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The Roles Of Task Complexity, Working Memory, and Task Modality in L2 Development: A Review of Empirical Studies

Zihan Geng
Texas A&M University, gengzihan@tamu.edu
Li-Jen Kuo
Texas A&M University, lijenkuo@tamu.edu

Abstract

With the promotion of interactive tasks in educational contexts, researchers in second language acquisition have evaluated the effectiveness of task-based language teaching (TBLT). More recently, cognitive demanding variables in tasks have drawn a lot of attention, and the contradictory predictions on learners' L2 production of Robinson's Cognition Hypothesis and Skehan's Trade-off Hypothesis even further promote more research on this topic. As working memory (WM) also plays a critical role in cognitive demands, researchers begin to investigate the interactive influence of task complexity and WM in recent years. An additional variable being neglected by most researchers is task modality. Findings of recent research have provided evidence for the influential role of the mode in learners' L2 production. The purpose of this article, therefore, is to review the theoretical framework and previous studies involving these variables, and to provide insights for future research.

Keywords: SLA; task complexity; working memory (WM); modality; L2 development

Introduction

Over the past a few decades, tasks have been viewed as a primary component of second language instruction. A burgeoning area of research on task-based language teaching (TBLT), therefore, has been conducted by either comparing TBLT with other language teaching approaches or by investigating TBLT itself in terms of task feature, interaction in tasks, and learner factors. The findings of previous research tend to advocate the effectiveness of TBLT in second language acquisition (SLA) (e.g., Ellis, 2003; Skehan, 1996; Van den Branden, Bygate, & Norris, 2009; Willis & Willis, 2008). More recently, the focus of research on TBLT has been switched to the impact of task feature and the influence of learner factors on language learning. Specifically, task feature and learner factors in terms of task complexity and working memory (WM) respectively have been drawing more and more researchers' and educators' attention in recent years. As both task complexity and WM fall into the cognitive dimension, and WM has been viewed as one of the primary cognitive factors affecting second language (L2) learning (e.g., Baralt, 2010; Goo, 2012; Kormos, 2011; Kormos & Trebits, 2011; Mackey, Philp, Egi, Fujii, & Tatsumi, 2002; Revesz, 2012), it is necessary to take WM into consideration while exploring the effect of task complexity. However, to date, very few studies have examined the interactive effects of task complexity and WM on learners' L2 production.

Another element that may also affect learners' L2 production would be the modality of task performance. A few researchers have noticed the potential impact of this factor and begun to explore whether there is significant difference in learners' L2 production across modalities (i.e. oral or written) (e.g., Kormos & Trebits, 2012; Yuan & Ellis, 2003).

Drawing on the lack of research on the interactive effects of task complexity and WM on Learners' L2 production and the fact that the influence of WM might be mitigated depending on the mode of task performance (Payne & Whitney, 2002), the present study aims to investigate the role of task complexity and working WM in both oral and written task performance.

In the subsequent literature review, we first provided a brief introduction on TBLT with its goals and distinct features. After that, the more specific concept, task complexity, was discussed based upon two relevant but contradict hypotheses, along with the findings of previous studies on task complexity. In the next section, we explored the nature of WM and how it

influences second language acquisition. Finally, we compared and emphasized the differences between speaking and writing in language learning along with empirical findings.

Literature review

Task-based language teaching (TBLT)

"TBLT was developed as an alternative to traditional methods such as grammar translation, the Audiolingual Method or present – practice - produce" (Ellis & Shintani, 2014, p. 134). Traditional language teaching methods, like present – practice – produce (PPP), focus primarily on developing learners' linguistic competence. Whereas, being viewed as a strong version of communicative language teaching (CLT), which aims to develop learners' communicative competence, TBLT is utilized to develop both learners' linguistic competence (i.e. acquire a new language) and interactional competence (i.e. use the target language) through the performance of tasks (Ellis & Shintani, 2014).

Ellis (2003) summarizes various definitions of tasks and defines tasks as "activities that call for primarily meaning-focused language use" (p. 3). Ellis also proposed criterial features of a task, which helps to distinguish tasks from exercises (i.e. activities primarily require form-focused language use): (1) a task is a workplan; (2) a task should have a primary focus on meaning; (3) a task should involve real-world process of language use; (4) A task should involve any of the four language skills; (5) A task should engage cognitive processes; (6) a task should have a clear defined communicative outcome. These criteria ensure that while performing a task, learners treat language as a "tool" rather than an "object".

Regarding the authenticity of a task, Willis and Willis (2008) suggested three different levels. The higher the level is, the "more" authentic a task would be.

Level 1: it provides opportunities for learners to produce meanings that will be useful in the real life.

Level 2: it engages learners produce discourse that commonly used in daily conversations.

Level 3: it involves activities occurring in the real world.

In this model, task complexity is increasing along with the authenticity - starting with the lowest level which only requires simple authentic meanings to the highest level that requires the same complexity level as activities in the real world.

Task complexity and L2 production

As discussed above, Willis and Willis' (2008) authenticity model is corresponding to Robinson's (2001, 2007b) Cognition Hypothesis, in which it is stated that "tasks should be designed and sequenced for learners on the basis of increases in their cognitive complexity" (Robinson, 2007b, p. 193). In relevant to the impact of task complexity, Robinson predicted that as the task complexity increases along resource-directing variables, which is discussed later in this section, more complex and accurate utterances would be found in learners' L2 production. This prediction is based upon the hypothesis that learners are able to access to multiple and non-competitional attentional resources. The higher level of cognitive demanding would lead to more attention to the linguistic form which results in greater linguistic complexity and higher accuracy. However, another cognitive demands model - Skehan's (1998, 2009) Trade-off Hypothesis – provides a different view on the effect of task complexity. It was asserted that learners' attentional resources are limited and the attention would be first drawn to the meaning rather than linguistic forms. Therefore, the more complex a task is, the more attention would be drawn to the meaning leaving less attention to form, which leads to low complexity and accuracy in L2 production. Even if one of the aspects increases, for example, complexity, the other would decrease.

The two hypotheses have greatly promoted research exploring the role of task complexity on learners' L2 production. According to Robinson's (2007a) Triadic Componential Framework, shown in Figure 1, the cognitive demands of tasks can be manipulated through resource-directing variables and resource-dispersing variables. Resource-directing variables influence learners' meaning-form mapping by providing opportunities for metalinguistic awareness to occur, which entails directing attention to language itself and therefore, results in more accurate and complex utterances in L2 production (Kuo & Anderson, 2008; Robinson, 2007a). On the contrary, resource-dispersing variables do not impact learners' meaning-form mapping, rather, they influence learners' performative demands by operationalizing learners' accessibility to their existing interlanguage system. Therefore, the more complex the task is, the less access to the interlanguage system resulting in low accuracy and less complexity in L2 production.

Previous empirical studies on task complexity have generally fallen into three dimensions: resource-directing (e.g., Kormos, 2011; Revesz 2011; Robinson, 2007b), resource-dispersing (e.g., Hsu, 2015), and the mix of the two (e.g., Gilabert, 2007).

Task Complexity (Cognitive factors)	*Task Condition* (Interactive Factors)	*Task Difficulty* (Learner factors)
(Classification criteria: cognitive demands) (Classification procedure: information-theoretic analyses)	(Classification criteria: interactional demands) (Classification procedure: behavior-descriptive analyses)	(Classification criteria: ability requirements) (Classification procedure: ability assessment analyses)
(a) Resource-directing variables making cognitive/conceptual demands	*(a) Participation variables* making interactional demands	*(a) Ability variables* and task-relevant resource differentials
+/− here and now +/− few elements −/+ spatial reasoning −/+ causal reasoning −/+ intentional reasoning −/+ perspective-taking	+/− open solution +/− one-way flow +/− convergent solution +/− few participants +/− few contributions needed +/− negotiation not needed	h/l working memory h/l reasoning h/l task-switching h/l aptitude h/l field independence h/l mind/intention-reading
(b) Resource-dispersing variables making performative/procedural demands	*(b) Participant variables* making interactant demands	*(b) Affective variables* and task-relevant state-trait differentials
+/− planning time +/− single task +/− task structure	+/− same proficiency +/− same gender +/− familiar	h/l opennes to experience h/l control of emotion h/l task motivation

+/− few steps	+/− shared content	h/l processing anxiety
+/− independency of steps	knowledge	h/l willingness to
+/− prior knowledge	+/− equal status and role	communicate
	+/− shared cultural	h/l self-efficacy
	knowledge	

Figure 1. The Triadic Componential Framework for task classification (Robinson, 2007a)

The majority of previous research on task complexity has been conducted along resource-directing variables. For example, Robinson (2007b) examined the effect of task complexity on L2 interaction, uptake (i.e. student's immediate response to the interlocutor's corrective feedback), and perception of task difficulty with 42 EFL learners. In the study, Robinson manipulated task complexity along [+/- reasoning] through a picture-narration task. The results showed that tasks requiring more complex reasoning significantly promoted interaction and uptake. Revesz (2011) also manipulated [+/- reasoning] together with [+/- few elements] to explore its impact on interaction and L2 production. The results suggested that as the task complexity increased, significantly more language learning opportunities (i.e. linguistic interaction), higher accuracy and lexical diversity was found in learners' L2 production. However, the participants also demonstrated lower syntactic complexity in the more complex tasks, which is partly in accordance with the Trade-off Hypothesis.

In another study evaluating the role of task complexity, Kormos (2011) manipulated [+/- causal reasoning] in a story-telling task, in which the participants were required to complete two written narrative tasks one after the other. The [+/- causal reasoning] was achieved through a cartoon description task, which only required simple information transmission, and a picture-story task, in which the participants had to tell a story out of six unrelated pictures. The results provided strong support to the Cognition Hypothesis that higher level of task complexity triggered more L2 lexical, syntactic and morphological development.

With regard to manipulating task complexity along resource-dispersing variables, Hsu (2015) conducted a study with 42 undergraduate EFL learners, whose English proficiency level was intermediate. The difference between the complex version of the task and the simple one is

whether there was planning time provided during the task. The study employed story-telling tasks, in which the complex group had nearly no time (0.5 minutes) to prepare their L2 production while the simple group owned 10 minutes for the preparation. The results of the study demonstrated higher accuracy and grammatical complexity in the L2 production of the complex group. Whereas, the simple group achieved more fluent and lexically varied language.

Research has also been conducted looking into the impact of two variables covering both resource-directing and resource-dispersing. Gilabert (2007) investigated learners' L2 production along [+/- planning time] and [+/- here-and-now]. Forty-eight EFL college students participated in the study. Four groups with various cognitive demanding levels were administrated: planned here-and-now, unplanned here-and-now, planned there-and-then, unplanned there-and-then. The results suggested that planning time was not a significant factor on learners' structural complexity and accuracy while it did have great influence on lexical complexity and fluency. In terms of the impact of [+/- here-and-now], Gilabert found that in more complex tasks, learners demonstrated lower fluency and lexical complexity but higher accuracy. There was no significant impact on structural complexity.

In sum, though the general findings tend to be more compatible with the Cognition Hypothesis, the role of task complexity remains enigmatic. Just as highlighted in Revesz (2011), the predictions of the Trade-off Hypothesis are also attested when some specific aspects of task performance are controlled. The mixed findings suggest the need for further exploration on the effects of task complexity and also other potential factors (e.g., individual difference that may moderate the influence of task complexity).

Working memory, task complexity and L2 development

Individual difference factors have been hypothesized to be influential on the impact of task complexity (Robinson, 2011; Ozfidan, Machtmes, & Demir, 2014). Among these factors, working memory (WM) has been viewed as a crucial cognitive factor in cognitive psychology (Goo, 2012). In the model of information processing, WM is emphasized on its capacity limitations (Mayer, 1996). In the area of second language acquisition (SLA), WM is also regarded as one of the main cognitive elements impacting L2 development (e.g., Baralt, 2010; Goo, 2012; Kormos, 2011; Kormos & Trebits, 2011; Mackey, Philp, Egi, Fujii, & Tatsumi, 2002; Revesz, 2012).

Before moving on to the research relevant to the role of WM in L2 development, the definition of WM and its components are distributed in the following discussion. WM is defined as "… a limited capacity system, which temporarily maintains and stores information, supports human thought processes by providing an interface between perception, long-term memory and action" (Baddeley, 2003, p. 829). Baddeley and Hitch (1974) proposed the multicomponent model of working memory involving a central executive system (i.e. a general information processing controller), and two subsidiary systems: a phonological loop (i.e. temporarily storing phonological information) and a visual-spatial sketchpad (i.e. storing and processing visual and spatial information). Later, in Baddeley (2000), an episodic buffer holding and integrating information, was added into the model. With respect to the area of SLA, WM has been evaluated in terms of the phonological loop, often measured by immediate serial recall of numbers or words, and its general simultaneous storage and processing function measured by span tasks (Baddeley, 2003; Baralt, 2010).

Empirical evidence has provided insights on the significance of WM on a variety form of learning, such as language comprehension. Higher WM learners were found to be better at vocabulary development, writing, reading, and listening. (Linck, Osthus, Koeth, & Bunting, 2014)

In order to elucidate the relationship between WM and SLA, a growing body of research studies witness the implication of WM in L2 processing. A recent meta-analysis of 79 studies on WM and SLA has shown the robust effects of WM - "WM is positively associated with both L2 processing and proficiency outcomes, with an estimated population effect size (ρ) of .255" (Linck et al., 2014, p. 861). The covariate analyses demonstrated even larger effect size for the executive control and the verbal measure of WM.

In the specific area of SLA, researchers have also been devoted to evaluate the potential impact of WM in L2 interaction (e.g., Goo, 2012; Mackey, Philp, Fujii, Egi, & Tatsumi, 2002; Revesz, 2012), L2 production (e.g., Gilabert & Munoz, 2010; Kormos, 2011; Kormos & Trebits, 2011; Niwa, 2000), and L2 development (e.g., Baralt, 2010; Kim, Payant, & Pearson, 2015).

Mackey et al. (2002) evaluated the role of WM in noticing (i.e. noticing the target linguistic feature), interaction and English question development with a pre-test, post-test, delayed post-test design. Learners' WM was measured via nonword recall, and first language

(L1) and L2 listening span tasks. The findings revealed that high-span learners achieved more noticing and more English question development compared with low-span learners.

In another study, Goo (2012) examined the interactive effects of WM and recasts (i.e. correcting learners' erroneous utterance by providing the correct form, without metalinguistic explanation), and metalinguistic feedback (i.e. explaining the linguistic rules) on the learning of the English *that*-trace filter. The results indicated that WM significantly predicted the effectiveness of recasts but not metalinguistic feedback on the acquisition of *that*-trace filter.

Revesz (2012) also investigated the relation between WM and corrective feedback (i.e. recasts) on L2 development. Ninety beginner-level EFL learners participated in this study. Phonological short-term memory was assessed with a digit span task and a nonword span task. The complex WM was measured with a reading span task. An additional variable in this study is the mode of task performance. Revesz employed both oral and written tests to measure the participants' L2 development. The findings showed that learners with higher reading span (the complex WM) achieved more development on the written tests, while the ones who had higher digit and nonword span (the phonological loop) performed better on the oral test. Revesz attributed the results to the mode of the tests that the oral assessments tended to measure procedural knowledge while written assessments were more conductive to the use of declarative knowledge.

In regards L2 production, Gilabert and Munoz (2010) inquires into the relationship between WM and English language attainment and performance. Moderate correlations were found between WM and lexical complexity only in the high-proficiency group. Gilabert and Munoz interpreted the result by relating it to Mizera (2006) that WM seemed to be most influential at later stages of acquisition as beginning learners "may need to use more cognitive resources to store intermediate products between conceptualization and formulation than advanced learners" (Gilabert & Munoz, 2010, p.37). However, this interpretation could not be applied to the findings of Kormos and Safar (2008), in which a weak to moderate correlation between WM and speaking ability was found in beginning learners.

Research has also addressed the impact of WM in a technological language learning environment. Both Payne and Whitney (2002), and Payne and Ross (2005) investigated the impact of WM on the students' output in a CMC context. Both studies tested the hypothesis that

synchronous computer-mediated communication (SCMC) can form the same cognitive mechanism as it is in a face-to-face (FTF) spontaneous conversation, and therefore, SCMC could indirectly improve learners' L2 oral proficiency. The researchers distinguished executive function and phonological capacity of WM. Both findings reveal the correlation between WM and learners' L2 oral output, and also suggest the beneficial role of SCMC in reducing memory load for, especially, low-proficiency learners. The difference is that Payne and Whitney (2002) only found association between phonological capacity and language gains, whereas Payne and Ross (2005) showed the major impact of executive function.

Despite of the substantial research studies on WM, very few have related WM to task complexity, which also manipulates cognitive demands in task performance and language development. Kormos and Trebits (2011) examined the role of WM on learners' L2 performance in various task complexity levels. Similar to the design of Kormos (2011), the researchers also employed the cartoon description task (simple version) and the picture-story task (complex version). Learners' WM was evaluated through the backward digit span test. Kormos and Trebits found that only in the low complex task, a significant impact of WM on syntactic complexity was found. The researcher interpreted the finding that although the picture narration task seemed to be more complex, there might also be higher attentional demands on students in the cartoon description task as they had to follow the given story line with their limited linguistic resources. The results also demonstrated that low backward digit span students produced shorter clauses in the cartoon description task (simple), which implied that higher WM might help students produce more complex sentences in specific tasks.

Negative influence of higher WM on learners' oral fluency was found in Niwa (2000) in more complex narrative tasks, which suggests that higher WM individuals tend to primarily distribute their attention to the reasoning and linguistic aspects of the task.

In a more recent study, Kim et al. (2015) explores the interactive effect of task complexity and WM on English language learners' noticing in recasts and the subsequent development on English question structures. Eighty-one participants completed three interactive tasks and three oral production tasks in the study. The results demonstrated that learners' WM capacity was "the only significant predictor of the amount of noticing of recasts and question development" (p. 571). Further, higher WM learners involved in the more complex tasks seemed

to benefit the most in the study. Kim et al. interpreted the results by drawing on the Cognition Hypothesis that learners in the complex group were pushed to process information and make decision simultaneously, which requires higher WM capacity. The high cognitive demanding fostered noticing and the subsequent linguistic development. The study adds insights into the role of WM in task complexity dimensions and suggests that lower WM learners may not benefit as much in higher cognitive demanding tasks and therefore individual differences, such as WM, should be considered in classroom task design.

In relation to technology mediated language acquisition, Baralt (2010) explored the role of task complexity and WM in L2 development in both the face-to-face (FTF) and online computer-mediated communication (CMC) modes. The findings suggested that WM did not play a significant role between task complexity and the production knowledge development whereas it did associate with the development of the receptive knowledge in the simple group and only in the FTF mode.

The mixed findings, either in a FTF mode or in an online condition, warrant more research into the interaction between WM and task complexity. Some other potential factors, such as age and language proficiency, should also be taken into consideration in future research.

Spoken and written task performance

Research in TBLT has generally focused on speaking tasks. However, Modality has also been proposed to be a manipulation of source-directing demands in task complexity as the nature of writing fosters opportunities for learners to process and focus on the linguistic aspects of the language compared to speaking (Kormos, 2014). Even though writing does not necessarily indicate unlimited time, writers somewhat have less pressure than speakers who need to divide their attention between conceptualizing the information and linguistically encoding it simultaneously (Yuan & Ellis, 2003). On the contrary, writing enables learners to plan and encode their messages separately, which seems to be less relevant to WM.

The various cognitive loads involved in oral and written processes could also be explained in the language production models (Ozfidan & Burlbaw, 2017). According to Levelt (1992), oral language production consists of three stages: conceptualization, formulation, and articulation. Among the three stages, conceptualization, which is maintained in WM and determines the semantic content of the utterance, is believed to consume substantial attentional

resources. The process of writing is completed through planning, translating, and reviewing (Kellogg, 2001). All three processes are interactive and are built upon resources of WM. Therefore, although both speaking and writing involve three processes, the ways of functioning in terms of cognitive demanding are quite different.

With regard to task performance, oral performance includes oral narration and FTF oral interaction. Written performance involves written narration and CMC interaction. Previous studies indirectly evident that online chatting taking the form of writing, may be more beneficial for learners with low WM compared with a FTF oral mode (Payne & Whitney, 2002).

To date, only a handful of studies with inconsistent findings have addressed how the mode of performance impacts learners' L2 production. Granfeldt (2008) conducted a study with French learners and found greater lexical diversity and higher accuracy in speaking than in writing in more complex tasks. No effect had been revealed on syntactic complexity. Kuiken and Vedder (2011) explored the influence of task complexity and the mode of task performance on learners' L2 production. The findings confirmed the role of the mode of performance that in more complex tasks, learners produced more syntactically complex language in writing, but there was no significant difference on lexical diversity. In contrast, Kormos and Trebits (2012) demonstrates that more complex tasks induced higher lexical variety in writing but the performance was similar in terms of syntactic complexity. In Tavakoli (2014), more syntactically complex output was found in the simpler writing tasks than in the speaking tasks.

There is, to date, one single study which involves the role of task complexity, task modality, and learners' cognitive factors in the investigation. Zalbidea (2017) evaluated the independent and interactive roles of all the three dimensions on L2 production. Thirty-two intermediate Spanish learners completed simple and complex argumentative tasks in oral and written conditions. The statistical analyses revealed that task modality appeared to have more influence on L2 production than task complexity. Overall, oral speeches were greater in terms of syntactically complexity while written productions obtained more lexical complexity and greater accuracy. The association of WM and L2 production was only observed in more complex tasks. Zalbidea asserted that "during tasks with high conceptualizing demands, learners with higher working memory are better equipped to devote attentional resources to introducing argumentation via subordination in speaking and to accuracy monitoring in writing … WMC

seems particularly relevant for the encoding and revision of more advanced grammatical structures, such as feminine gender agreement" (p. 348).

Conclusion

The present literature review takes attempt to synthesize the recent research finings with regards to the dimensions manipulating on learners' cognitive load in task-based language learning. Independent and interactive effects of task complexity, WM, and task modality are discussed. The general findings, though with some exceptions, on task complexity tend to be more compatible with Robinson's Cognition Hypothesis, which suggests that higher cognitive demanding leads to more complex and accurate L2 production simultaneously. In terms of WM, empirical evidence has provided great insights on its significance in a variety form of learning, such as language comprehension. In the area of SLA, WM is also regarded as one of the main cognitive elements impacting L2 development. Very few studies addressed the interactive influence of WM and task complexity and the mixed findings highlight the need for future research. Compared to task complexity and WM, research on task modality seems to be a new burgeoning area. Due to the different natures of speaking and writing, task modality appears to also play a robust role in linguistic performance. In a task-based language learning context, the modality seems to become the more dominant factor of cognitive demands operated on the learners, and WM is the key in this process. Given very little research considering all the three cognitive dimensions, it is very difficult to predict the linguistic performance under the influence of all three. Future research should take the three factors into account while designing tasks and interpreting the results. It is also important for field educators to knowledge the potential effects of all three in classroom teaching. For instance, learners with lower WM capacity may find it very challenging to complete a complex oral task.

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