The Effects of Cognitive Task Complexity on Learners' Performance

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Abstract: In the field of task-based language teaching, sequencing tasks is of substantial importance. One of the proposals for sequencing tasks is cognitive task complexity. Robinson, as one of the proponents of sequencing tasks based on cognitive task complexity, distinguishes between three factors of: task complexity (i.e. the intrinsic cognitive demands of the task), task conditions (i.e. features of tasks which are determined by the situational setting and conditions in which they take place), and task difficulty (i.e. learners' perceptions of the demands made by the task and the resources that learners bring to the task). After presentation of Robinson's cognitive task complexity model, there has been a great deal of research which has investigated the influences of the components of this model on the three dimensions of performance including accuracy, fluency, and complexity. The present paper is a brief review of the studies that have been conducted in this respect.

Keywords: Cognitive Task Complexity, Accuracy, Fluency, Lexical and Syntactic Complexity

1. Introduction

In the history of language teaching there has always been a search to find the most effective ways of teaching language. This marathon has been started with traditional approaches and continues to the post-methods era [1]. The traditional approaches of language teaching were mostly form-focused and were known as PPP approaches (present, practice, and produce). These form-focused approaches ended up with students who were not able to use their language knowledge to communicate. Following the change of the focus of language teaching approaches from learning grammatical features of language to learning the ability to use language for authentic communication [2], task-based language teaching (TBLT) came to prominence. TBLT uses tasks "as the core unit [s] of planning and instruction in language teaching" [1]. Advocates of TBLT argue that the most effective way to teach a language is by engaging learners in real language use in the classroom and by involving learners in tasks which require them to use the language for themselves.

2. Information Processing Approach to Task

After using tasks as the basic unit of the syllabus, the major concern is what the best criterion is for ordering and sequencing tasks. The information processing perspective approach proposes the use of task complexity as the criterion for sequencing tasks [3]. This perspective is also concerned with the effects of task features on the performance of learners. There are two well-known models of task complexity in this perspective: (1) Skehan's [4] limited attentional capacity model (LAC), (2) Robinson's [5] cognition hypothesis (CH) model.

2.1. Skehan's Limited Attentional Capacity Model

Skehan's LAC model is based on the information processing perspectives. In this model, Skehan advocates a single resource model of attention and claims that "learners cannot attend to everything equally" [6]. He argues that there will be a trade-off between dimensions of performance.

Consequently, three areas of performance (i.e. accuracy, fluency, and complexity) will compete with one another for attentional resources [7]. As Skehan puts it, in tasks which are cognitively demanding, attentional resources are drawn away from language forms and great deal of attentional resources is paid to meaning, as a result, learners will produce more fluent language; but the remained attentional capacity cannot be devoted to both accuracy and complexity; consequently, one of these aspects will be increased. In this respect, Skehan mentions that in applying the most cognitively complex tasks, greater fluency may be accompanied by greater accuracy or greater complexity, but not both.

Skehan states that the three dimensions of performance (i.e. accuracy, complexity, and fluency) are based on two different systems of rule-based and exemplar-based systems and learners construct both an exemplar-based system and a rule-based systems. The rule-based system which consists of abstract representations of the underlying patterns of the language requires more processing thus is best suited for more controlled, less fluent language performance. On the other hand, the exemplar-based system which includes ready-made formulaic chunks of language can be easily and quickly accessed, therefore is ideally suited for occasions calling for fluent language performance.

Skehan proposed a model for task classification [4]. In his model, Skehan introduced three factors of code complexity "language required" (p. 99), cognitive complexity "thinking required" (p. 99), and communicative stress "performance condition" (p. 99). The first factor, code complexity, has to do with the two areas of syntactic and lexical difficulty of tasks [7]. This factor involves "more advanced structures, which require the use of wider repertoires of structures, or greater densities of advanced structures, such as complex tenses or subordination or embedding" (p. 51). The second factor, cognitive complexity, is concerned with content features of input. He makes a distinction between two aspects of cognition named: cognitive familiarity and cognitive processing. Cognitive familiarity refers to the "access to ready-made or pre-packaged solutions" (p. 52), in other words, task completion requires retrieving and mobilizing of relevant aspects of schematic knowledge [4]. Cognitive processing, in contrast, refers to the "work out solutions to novel problems" (p. 99), in other words, task completion requires online computations and active thinking [7].

Skehan broke down cognitive familiarity into three components of: (1) topic familiarity and predictability (i.e. availability of organized background knowledge); (2) familiarity of discourse genre "availability of easifying macro-structure" (p. 100); and (3) familiarity of task (i.e. being familiar with the task because of having been encountered with it before). Cognitive processing also includes four parts of: (1) information organization (i.e. naturalness of organization of task relevant information); (2) amount of computation (i.e. the amount of needed simultaneous transformation or manipulation of information); (3) clarity and sufficiency of information (directness of available information and need to make inference); and (4) information type (i.e. nature of available information concrete/abstract, static/dynamic, contextualized/ decontextualized) [4].

Finally, the third factor, communicative stress, is concerned with the conditions under which the task needs to be done. Aspects that are involved in communicative stress are: (1) time limits and time pressure (i.e. how quickly the task has to be done, and urgency in the manner that it needs to be done); (2) speed of presentation (if the learners are supposed to do the task at the speed that they want or they have time limits); (3) number of the participants; (4) length of texts used; (5) type of response (modality: reading, writing, speaking, and listening); (6) opportunity to control interaction (the influence that participants can have on task on the way that it is done).

Skehan argued that having such a system has the advantage of allowing tasks to be: (a) analyzed, (b) compared, and (c) sequenced based on some principled basis. Moreover, it helps to establish effective balance between fluency, accuracy, and complexity [4].

2.2. Robinson's Cognition Hypothesis Model

Robinson, in his CH model holding a multi-resource view of attention, predicted that dimensions of cognitive task complexity belong to different attentional resources, as a result meaning and form are not in competition for attention. In CH model, it is claimed that pedagogical tasks should be designed and sequenced on the basis of increase in their cognitive complexity [5].

In another model for sequencing tasks, Robinson proposed the triadic componential framework (TCF). In this framework he distinguished three dimensions which interact to influence task performance and learning. Three components of TCF are: Task complexity, task conditions and task difficulty. These dimensions of complexity are design features of tasks which can be manipulated to increase or decrease the cognitive demands tasks make on the learner while they are performing the task [5, 8].

The first category in TCF is task complexity which refers to "the intrinsic cognitive demands of the task" [5]. Task complexity consists of two types of resource-directing variables which "make greater resource demand, but lead learners to use specific features of the language code" (p. 4) and resource-dispersing variables which "make greater resource demand without leading them to use specific features of language code" (p. 4). In the earlier version of the TCF, Robinson mentioned three resource-directing variables: (1) [+/- few elements] which refers to "few, easily distinguished, vs. many similar elements" (p. 5); (2) [+/- here-and-now] which refers to "whether the task requires reference to events happening now, in a mutually shared context" (here-and-now) (p. 5) vs. to events that occurred in the past, elsewhere (there-and-then); and 3) [+/- no reasoning demands] which is the extent to which "the speaker [has to] justify beliefs and support interpretations of why events follow each other by giving reasons" (p. 5). In a more recent study Robinson added [+/- perspective taking], and replaced [+/- no reasoning demands] by a distinction between three kinds of reasoning [8]. The added variables are: (3) [+/- spatial reasoning]

referring to "spatial location where easily identifiable and mutually known landmarks can be used vs. reference to location without this support" (p. 165); (4) [+/- causal reasoning] refers to "simple information transmission vs. reasoning about causal events and relationships between them" (p. 165); (5) [+/- intentional reasoning] which refers to "simple information transmission vs. reasoning about other peoples' intentions, beliefs, and desires and relationships between them" (p. 165); and (6) [+/- perspective taking] which refers to "whether the task requires the speaker/listener to take just one first-person perspective on an event or multiple second and third person perspectives" (p. 165). Robinson states that increasing task complexity along resource-directing dimensions call learners' attention to the linguistic features which are needed to meet task demands as a result of which learners will be led to higher complexity and greater accuracy in their output [5].

In contrast to resource-directing variables, resource-dispersing variables "increase task complexity, but do not direct them to any aspect of the linguistic system" [3] which help them to complete the task. Resource-dispersing variables include: 1) [+/- planning time] which is "giving time for planning how to do the task" [5] vs. not giving it; 2) [+/- single task] which refers to tasks that "require only one thing to be done" (p. 22) vs. those which "require two (dual) or many (multiple) things to be done simultaneously" (p. 22); and 3) [+/- prior knowledge] which refers to "providing background knowledge needed for task performance" (p. 22) vs. not giving it. Like resource-directing variables, Robinson added three new dimensions to the previous ones [8]. Those new dimensions are: 4) [+/- task structure] referring to the "tasks where there is a clear structure available to help in deciding which steps are needed to complete it" (p. 166) vs. those

without one; 5) [+/- few steps] referring to the "tasks where one or few steps are needed to complete it" (p. 166) vs. those requiring many steps; and 6) [+/- independency of steps] which refers to "the tasks where there is no necessary sequence or 'chain' in which steps are followed" (p. 166) vs. those which require participants to follow a strictly chained sequence in which one step must be performed before another. Increasing task complexity along resource-dispersing dimensions deplete learners' attention without directing it to any specific linguistic aspect of L2 production, as a result performance will suffer [5].

The second component of the TCF is task condition which is the features of tasks which are determined by the situational setting, and conditions in which they take place. This category includes two components of participation variables and participant variables. Participation variables include: (1) closed task vs. open tasks; (2) one way tasks vs. two-way tasks; 3) convergent tasks vs. divergent tasks. Participant variable consists of: (1) same/ different gender; (2) extent of familiarity; and (3) power and status.

The third component is task difficulty. This category is "between learners variables" (p. 24) and is concerned with learners' perceptions of the demands made by the task and the resources that learners bring to the task as well. Task difficulty consists of two variables: (1) affective variables (e.g. motivation, anxiety, and confidence) are temporary and may change or affect the size of available resources; and (2) ability variables (e.g. intelligence, working memory, and aptitude) are more permanent and stable over a course of instruction.

In sum, Skehan [4] and Robinson [5, 8] have different predictions about the effects of cognitive complexity of the task on learners' language production (Table 1).

Table 1. Different views on the effects of task complexity on L2 production.

Task complexity	Skehan [4]		Robinson [5]	
+ complex	Meaning	Form	Meaning	Form
		+ accuracy, - complexity		+ accuracy, + complexity
	+fluency	Or	-fluency	Or
		- accuracy, + complexity		- accuracy, - complexity

Note: '+complex' = applying the more complex task; '+' = higher gain in the complex task; '-' = lower gain in the complex task.

3. Research into Cognitive Task Complexity

Researchers have manipulated task features by increasing or reducing the cognitive demand of tasks in order to see their effects on the language production of learners. The following sections are the summary of some of those studies.

3.1. Studies on +/- Few Elements

Kuiken and Vedder investigated the effects of cognitive task complexity along (+/-few elements) on written performance of learners at different levels of language proficiency [9]. The participants were 84 Dutch learners of Italian and 75 Dutch learners of French who were divided into low and high

proficiency groups and they all performed both simple and complex tasks. Students' written performance was coded in terms of accuracy, syntactic complexity and lexical variation. The results of the study revealed that with regard to the effect of task complexity on the accuracy, students performed better in the complex than in the non-complex condition. But with respect to lexical variation and the use of frequent words, mixed results were found. The students of Italian used significantly high frequent words in the complex task, whereas French students used more infrequent words in the complex task.

3.2. Studies on +/- Here-and-Now Dimension

In a study Brown, Anderson, Shilcock, and Yule examined the effects of (+/-here-and-now) dimension on the oral performance of the participants along concrete vs. abstract

tasks [10]. The results of the study showed that in the (+here-and-now) condition (the task with pictorial support) the learners kept on talking about the pictures; but they bored soon when they were performing the abstract task (the aural stimulus was provided). These findings indicated that the pictorial input had less cognitive demands on the learners' attentional capacity which resulted in greater accuracy and fluency, while fluency was decreased during the complex task.

Robinson investigated the effects of here-and-now vs. there-and-then tasks on learners' oral performance [11]. The participants were 12 EFL learners who were at the intermediate level. The results displayed that the most complex task (there-and-then) generated more accuracy and lexical complexity, but less fluency. Regarding structural complexity, no significant effect was found.

In a study carried out by Skehan and Foster, the effects of contextual support was examined along the four conditions of: (1) watch and tell simultaneously, (2) storyline given, then watch and tell simultaneously, (3) watch first then watch and tell simultaneously, and (4) watch first then tell [12]. The results unveiled that tasks with clear inherent sequential structure brought about greater fluency and accuracy, especially in planning conditions. Complexity was increased in the most complex condition (watch first, then tell).

Iwashita, McNamara, and Elder designed a study under testing conditions and explored the effects of planning time and (+/-here-and-now) on learners' oral performance [13]. The participants were 193 learners who were asked to tell a story based on prompts. The results presented that in the (-here-and-now) accuracy was increased, while complexity and fluency were not influenced.

Ishikawa investigated the effects of (+/-here-and-now) on leaners' written performance [14]. The results of the study showed that in there-and-then condition greater accuracy, structural and lexical complexity were gained, while fluency was increased in here-and-now condition.

Rahimpour probed the effects of (+/-here-and-now) under three conditions of: (1) here-and-now; (2) there-and-then; and (3) both of them, on Iranian learners' oral performance [15]. The results demonstrated greater accuracy but less fluency and less complexity in thw there-and-then condition.

Rahimpour and Hoseini investigated the impacts of task complexity (+/-here-and-now) on L2 learners' written narratives [16]. Participants of the study were 52 Iranian English learners. The findings of the study revealed that there was a statistically significant effect of task complexity only on the fluency of L2 learners' written narratives. On the other hand, accuracy and complexity of L2 learners' written performance were not affected significantly by increased task complexity.

Abdollahzadeh and Fard-Kashani probed the effects of (+/-here-and-now) and language proficiency on learners' written narrative discourse [17]. Students' performance was analyzed by three measures of complexity, accuracy and fluency (CAF). The findings indicated that more complexity and accuracy were found in the complex task with high-proficiency learners. However, fluency was not affected by task complexity and language proficiency.

3.3. Studies on +/- Reasoning Dimension

Robinson explored the effects of intentional reasoning on learners' oral production [8]. The participants of the study were 42 Japanese L1 university students who performed three narrative tasks in pairs. Students were given picture strips which were random in order. They were supposed to find the correct order of the pictures by inferring the intentions of the characters in the pictures. The results of the study indicated that in the complex task, complexity of the learners' production was increased, while fluency and accuracy remained unaffected.

3.4. Studies on +/- Planning Time Dimension

Ellis probed the effects of three planning conditions on learners' performance [18]. The planning conditions were: (1) both online planning and strategic planning; (2) just strategic planning, and (3) neither strategic nor online planning. He reported that when learners were given planning time, they produced more accurate language. He claimed that his findings were in line with Skehan's LAC model because when they had time and they were not under time pressure, they employed their rule-based system and produced more accurate language.

Crookes examined the effects of planning on learners' oral production [19]. The participants were 40 Japanese learners of English as a second language. They performed two monologic production tasks with and without time for planning. It was found that providing learners with time to plan their utterances results in more complex interlanguage production.

Foster and Skehan investigated the influences of planning on learners' language performance [20]. The subjects were 32 pre-intermediate EFL students who performed three different tasks (personal information exchange, narrative, and decision-making) in three different planning conditions (unplanned, detailed planning which subjects received guidance on how they might use the 10 minutes, and undetailed planning received no guidance). The results of the study reported strong effects of planning on fluency and complexity. Regarding accuracy, the most accurate performance was produced by the undetailed planners. In addition, interactions between task types and planning conditions indicated that the effects of planning were greater with the narrative and decision-making tasks than with the personal information exchange task.

During a study Skehan and Foster explored the effects of planning on fluency, accuracy, and complexity of learners' oral production [21]. Forty EFL students performed three tasks (personal task, a narrative task, and a decision making task). There were two planning conditions (10-minute planning time vs. no planning time) in the study. The results showed that under planning condition, accuracy was increased in personal and narrative tasks, complexity was increased in personal and decision-making tasks, and finally, fluency was also increased in narrative and decision-making tasks.

Mehnert explored the effects of different amounts of planning time on the speech performance of L2 speakers [22]. Subjects of the study were 31 Germans who were divided into four groups and each participant performed two tasks. The two tasks varied in the degree of structure they contained and the familiarity of information they tapped. Moreover, there were four planning groups: (1) no planning time; (2) one-minute planning time; (3) five-minute planning time; and (4) 10-minute planning time. The results demonstrated that fluency and lexical density of speech increased as a function of planning time. Accuracy of speech was improved with only one-minute planning. Complexity of speech was significantly higher for the 10-minute planning condition only. No significant differences were found for the effects of planning on the different tasks.

In a study carried out by Foster and Skehan, the effects of source of planning and focus of planning on task-based performance was probed [6]. Sixty-six intermediate students were asked to perform three tasks of: personal information exchange task, narrative task, and decision-making task. There were three sources of teacher-led, solitary, and group-based planning and two focuses on planning which were toward language and toward content. The results of the study indicated that the teacher-led condition generated significant accuracy effects, while the solitary planning condition had greater influence on the complexity and fluency. Group-based planning did not lead to significantly different performance from the control group. Finally, there was little effect on performance as a result of the language vs. content planning condition.

Ortega probed the effects of planning with the two conditions of no planning and 10-minute planning time on learners' oral production [23]. The planning condition resulted in more fluent and more complex production, while accuracy was not affected.

Wigglesworth investigated the effects of two factors of resource-dispersing dimension on the learners' production [24]. The conditions were: (1) structured vs. unstructured tasks; (2) familiar vs. unfamiliar tasks; also, the tasks were conducted under two conditions: (1) native vs. nonnative interlocutor; (2) no planning vs. five-minute planning time. The results of the study revealed that the planned groups outperformed the other groups, regardless of the task structure and degree of familiarity.

Yuan and Ellis examined the effects of planning and proficiency level on learners' performance [25]. Planning had three levels: (1) no planning time; (2) 10-minute planning time; (3) online planning time. The online planning time group outperformed the other groups in terms of accuracy and structural complexity. The 10-minute planning group produced greater structural and lexical complexity; while, accuracy was not affected.

Gilabert probed the effects of planning time and (+/- here-and-now) on learners' oral performance [26]. The participants were 48 English learners at the lower-intermediate level, and each participant performed four tasks. There were four conditions in the study: (1) (+here-and-now) and (+planning time); (2) (+here-and-now) and (-planning time); (3) (-here-and-now) along (+planning time); and (4) (-here-and-now) and (-planning time). The results indicated that the planning condition resulted in greater accuracy, fluency, and lexical complexity, but there were no significant differences in the structural complexity. Regarding (+/- here-and-now), higher accuracy, less lexical complexity, and less fluency and no significant differences in structural complexity were founded.

Ellis and Yuan investigated the effects of planning on learners' written performance in terms of accuracy, fluency, and complexity [27]. There were three types of planning conditions: pre task planning, unpressured online planning, and no planning. The participants were 42 undergraduate English majors who were asked to narrative a story. The results demonstrated that the pre-task planning condition produced greater fluency and greater syntactic variety, whereas unpressured online planning resulted in greater accuracy. Writers in both of the planning groups outperformed the no-planning group in all three aspects of their performance.

Tavakoli and Skehan explored the effects of planning time (no planning and five-minute planning), task structure and proficiency level on learners' performance [28]. The participants were asked to perform four tasks, two structured tasks and two unstructured tasks. The planning condition generated more fluent, accurate, and complex language. Regarding proficiency level, greater accuracy and complexity were generated.

Shin probed the effects of planning on writing performance of 157 Korean learners of English [29]. Learners were asked to perform two tasks of expository writing and argumentative writing tasks in two different planning conditions of: individual planning condition (learners were given 10 minutes for individual planning) and collaborative planning condition (learners were allowed to interact with a peer during planning but completed task individually). The results of the study indicated that the expository writing task and collaborative planning condition, led to high scores in all of the measures. On the other hand, in the argumentative writing task, no significant differences were found between the two planning conditions.

Ong and Zhang investigated the effects of task complexity on fluency and lexical complexity of learners' written performance [30]. The participants were 108 Chinese EFL tertiary students who were asked to write an argumentative writing about ''International Sports Competition''. Task complexity was manipulated along the three factors of: (1) availability of planning time (with four levels of extended pre-task, pre-task, free-writing, and control); (2) provision of ideas and macro-structure (with three levels of topics, ideas, and macro-structure given; topic and ideas given; and topic given); and (3) draft availability (with two levels of draft available vs. draft unavailable). The results unveiled that increasing task complexity along planning time produced significantly greater fluency and lexical complexity. Increasing task complexity along the provision of ideas and

macro-structure produced significantly greater lexical complexity but no effects on fluency. Furthermore, increasing task complexity along draft availability produced no significant differences on fluency and lexical complexity.

Examining the effects of planning (no-planning, strategic planning, and unpressured within-task planning) on learners' written production in terms of accuracy, Bagheridoust and Allahyari-Fakoor asked 24 EFL university students to write an argument/compare and contrast writing tasks. The findings of the study demonstrated that the participants in the strategic planning group achieved statistically greater levels in accuracy measures than the other two groups.

Ghavamnia, Tavakoli, and Esteki probed the effects of planning on learners' written production [32]. The participants of the study were 40 intermediate Iranian EFL learners who were randomly assigned to either the pre-planning or the online planning conditions and were required to write a story based on a series of pictures. The findings of the study showed that the performance of the pre-task planning group was more complex and fluent, whereas the online planning group produced more error free clauses indicating a more accurate writing performance.

3.5. Studies on +/- Single Task

Robinson and Lim examined the effects of increasing task complexity along single vs. dual tasks on learners' oral production [33]. The participants of the study were 44 Japanese university undergraduates who performed one single and one dual task. In the single task they were supposed to describe a marked route from point A to point B and in the dual task they were asked to first think and find the route and then describe it to the listener (route was unmarked). Students' performances were assessed for accuracy, fluency, and complexity. The results of the study revealed that in the dual task, fluency was decreased, while complexity was increased, and accuracy was not affected by the cognitive complexity of the task.

3.6. Studies of Task Structure

Bygate investigated the effects of task structure on learners' oral performance [34]. Sixty-seven low intermediate level secondary school learners of English were asked to perform two tasks of an argument and a narrative task. In his study, his focus was on grammatical complexity of learner language. The results showed that from the four measures that he used, students performing narrative task outperformed students who were performing argument task in three of those measures. While in one of the measures there was no significant difference between the two groups.

Tavakoli and Foster explored the influences of narrative structure and storyline complexity on learners' performance [35]. The participants were 100 learners of English, 60 based in Tehran and 40 based in London and they all were at the intermediate level. Each participant performed two of four narrative tasks that had different degrees of narrative structure (loose or tight) and storyline complexity (with or without

background events). Narrative tasks with a background element resulted in more complex language. Narrative tasks with a tight narrative structure lead to more accurate language. The tightly structured storyline resulted in greater fluency than the loosely structured storyline. Task design did not influence lexical diversity significantly. In another study, Foster and Tavakoli replicated their study and they confirmed the results of their previous study [36].

Kormos probed the influences of task complexity on linguistic and discourse characteristics of written narratives of learners [37]. The participants were 44 upper-intermediate foreign language learners. They completed two tasks: in one task they were asked to describe a picture strip which had a coherent storyline, while in the other one they were asked to narrate a story which did not have a coherent storyline. The results of the study revealed that task complexity increased the lexical complexity, but did not affect accuracy and cohesive characteristics of learners' written performance.

3.7. Studies on +/- Prior Knowledge

Finardi explored the effects of task repetition on the oral production of learners [38]. The participants were 24 learners who performed a picture description task. The results demonstrated that task repetition increased the complexity of learners' performance while their accuracy was decreased.

4. Conclusion

This study provided a review of the researches which have investigated the effects of task complexity on the three different dimensions of learners' performance (i.e. accuracy, fluency, syntactic and lexical complexity). Most of the studies reported that fluency was decreased as a result of complex tasks [10, 11, 12, 14, 15, 22, 23, 25, 26, 27]. Regarding the effects of increasing cognitive complexity of tasks on syntactic and lexical complexity, the studies demonstrated mixed results, some of them indicated that more complex tasks generated less complex production [15, 19, 22, 23, 27]; while some other studies reported more complexity for more complex tasks [11, 14, 25]. With respect to the influences of task complexity on accuracy, like complexity measures, the results were inconsistent. While some studies reported greater accuracy in more complex tasks [11, 14, 15, 25], some other studies reported lower accuracy [10, 18, 21, 22].

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