

THE INTERPLAY OF WORKING MEMORY AND SECOND LANGUAGE LEARNING AMONG THE PAKISTANI UNDERGRADUATE ESL LEARNERS

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Abstract

The present study investigates the role of working memory in second language learning with special focus on the writing aspect of language. Since long, the role of working memory in Second Language Acquisition (SLA) has been studied by the researchers. As suggested by Hayes (1996) and Kellogg et al, (2013) “writing models play a significant part in the product and process aspects of writing and thus are supporting the role of working memory (Hayes (1996) and Kellogg et al., (2013). The present study thus aims to investigate how working memory capacity correlates with writing aspect of second language learning among Pakistani ESL learners. Hayes and Kellogg (2013) suggest that working memory plays a key role in L2 writing reference to the cognitive abilities. For this purpose, quantitative approach is used to answer the significant research questions. Findings of the study show a positive correlation between working memory capacity, and L2 writing performance. Learners with higher working memory capacity were able to produce more accurate and complex sentences as compared to the learners with lower working memory capacity. The study will be beneficial in developing the teaching techniques that ensure the second language learning by designing tasks that align with the cognitive abilities of learners. Finally, the research will contribute to the field of SLA by offering new insights into the role of Cognitive load in L2 acquisition.

Introduction;

It is well known that acquiring a new language (L2) is a difficult task that demands a large amount of cognitive, linguistic, and affective resources (Godfroid & Hopp, 2022). One of the most commonly studied constructs on cognitive factors, working memory (WM) has continued to gain relevance in the study of applied linguistics and psycholinguistics. “WM is characterized as a temporary holding and actively processing information, which has limited capacity and is involved in virtually all goal-directed cognitive tasks, such as solving mathematical problems or a conversation” (García-Madruga et al., 2022). WM is paramount in L2 learning where the learner has not yet automatized key linguistic forms so when executing syntactic parsing, lexical access, and discourse planning, they must be under conscious control through effortful control. This adds pressure on WM as opposed to the use of first-language (L1), where these operations are to a large extent automatic.

WM is certainly implicated in L2 writing, but we are still ignorant of how the various WM processes interact with writing sub-processes (planning, translating, revising), and how task and learner variables influence the nature of this association. Comparatively, less research has been done on the relation of writing and working memory as compared to the reading component of L2 learning. Olive (2003) suggests that the lack of research in this field may be due to the fact that writing is a very complicated cognitive task which is involved in language production and that the usage of WM capacity in writing is not clearly depicted. The only way to overcome this gap is to conduct an integrated, component-specific and context-sensitive

investigation, one that not only measures WM accurately but also looks at its effect across genres, levels of proficiency and cognitive load situations. The aim of the present study is to address this gap.

The purpose of this study is to examine the relation between working memory capacity and L2 writing accuracy here includes correct grammatical and syntactic structures while complexity in this study is equal to the number of sub-ordinate clauses present in one hundred words produced by the participant. This is done by dividing L2 writing performance in two sub fields of L2 accuracy and L2 writing complexity and investigating its relation with working memory capacity in L2 learners belonging to the different academic levels. By including undergraduate students in the study, this study aims to find if WMLink remains constant across different academic levels or it changes where the academic writing demands become higher. In order to investigate this, the present research addresses the following research questions.

1. Whether or not there is a link between working memory capacity and L2 writing performance?
2. What is the relationship between WM capacity and L2 writing accuracy?
3. Whether or not there is a relationship between WM capacity and L2 writing complexity?

In order to explore these questions, the researchers explored whether a person's working memory capacity predicts his L2 writing performance. The rationale for the first question stems from the idea that Working Memory works as a significant cognitive resource and during the process of composition, it supplies for simultaneous demands (Kellogg, 1996; Hayes, 2012). The second question narrows down the focus of the study to accuracy. It estimates to what extent learners follow the grammatical norms of the target language. This question will answer if the WM capacity is directly linked with syntactic control in L2 writing. The third question seeks to answer if there exists a relation between working memory capacity and writing complexity. It has been evaluated by estimating the number of sub ordinate clauses in the participants' writing. According to the Limited Capacity Model (Lang, 2000), two main processes of maintaining accuracy and establishing complexity may compete with each other for resources (Skehan, 1998). Thus, theoretically, if working memory is balancing this competition, the learners having strong working memory capacity should be able to produce grammatically complex sentences without the chances of committing increased errors. Thus, this question will answer if there is any correlation among working memory capacity and L2 writing complexity.

Literature review:

WM, in general, refers to a place of retaining and manipulating information, required for completion of an action, for a shorter period of time. The term 'Working Memory' was first used by Miller, Galanter and Pribram (1960) with the publication of their book. Miller et al., (1956) suggested that the most forward part of the frontal lobe can be called as WM where the action plans are retained for a shorter period of time till they are made, transformed and executed. In terms of how working memory operates, two major models of working memory have been proposed so far that include the Componential model and the Unitary model. They treat working memory in different ways. The componential model which is proposed by Baddeley et al., (1974) suggest that working memory uses different pools of resources that are independent of each other. This model defines storage components as the proxies of working memory. As all the components are independent, they are tested and investigated separately in research. The unitary model, brought forward by Daneman and Carpenter (1980), on the other hand, suggests that working memory is a global structure which unites the processing and

storage components that cannot be measured separately; instead it must be measured as the single concept. It suggests that there is a trade of resources between different components and if more resources are allocated to the single component other components are left with fewer resources.

Atkinson and Shiffrin (1968) presented a multi-stage model regarding the role of short term memory. This model contained a unitary Short Term Store (STS). This store was similar in function to the Working Memory proposed by Miller and colleagues. In the same time period when Shiffrin and Atkinson proposed their model, Baddeley was researching short term retention of the verbal information. Soon after Baddeley proposed a model named as Baddeley and Hitch's (1974) model which suggested that Working Memory is a separated and multi-faceted sub system of Short Term Store. Unlike Atkinson and Shiffrin's STS, which was a unitary system for all modalities, Baddeley's model suggested that there are different systems for different types of sensory information and thus he divided Working Memory into sub parts. These sub parts include visuospatial sketchpad, phonological loop, central executive and a most recently proposed fourth part, the episodic buffer. Several theories were proposed regarding how much amount of information is attributed to these sub systems that were suggested by Baddeley and Hitch. This led the researchers towards investigating the role of working memory in Second Language Acquisition (SLA). A major theory in the domain of working memory and second language acquisition is the Dual Coding Theory. It can be defined as a theory that identifies the way information is processed, coded and remembered using the verbal or imagery system based on their functional properties. It focuses on the connection which is developed as a result of interaction between verbal and non-verbal representations. These connections are known as "referential links". Another category of links described by the Dual Code Theory is that of associative connections. These connections operate within the verbal and non-verbal systems and bind representations.

Some studies have attempted to link working memory capacity with progress in second language learning. Specifically, there are many empirical studies that suggest a close relation between the central executive component of working memory and complex cognitive skills involved in the process of second language learning like reading, writing, listening and speaking (e. g., Ellis & Sinclair, 1996; Martin & Ellis, 2012; Service, 1992). Various tests have been employed by the researchers to measure working memory capacity. Methods of working memory calculation also kept changing based on these two different models. Two broad categories of working memory measures include the simple tasks and complex tasks. In a simple span task, there are two component goals. These two goals include remembering and reciting where reciting is used at the end of a task. In complex span tasks, there are three component goals; two being the same as in simple tasks while the third one is judgment. Complex span tasks are now the most widely used measures of working memory capacity. Originally simple tasks were developed to measure working memory capacity but later researchers Daneman and Merikle (1996) suggested that simple span tasks to evaluate short term memory hardly predict reading performance of learners. They concluded that working memory is much more than just passive storage, it actually is about active manipulation and active maintenance of information. Daneman and Carpenter (1980) constructed a reading span task to test simultaneously the processing and storing capacity of working memory. This emphasizes the importance of the central executive to the extent that it suggests that variations in the working memory are due to differences in attention control (Engle, 2002). Their work led to the capacity theory of comprehension which states that working memory is required for

language comprehension, it helps in resolution of syntactic ambiguity. It supports syntactic modularity by interaction of the syntactic and pragmatic information.

In the area of Second Language Acquisition, working memory plays a major role in input processing, form meaning mappings, grammar learning as well as real time production. Learners who have higher working memory capacity are expected to benefit more from the form focused instructions as compared to the ones with lower working memory capacity. Kellogg (1996) and Hayes (2012) suggested that writing makes complex demands in SLA because it requires simultaneous demands of planning, translation of ideas into words and also reviewing for the purpose of checking accuracy and coherence. Findings across decades have consistently indicated that learners with higher WM capacity often demonstrate superior performance in integrating linguistic knowledge with real-time communication demands. This historical progression of research has established WM as a critical cognitive variable in SLA, paving the way for contemporary studies examining its influence on specific skills such as L2 writing. Writing ability is in fact the interaction of visual, motor, conceptual and linguistic modules. Bereiter and Scardamalia (1987) describe writing as “a skill that is developed at some higher levels in some people than in others”. The motor movement in the working memory is actually responsible for the process of writing and reading. This motor system plays a role in planning and executing the muscle movements that express language.

The present studies in the area of Second Language Acquisition (Manchón & Sanz, 2023; Granena, 2023) suggest that writing serves as an important indicator to understand the role of working memory in L2 learning. In the field of WM and L2 writing, two major theoretical models have been proposed, over the last decades, based on their historical context. The first model in this respect was forwarded by Hayes and Flower (1980) and the second major model was of Kellogg (1996). Hayes and Flower’s (1980) model is the clear depiction of three phases of writing including planning, translating and revising. Later, Hayes (1996) modified this model and gave special importance to those sources of knowledge that are situated in Long Term Memory. Secondly, Kellogg’s model describes the cognitive functioning in the writing process focusing on the individual differences in working memory capacity. The central role of working memory in L2 writing has been highlighted by both Hayes’ (1996) and Kellogg’s models (1996) of L2 writing.

As per the cognitive models of writing (Hayes, 1996; Kellogg, 1996, 2013), writing is always a multi-component process that involves the coordination of planning, translating, and reviewing activities and role of WM in coordinating these activities is very significant. Kellogg (1996) proposed Precise Hypotheses that gave special importance to the specific working memory subcomponents and its function in different processes of writing. For a long time, the researchers, like Cowan (2005), suggested that memory remains a fixed trait having strict limits. Later on, some researchers suggested that learners can become more proficient in using working memory capacity if they are exposed to the targeted training (Schwaighofer, Fischer, & Bühner, 2015). His model specifically focuses on the role of working memory in writing. Hayes and Flower provided a revised model of text production consisting of three processes; planning, translating and reviewing. Planning, according to this model, involves generating text layout and organizing ideas. The translating phase involves the culmination of ideas for the actual process of writing. Ideas are revised and reconstructed during this phase of the writing process. As the name suggests, the reviewing component involves reviewing the text where the writer makes edits in the piece of writing. In the revised model of Hayes and Flower, these three components of the writing process were renamed as: text interpretation, reflection and text production. During the text interpretation, the subject derives from graphical and

linguistic representations present in the text such as reading, listening and scanning graphics in the text. During the reflection process, internal representations formed during the first phase are evaluated and transformed. In the last phase of Hayes and Flower's (1981) new model, a written, graphic or spoken output is formed by combining the internal representation formed in the previous phases of the writing process. In this updated model, they clearly mentioned the role of working memory that they didn't clearly mention in their previous model.

By extending Hayes and Flower's (1981) model, Kellogg (1996) proposed that all components presented in Baddeley's (1986) Working Memory model are used in the formulation components of writing. He further suggests that all the three components of working memory are used during the composing process of writing. In this model, Kellogg divides writing into six processes namely planning, translating, programming, executing, reading and editing. Different parts of working memory are specified for different processes. The WM requirements in L2 writing usually exceed those in L1 owing to the lack of automatization of linguistic representations, which obliges the learner to consciously attend to lower-level linguistic processing even as he or she is planning the discourse at the higher levels. This suggests that WM is not a universal leadership booster of L2 writing, but the impact of the WM factor depends on the relationship between cognitive capacity, task, and learner profile. Therefore, it is crucial to explore the connection between Working memory capacity and L2 writing ability. Study of previous literature shows that although a lot of research has been done on the subject of relation between working memory and second language acquisition, the studies on the relation between working memory and second language writing are comparatively less. The present study endeavours to find the link between working memory and second language writing among the undergraduate students, the students of grade ninth, tenth, 1st year, and of 2nd year. The current research, thus, aims to investigate type of relation that exists between working memory capacity and second language writing.

Methodology:

The current research is designed to analyze the role of working memory in second language learning by relating working memory capacity with L2 writing. The present study uses Correlational research design. This design was adopted to determine statistically if there exists a relation between the cognitive ability to retain and manipulate information and second language learners' writing proficiency. McCombes (2019) defines this design as a measure of relationship between two variables without the researcher manipulating either of them. The research population for this study comprises undergraduate students from grade ninth, tenth, first year, second year and BS students till 6th semester. DeRenzo (2020) suggests that researchers prioritize selecting participants who can provide informed consent, with special attention to vulnerable populations. (DeRenzo et al., 2020). The participants of the study thus belong to different age groups and are at different levels of education and second language proficiency. All of the participants have been taught English as a major subject in their previous years of education. Kerlinger (1986) defines Sampling as taking any portion of a population or universe as representative of that population or universe (Kerlinger, 1986). A purposive sample of 100 students was chosen based on their approval of the aims of the research and their interest in the working memory capacity test. The selection for the study focused on accessibility, cooperation as well as the relevance to the research context.

The sample of this study shows diversity in terms of the participants' academic performance, socio-economic background and gender. These factors were considered important for the study because it can provide information about individual working memory capacity and how it varies across different variables such as gender. In order to ensure

ecological validity and classroom diversity, the research excluded no participant based on their English level proficiency from the sample of 100 undergraduate students. The study employed Purposive Sampling which is a non-probability sampling technique.

The present study uses different types of variables. For example, working memory capacity is an Independent variable while L2 writing accuracy and L2 writing complexity belong to the category of dependent variables. Some other categories of variables are also there in the study. Gender, for example, is a dichotomous variable. The level of second language learning interest is a polychotomous variable. Working memory capacity scores and L2 writing proficiency scores belong to the category of continuous variables. The present study used Quantitative tools for data collection. The OSPAN developed and used by Turner and Engle (1989) test was used to evaluate the working memory capacity of the participants. Besides, an L2 narrative writing task was conducted in order to analyze the participants' L2 writing proficiency. This was based on a visual storyboard prompt. In this task, students were asked to write a story in L2 (English) based on the given visual prompt. The scores in this task were collected by both Accuracy and Complexity tasks. Working memory capacity was measured through binary scoring which was used for the OSPAN Task. Each item in the test consisted of a simple arithmetic equation followed by a word that participants needed to memorize. Each participant who recalled each word correctly in the exact sequence was given 1 point for each word. The final score ranged from 0 to 47.

In order to ensure comparability across texts of varied lengths, standardized error rate was used to calculate writing accuracy. In the first step, the number of words was counted for each text. After that, the number of errors was calculated per 100 words of the text by dividing the total number of errors over total number of words in the text and multiplying it with 100. Errors in the text included grammar and syntax errors, lexical choice errors, word order and agreement issues as well as repetitions. Accuracy was then calculated by subtracting the error rate from 100. Complexity in the text was collected by calculating the number of subordinate clauses per 100 words of text and then applying the following formulae;

Complexity Score = (Subordinate Clauses / Total Words) × 100

The current study did not employ the existing data for the research instead the researcher themselves collected it from the participants. Thus, the primary data collection method was used to investigate the role of working memory capacity in L2 writing by administering both OSPAN and L2 writing tasks. Current research has followed all the ethical considerations guarding the private information of the participants by ensuring anonymity. In the present study, tests used were already reviewed by academic experts in psycholinguistics. L2 writing samples were double checked for consistency in error and clause counting. Quantitative data was collected through OSPAN and L2 writing tasks and was analyzed using SPSS software.

Accuracy and complexity scores were computed manually and were then input for further evaluation in SPSS Software. SPSS stands for Statistical Package for Social Sciences. It was adopted for data analysis due to its comprehensive features and its ability to apply different tests on the complex data such as Pearson Correlational Coefficient. Current study employed descriptive tests, like mean, Standard Deviation and frequency. In the present study, data was displayed in the form of tables to present descriptive statistics such as mean, frequencies and standard deviation. Bar graphs showed comparative performance across different variables. Scatterplots were used to illustrate correlation between working memory and writing performance.

Data Analysis

Quantitative data were collected using an OSPAN test to calculate working memory capacity and a narrative task for L2 writing. Data preparation was carried out by checking any missing values in the dataset. For all types of variables, the correct data type was selected and derived scores were calculated following the method discussed earlier. For the calculation of error rate per 100 words, accuracy scores and complexity scores, the following formulae were used;

$$\text{Error rate} = (\text{total errors} / \text{total words}) \times 100$$

$$\text{Accuracy score} = 100 - \text{Error rate per 100 words}$$

$$\text{Complexity score} = (\text{Subordinate clauses} / \text{total words}) \times 100$$

The computed values of the variables were rounded to three decimal places for reporting. The researchers then created an excel sheet which served as the basis for further analysis. The final sample contained 100 participants. In order to achieve sufficient subgroup size for subgroup analysis, all semester level categories were merged into a single 'BS Sem' category. Initially, different categories were formed on the basis of different semesters of BS. All these subcategories were later merged in order to get sufficient sample size for further analysis. Thus the resulting academic level categories were named as 9th, 10th, 11th, 12th and BS Sem. Another sub group named 'gender' contained two main categories as 'Male' and 'female'. Frequency distributions across different subgroups like academic level and gender is given below;

Table 4.1: Frequency Distribution across Academic

Academic Level	Frequency
9 th grade	15
10 th grade	16
11 th grade	18
12 th grade	33
BS Semester	17

Table 4.2: Frequency Distribution across Gender Level

Gender	Frequency
Male	33
Female	66

As indicated in table 4.1 and 4.2, the sample achieved fairly balanced male and female representations that are sufficient for analysis and comparison. The students from five academic levels participated in the study. It helped in finding the developmental trends in working memory and L2 writing. Although the number of participants was not perfectly equal as the data showed, each category was still represented for meaningful comparisons.

In order to examine the hypothesized relation, inferential statistics were used to investigate the relation between working memory capacity and different aspects of L2 writing. Pearson moment correlation was used separately for checking overall writing performance, writing accuracy and writing complexity. The correlation coefficient showed a moderate positive relation between working memory and overall writing performance. The relation is also statistically significant. It suggests that learners who possess strong working memory capacity showed good performance in writing. It meant that these learners balanced different demands of writing in a more effective way including planning content, managing and organizing ideas, monitoring grammar as well as producing complex sentences.

Descriptive statistics, frequency, mean, and standard deviation was calculated for all variables.

Table 4.3: Means and Standard Deviations of the Variables

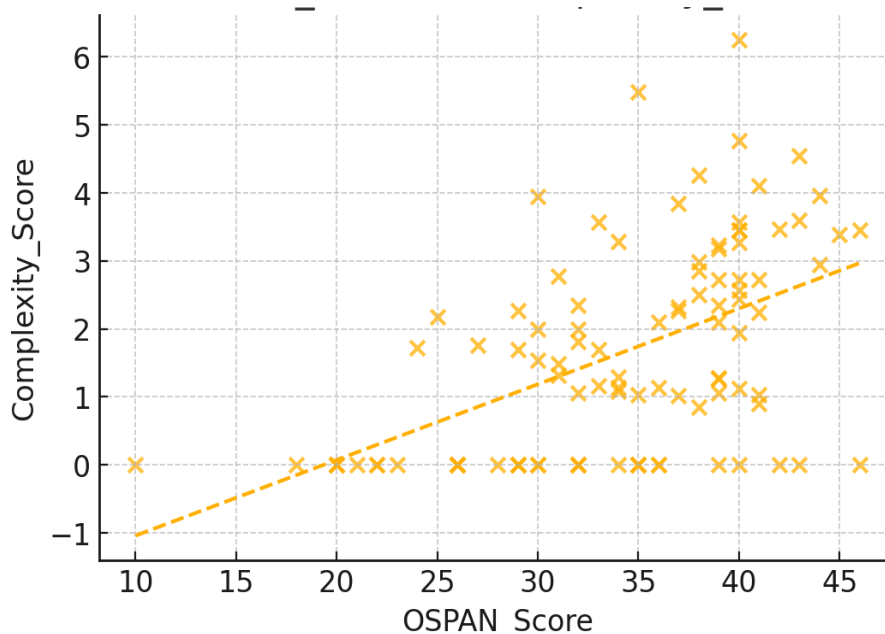
Variable	N	Mean	Std. Deviation	Minimum	Maximum
OSPAN_Score	99	34.303	6.993	10.000	46.000
Accuracy_Score	99	69.922	20.094	9.091	98.621
Complexity_Score	99	1.666	1.531	0.000	6.250

The findings are thus supported by Kellogg's model suggesting that working memory works like an engine that produces higher quality writing. Besides, these findings support the view presented by McCutchen (2000) who suggested that if an individual is having some limitations in his working memory, it can affect his ability to maintain accuracy and complexity simultaneously during the process of writing. In the present study, students with lower working memory capacity made more grammatical errors in their process of writing and used simple sentence structures instead of advanced sentence structures. Thus, it provides an empirical evidence to this hypothesis that cognitive resources are directly involved in producing linguistic output and directly influence it.

Regarding the second research question about the relation between working memory capacity and L2 writing accuracy the findings of the test showed a stronger positive correlation than with overall performance. This suggests that working memory in particular is important for accuracy in writing. In the study, participants with higher working memory capacity produced a smaller number of grammatical and syntactic errors as compared to low working memory capacity students. This finding is in line with Skehan's (1998) trade off hypothesis. It suggests that learners must allocate attentional resources between accuracy, complexity and fluency. Thus, the individuals with higher working memory resources are better able to maintain accuracy without alleviating resources for other aspects of writing. The present study supports this view of Skehan (1998) that accuracy is that aspect of writing which is mostly affected by working memory because it requires continuous attention to form along with managing ideas.

These findings also align with the Baddeley's model of working memory. It suggests that central executive is actually the main component of working memory which functions in balancing and selecting resources for different tasks. In the process of writing, central executive performs this role by monitoring ongoing text production by checking for errors and correct inappropriate forms. It supports the idea that learners who contain stronger working memory capacity actually possess more efficient executive control which helps them in identifying and correcting errors in real time.

Pearson correlation was applied between working memory capacity and complexity scores. Complexity was calculated by the ratio of subordinate clauses per T-unit.



The result of the correlation shows that although the relation between working memory capacity and complexity is positive and statistically important, it was weaker as compared to the relation between working memory and accuracy. This suggests that although working memory significantly functions in enabling learners to produce complex sentence structures, the relation is not as strong as it is with accuracy.

These findings are not surprising if we look at the developmental trajectory in SLA. Ortega (2012) suggested that complexity develops late in learners as compared to accuracy and fluency. This is because it not only requires cognitive resources but also exposure to and practice with advanced language structures. Thus it suggests that while working memory allows learners to use complex language forms, it may not guarantee their mastery in developing complexity without proper instructional input.

The amount of variability in the complexity scores seems interesting. It was even greater than that observed for accuracy. Some learners with higher working memory scores produced simple sentences. This may happen because their institution prioritized accuracy over complexity. Some learners with average working memory scores used advanced sentence constructions even at the cost of errors. This finding supports Robinson's (2005) Cognition Hypothesis as it proposes that task demands and instructional focus may also influence the complexity outcomes in learners' written performance.

Thus, findings suggest that although working memory provides necessary conditions for complexity, it is not sufficient. In order to achieve success in establishing complexity in a written performance, instructors need to supplement cognitive resources with extensive and explicit practice in producing complex structures such as relative clauses or conditionals.

Table 4.4: Subgroup correlations — Female

Var1	Var2	R	P	N
OSpan Score	Accuracy Score	0.8015	0.0	66
OSpan Score	Complexity Score	0.5148	0.0	66
Accuracy Score	Complexity Score	0.5083	0.0	66

Further analyses were performed by the researchers to explore whether these relations varied or remained constant across demographic subgroups, especially gender and academic level.

Table 4.5: Subgroup correlations — Male

Var1	Var2	R	P	N
OSPAN Score	Accuracy Score	0.9124	0.0	33
OSPAN Score	Complexity Score	0.5017	0.0029	33
Accuracy Score	Complexity Score	0.4541	0.0079	33

In order to evaluate academic level comparisons, participants were divided into broad academic categories including secondary school students from grade 9th to 12th and BS level students. The analysis shows that BS students performed better and scored significantly higher in both accuracy as well as complexity as compared to the students of secondary grade. This finding is consistent with the developmental trajectory in SLA. According to studies in SLA, when learners are exposed to English for a longer period, they develop more accurate and complex writing. Cognitive maturity also plays a major role in it. According to Ortega (2012), syntactic complexity develops well in the advanced stages of L2 proficiency. This explains the reason of high complexity scores among BS level students.

Pearson correlation analysis was calculated separately for secondary grade and BS level participants to observe how working memory capacity related with accuracy and complexity within each level.

Table 4.6: Subgroup correlations — 10th

Var1	Var2	R	P	N
OSPAN Score	Accuracy Score	0.8875	0.0	16
OSPAN Score	Complexity Score	0.8006	0.0002	16
Accuracy Score	Complexity Score	0.644	0.0071	16

Pearson correlation analysis calculated for 10th grade students shows a significant positive correlation between working memory capacity and accuracy. Analysis shows that accuracy and complexity are positively related.

Pearson correlation analysis calculated for 11th grade students shows a strong positive relation between OSPAN scores and writing accuracy. Accuracy and complexity were found to be moderately correlated.

Table 4.7: Subgroup correlations — 11th

Var1	Var2	R	P	N
OSPAN Score	Accuracy Score	0.8875	0.0	16
OSPAN Score	Complexity Score	0.8006	0.0002	16
Accuracy Score	Complexity Score	0.644	0.0071	16

Table 4.8: Subgroup correlations — 12th

Var1	Var2	R	P	N
OSPAN Score	Accuracy Score	0.8777	0.0	33
OSPAN Score	Complexity Score	0.4388	0.0106	33
Accuracy Score	Complexity Score	0.4372	0.011	33

Pearson correlation analysis calculated for 11th grade students shows a moderate positive relation between OSPAN scores and writing complexity and a strong positive relation between working memory capacity and writing accuracy.

Table 4.9: Subgroup correlations — 9th

Var1	Var2	R	P	N
OSPAN Score	Accuracy Score	0.6871	0.0047	15
OSPAN Score	Complexity Score	0.4664	0.0797	15
Accuracy Score	Complexity Score	0.4906	0.0634	15

Pearson correlation analysis calculated for 9th grade students shows significant positive relation between OSPAN scores and writing accuracy. The relation between working memory capacity and writing complexity and between complexity and accuracy is not statistically significant at this stage of L2 learning.

Table 4.10: Subgroup correlations — BS Level

Var1	Var2	R	P	N
OSPAN Score	Accuracy Score	0.8124	0.0001	17
OSPAN Score	Complexity Score	0.5622	0.0188	17
Accuracy Score	Complexity Score	0.445	0.0735	17

Results of the correlation suggest that working memory correlated more with accuracy as compared to complexity for secondary students. This means that students with higher working memory capacity show good performance in error correctness at early stages but their reservoir of sentence construction is limited at this stage. This also suggests that the development of complexity does not only depend on working memory but it is also affected by the lack of enough exposure to advanced language structures.

BS level students, on the other hand, performed well in establishing complexity in their writing and showed a stronger correlation with complexity than with accuracy because these learners already possess a higher level of grammatical stability they are able to utilize their cognitive resources for managing longer, more advanced discourse level structures. This finding is again consistent with Skehan's (1998) Trade off hypothesis which suggests that allocation of working memory resources changes as the learners' progress. Thus secondary grade students use working memory resources for maintaining accuracy while BS level students use it for establishing complexity.

Conclusion:

The present research investigated the relation between working memory capacity and L2 writing while focusing on two main dimensions of writing that are complexity and accuracy. Descriptive and inferential analyses showed significant relationship between cognitive skills accuracy and complexity across subgroups of gender and academic levels. Students having

strong working memory capacity were able to produce complex and accurate sentences as compared to the learners containing lower working memory capacity. The study provided important pedagogical and theoretical implications along with giving directions for the future research. In light of the findings provided by the study, a clear cognitive roadmap for L2 writing can be developed by the instructors. This informed cognitive roadmap should begin with task calibration. It means that the linguistic tasks should not be designed based only on linguistic proficiency of learners but the processing space that the learners can afford should also be taken into account while designing the tasks. For example, the individuals with lower working memory capacity cannot fulfil the demand of simultaneous attention to grammar, vocabulary, structure and argumentation because it can exceed their working memory capacity. It may lead to frustration and errors. For such learners, carefully designed tasks can be beneficial like the ones that start from sentence level processing process to paragraph coherence and finally move towards essay level complexity. It can help such learners in building linguistic proficiency without posing much burden on their cognitive resources.

An important insight provided by the present study is that besides linguistic and environmental variables, the linguistic theories and pedagogical institutions must consider the role of cognitive variables in determining the academic success of learners.

Overall, the present study not only provides useful insights and advances knowledge in the field of SLA but it also serves as a foundation for successful L2 writing production. Instructors, curriculum developers and learners can actually find a more inclusive and responsive approach towards success in L2 writing performance by considering the fact that it is not only linguistic or environmental variables that matter but also cognitive abilities of learners are equally important in determining the success of learners in L2 writing.

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