements	With Structural Constraint		Without Structural Constraint		P
		Means	SD	Mean	SD	
Accuracy	E/T	.606	.327	.385	.311	.014
	E/W	.036	.020	.024	.018	.020
Syntactic Complexity	S/T	2.434	.396	2.209	.346	.031
	W/T	16.857	2.589	16.822	3.353	.966
Lexical Complexity	MSTTR	.703	.025	.706	.058	.793
Fluency	Length	267.3	47.4	298	38.9	.012

As can be noted in Table 1, the three measures E/T ($p=0.014$), E/W ($p=0.020$), and Length ($p=0.012$) all achieved significant level of difference, indicating that the task structure had a significant effect on the accuracy and fluency of students' written production in the condition of no planning. Specifically, the participants' linguistic output was more accurate and fluent in the task without structural constraint. The opposite was true for complexity, where syntactic complexity was higher in the task with structural constraint, but only one of these measures (S/T) reached significance ($p=0.031$), while no significant difference was found for lexical complexity. This suggests that the task structure does have a significant effect on accuracy, syntactic complexity, and fluency of participants' written output, but in contrast to the predictions of the Cognition Hypothesis, the data from this study suggests that increasing the task complexity along the resource-dispersing dimension (i.e. the task does not provide structural constraint and does not provide planning time) is associated with a significant increase in accuracy and fluency of students' written text, with only syntactic complexity was negatively affected. This is

partially in line with Ong & Zhang's (2010) findings. The results show a competitive relationship between syntactic complexity and accuracy and fluency, which is consistent with previous research suggesting a competitive relationship between linguistic complexity and accuracy (Jin et al., 2020) and tends to support Skehan's Competition Hypothesis.

Table 2. The effect of task structure in the condition of planning

Dependent Variables	Measurements	With Structural Constraint		Without Structural constraint		P
		Means	SD	Mean	SD	
Accuracy	E/T	.471	.283	.363	.192	.107
	E/W	.027	.014	.022	.012	.181
Syntactic Complexity	S/T	2.27	.367	2.47	.524	.112
	W/T	17.215	2.511	16.940	3.784	.754
Lexical Complexity	MSTTR	.703	.025	.726	.044	.019
Fluency	Length	297.6	57.2	325.9	68.1	.105

However, the variability between the two types of tasks in terms of accuracy, fluency, and syntactic complexity diminished and did not reach significant levels when students were given planning time. The possible reason for this is that the effects of structural constraint were weakened, as the subjects conceived or deliberated in planning which reduced their attentional load in writing. In terms of lexical complexity, subjects used more words in the tasks without structural constraint, and this difference reached a significant level ($p=0.019<0.05$), indicating that students used significantly more varied words in the tasks giving planning time and without structural constraint. From the above results, it is clear that unlike the inherent task structure, the extrinsic structural constraint of the task does not help writers as predicted by the Cognition Hypothesis, but may instead deprive writers of control over the task. Writers need to consume more attentional resources to focus on the structure requirement of the task, which in turn has a significant negative impact on writers' linguistic accuracy, fluency and lexical complexity in the condition of no planning. Skehan (1996:53) introduced the concept of task control in his study, arguing that control refers to the extent to which the participants within a task can exert an influence on the task and on how it is done. If the goals, structure, etc. of the task can be negotiated, then students are perceived to have a high degree of control over the task and, accordingly, the task will be less difficult. The data from this study tended to support Skehan's hypothesis.

Overall, task structure had a significant effect on learners' L2 written performance, with accuracy, complexity, and fluency of written output changing overall as the task structure variable changed, but this change was not fully consistent with the Cognition Hypothesis. In particular, the values of the syntactic complexity measures W/T remained largely stable, and there was some competition between syntactic complexity and accuracy and fluency. These suggest that L2 learners are sensitive to the cognitive demands of tasks and that as task complexity changes, so do the subsystems within their language system, in line with the adaptive feature of language in complexity theory.

4.2 The Effect of Planning on Written Output

ANOVA was also used to analyze the effect of planning on participants' language output, and the results are shown in Tables 3 and 4.

Table 3. The effect of planning in tasks without structural constraint

Dependent Variables	Measurements	With planning		Without Planning		P
		Means	SD	Mean	SD	
Accuracy	E/T	.363	.192	.385	.311	.758
	E/W	.022	.012	.024	.018	.721
Syntactic Complexity	S/T	2.469	.524	2.209	.346	.036
	W/T	16.940	3.784	16.822	3.353	.904
Lexical Complexity	MSTTR	.726	.044	.706	.058	.153
Fluency	Length	325.9	68.1	298.0	38.9	.070

Table 4. The effect of planning in tasks with structural constraint

Dependent Variables	Measurements	With planning		Without Planning		
		Means	SD	Mean	SD	P
Accuracy	E/T	.471	.283	.606	.327	.111
	E/W	.027	.014	.036	.020	.061
Syntactic Complexity	S/T	2.269	.367	2.434	.396	.120
	W/T	17.215	2.511	16.857	2.589	.608
Lexical Complexity	MSTTR	.703	.025	.680	.036	.008
Fluency	Length	297.6	57.2	267.3	47.4	.039

The data in Tables 3 and 4 reveal that the p-values of the measures in terms of accuracy are greater than 0.05 in the four tasks, indicating that planning does not have significant effects on accuracy of learners' written output, a result that is consistent with the findings of spoken-related studies, such as Ortega (1999), Mehrang & Rahimpour (2010), and Xu (2015), suggesting that there is some similarity between L2 written and spoken output in some aspects, most likely because participants were more concerned with content than linguistic forms when planning.

In the task without structural constraint, the p-value for the syntactic complexity measure S/T was 0.036, less than 0.05, indicating that planning resulted in more complex linguistic output, and the other complexity measure W/T was higher in the task with planning, although it did not reach significance. The mean of lexical complexity was similarly higher in the condition of planning, and the lexical complexity measure reached a significant value in the task with structural constraint ($p=0.008<0.05$), suggesting that planning increases syntactic complexity and lexical complexity and the significance can be reached with the interactive effect of other task features, which is consistent with the findings of Ong & Zhang (2010). These may be attributable to the fact that participants prepared for the content of the writing during planning, thus increasing the linguistic complexity.

Planning contributed to writing fluency and this effect reached significance in the task with structural constraint ($p=0.039<0.05$), which is consistent with the findings of He & Wang (2003), Ojima (2006), and Abrams & Byrd (2016) on L2 written performance, partially supporting Robinson's Cognition Hypothesis.

In conclusion, with the availability of planning, the attentional resources of L2 writers are redistributed, more towards complexity and fluency than accuracy, which is not entirely consistent with the Cognition Hypothesis, demonstrating that language has a set of self-regulatory mechanisms and that different allocations of resources occur to maintain internal balance and emerge as new linguistic features.

4.3 Interactive Effects of Task Structure and Planning

Table 5. Overall effects of task structure and planning on L2 written performance

Effect	Value (Wilks' Lambda)	F-value	P
Task structure	.824	3.530	.003
Planning	.877	2.312	.039
Task structure*Planning	.871	2.444	.030

Table 5 shows that task structure and planning both significantly affect students' overall linguistic output in L2 writing and that the interactive effects of task structure and planning also reach significant level. This suggests that these two variables do have a significant effect on students' overall L2 written performance.

5. Conclusions and Implications

This study analyzed the effect of manipulating task complexity along resource-dispersing dimension on L2 written performance, using task structure and planning as variables. The results found a significant interactive effect between task structure and planning. In the condition of no planning, subjects achieved higher accuracy and fluency but lower syntactic complexity in tasks without structural constraint. These findings only partially supported Robinson's Cognition Hypothesis. The results also demonstrated that syntactic complexity is competitive with accuracy and fluency, which was in line with Skehan's Competition Hypothesis. Planning had no significant effect on accuracy, and when completing a structural constraint task, planning promoted fluency and lexical complexity, but not syntactic complexity.

Combined with the results of previous related studies, it can be observed that the cognitive demands are very important factors in designing writing tasks. Writing is a complex process and task complexity is a multidimensional construct. Language accuracy, complexity, and fluency respond differently to the cognitive demands of the task, and an overly simplified perspective should not be adopted to assess task complexity. During the writing process, subsystems within the language system interact and change at different levels, and new linguistic features emerge in mutual adaptation and synergistic interaction. Language output demonstrated the characteristics of non-linear, multidimensional, and self-adaptive, in line with the complexity theory view of language. In addition, individual differences are an essential property of language systems, and different learners in the same language environment or task conditions may still show different states of language development. It is therefore recommended that L2 writing researchers and teachers should take into account task characteristics and individual differences when designing writing tasks, rather than using task complexity as the sole criterion.

In addition, structural constraint is a common feature of writing tasks in large-scale English proficiency tests (e.g. IELTS, CET 4-6), and the language output in this type of tasks is significantly inferior in terms of accuracy and fluency compared to tasks without structural constraint. This form of task structure does not help writers as predicted by Cognition Hypothesis. On the contrary, the restricted task structure somewhat reduces the writer's control over the task and affects the quality of writing output. Therefore, it is recommended that writers should be given appropriate autonomy over the structure of their compositions in task-based writing instruction and writing tests in order to improve the quality of linguistic performance in L2 writing.

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