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Research Paper

Aptitude-Treatment Interaction Effects on EFL Learners' Gains in Implicit Grammar Knowledge

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Abstract

The area of Individual Differences (IDs) and their interactions with instructional conditions have recently been a point of interest in second language acquisition. However, the effect of such interaction on aural implicit grammar knowledge has not been researched exhaustively. This study thus examined the interactive effects of aptitude and treatment conditions on implicit grammar knowledge as elicited aurally. Grammar knowledge was operationalized as the ability to comprehend past/present simple passive verbs. To this end, 120 EFL learners were randomly assigned to four groups: three teacher-generated experimental (Isolated Form-Focused Instruction, henceforth FFI, Integrated FFI, and Incidental) conditions, each lasting for six treatment sessions, and a control group receiving the same content with no instruction. Initially, learners took a pre-test and cognitive tests (LLAMA-D, LLAMA-F, and LSPAN). They then received the treatments, and three days after the treatments, they took an Aural Timed Grammaticality Judgment Test as a measure of implicit grammar knowledge. Results of a general linear model revealed a significant effect for treatment. Additionally, LSPAN was found to mediate the effectiveness of instruction, with the highest effect on implicit grammar knowledge under the Isolated FFI condition. Post-hoc analyses also demonstrated that instruction made a significant difference compared with no instruction, though, in comparison with other conditions, Integrated FFI proved to be more effective. Results provide EFL teachers and curriculum developers with awareness concerning the interaction between instruction and cognitive differences. For improving the effectiveness of instruction and acquiring implicit knowledge, cognitive tasks, especially those boosting working memory, are suggested.

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The explicit/implicit language knowledge dichotomy has received substantial investigative attention in second language acquisition (SLA) research. This heightened research attention is rooted in the assumption that variations in L2 learners' language attainment can be attributed to the difference in their acquired knowledge type (Bowles, 2011; N. Ellis, 2008; R. Ellis, 2005). Explicit knowledge is declarative, conscious, and controlled, whereas implicit knowledge is intuitive, procedural, unconscious, and uncontrolled (Andringa & Rebuschat, 2015; Hulstijn, 2005; Paradis, 2009; Rebuschat & Williams, 2012). Zhang (2015) describes implicit knowledge as being tacit in that it allows L2 learners to use language without conscious awareness.

According to Skill Acquisition Theory, through exposure to sufficient meaningful input and subsequent practice in a reasonable time span, instructed L2 learners are likely to develop automatized knowledge after it is fully procedural (DeKeyser, 2015). Automatized explicit knowledge, however, is viewed as conscious knowledge and is claimed to be different from implicit knowledge, which is without awareness (Suzuki & DeKeyser, 2017). It is noteworthy to mention that both implicit knowledge and automatized explicit knowledge can be tapped into quickly in timed tests, but the distinguishing point is that the former does not involve awareness, while the latter does (Suzuki, 2017). As measures of implicit knowledge, timed tests have been criticized due to some validation issues (Mostafa & Kim, 2020; Vafaee et al., 2017). However, task modality (aural vs. written) is a factor that can influence access to knowledge. For instance, aural Grammaticality Judgement Tests (GJTs) seem to be more precise measures of implicit knowledge when input is delivered aurally (Kim & Nam, 2017). Aural GJTs require online processing of knowledge and focusing on meaning (Loewen, 2009; Rebuschat, 2013; Shiu, 2018), which may not lead to learners' awareness, while focus on form or backtracking is possible in written GJTs (R. Ellis & Roever, 2018). Building upon these studies, the current study used an Aural Timed GJT for measuring implicit knowledge to add the aural modality, which has not been sufficiently addressed (Shiu et al., 2018).

Investigating variables that are likely to affect or modulate the acquisition of language knowledge and accelerate its rate has been a major pursuit of SLA research (DeKeyser, 2012). In instructed SLA, both incidental and intentional instructions have been proven effective in language learning, although explicit FFI in meaning-based classrooms has received greater prominence (Norris & Ortega, 2000; Spada, 2011). In instructions focusing on meaning, as in incidental conditions, learners' attention is unconsciously directed to meaning, and there is no focus on form. In FFI, learners' attention is shifted to forms of a language. Isolated and Integrated FFI are two types of FFI that are only different in the focus-on-form timing. In the Isolated FFI (a variant of focus on form), metalinguistic information is presented prior to the incidental (meaning-focused) learning. In contrast, in Integrated FFI, focus on form is provided during the incidental (meaning-focused) learning, as teachers direct students' attention to target structures in communicative contexts. Accordingly, instructional conditions used in this study are Incidental (Robinson, 2002), Isolated and Integrated FFI (Spada & Lightbown, 2008).

Language aptitude, as another variable, has been among the numerous variables assumed to potentially account for variability in the result of second language learning, apart from experience factors (i.e., practicing an L2), which has attracted substantial attention. Carroll (1981) conceptualized aptitude as a multi-dimensional construct encompassing grammatical sensitivity, phonetic coding ability, rote learning ability, and inductive language learning ability and developed the Modern Language Aptitude Test (MLAT). However, in consonance with Singleton's (2017) reference to the stagnant condition of the Carrollian concept of language aptitude as 'backwater,' new conceptualizations (e.g., Granena, 2013a; Robinson, 2002) were introduced. In one such conceptualization, there is a distinction between implicit and explicit types of aptitude, with considerable research attention.

Research has consistently shown that a major problem in language learning is that there is differential success in the case of L2 acquisition as opposed to universal success in the case of L1 acquisition (Hulstijn, 2005). As a primary concern, language learners do not take advantage of instruction uniformly and variable success in L2, in contrast to L1, has always been a key challenge in L2 classrooms with cognitively heterogeneous learners. In a nutshell, learners have different potentials or ability patterns, and they may learn languages optimally only when the way they are taught suits their ability patterns (Robinson, 2002). Robinson (2005) argues that this cannot be elaborated on by studying individual differences in isolation or by discussing the advantages of one pedagogic condition over the other alone. Rather, the relative learning achievement is due to an interaction between both learning conditions and learner characteristics. Therefore, research in the field of Aptitude-Treatment Interaction (ATI), as an increasingly important area in SLA, has led to a renewed interest in matching learners' fortes, in particular aptitude complexes, to the existing options in learning conditions and instructional techniques for discovering optimal classroom exposure and practice (Robinson, 2002). Explaining these ID intervention patterns is essential for theories of instructed second language acquisition as well as for effective pedagogy. The main objective of this study is thus to shine new light on interactive factors affecting L2 learners' ultimate attainment.

Although individual differences (henceforth IDs) have been actively pursued in SLA, studies on language aptitude, especially from the new perspective, with an expanded conceptualization of working memory (henceforth WM) and its interaction with instructional conditions to affect aural implicit grammar knowledge are scanty. In essence, research on aptitude lags much behind other ID variables (e.g., L2 motivation) with respect to the theoretical justification, educational applications, and testing (Wen et al., 2017). Therefore, to partially fill this void, the present study investigated the effects of cognitive variables on implicit grammar knowledge as elicited aurally under three instructional conditions. Explaining the learning outcome in terms of implicit knowledge and realizing how much of the acquired knowledge can be explained by instructional conditions as well as aptitude components can provide effective implications for language teaching and learning. It can provide awareness for EFL teachers and curriculum developers on the interaction between instructional types and learner characteristics, especially cognitive ones.

Review of the Literature

Theoretical background: Aptitude-Treatment Interaction hypothesis

In the Aptitude-Treatment-Interaction (henceforth ATI) line of research, as a theoretical framework, the way ID variables interact with variables of context has been investigated (DeKeyser, 2012). By taking IDs into account, ATI evaluates the interactional effectiveness of instructional interventions and learner variables in teaching/learning. Some studies (e.g., Erlam, 2005; Hwu & Sun, 2012; Hwu et al., 2014) assessing the interaction of aptitude and inductive and deductive conditions have concluded that aptitude is less involved in deductive instruction, as it reduces learners' processing demands through the external support that it provides. In the inductive condition, on the other hand, learners rely on cognition more, resulting in a greater association between aptitude and the final outcomes. In input-based conditions, requiring learners to analyze language, learners tap into aptitude more than in output-based conditions, where the demand for production may counterbalance the influence of aptitude (Erlam, 2005). Furthermore, inductive conditions are more beneficial for learners with higher aptitudes, while deductive conditions are more beneficial for learners with lower aptitudes (Hwu & Sun, 2012; Hwu et al., 2014).

Instructional effectiveness can be influenced by factors such as learner variables, which can influence reactions to instruction and mediate learners' outcomes as they account for variational performance (Dornyei, 2005; Suzuki & DeKeyser, 2017; Suzuki et al., 2019). By way of illustration, in a study investigating L2 learners' grammar acquisition under explicit and implicit conditions, Karimi and Abdollahi (2020) showed an advantage for explicit conditions. Nevertheless, the findings also revealed that the instructional conditions' effectiveness differed for learners with different belief profiles. Robinson (2005) also demonstrated that WM and grammatical sensitivity were predictive of achievement in implicit and explicit conditions, respectively. Additionally, Sanz et al. (2016) examined how WM capacity mediated the development of Latin across implicit vs. explicit conditions. They discovered positive associations between WM and learning across the implicit condition and claimed that explaining grammar and practicing along with explicit feedback equalizes the effect of learner variables.

Implicit Knowledge: Definition, measurement, and empirical evidence

Although evidence points to the crucial role of both types of explicit and implicit knowledge in L2 learning (R. Ellis, 2006; Ellis et al., 2009; Norris & Ortega, 2000), there is a preference for the development of implicit knowledge as it attenuates cognitive demands on WM with its restricted capacity (Erçetin & Alptekin, 2013; Kalyuga, 2009). Hence, it is assumed that language learning would be a more fruitful experience when knowledge is acquired implicitly since "the most highly prized goal of language learning is spontaneous, unreflecting language use" (Zhang, 2015, p. 458). Prevalent measures of implicit knowledge proposed in the literature are oral production, elicited imitation and timed grammaticality judgment tests (Bowles, 2011; Ellis & Loewen, 2007; Ellis et al., 2009; Erlam, 2006; Zhang, 2015). Given the importance attached to explicit/implicit knowledge dichotomy (R. Ellis, 2005; Erlam, 2006; Paradis, 2009), parallel attention to their measurement has also emerged. However, due to the inconsistency of measures gauging knowledge types for various target structures (Isbell & Rogers, 2020), research findings assessing them have also been inconsistent. For example, it is claimed that timed GJT results are likely to be contaminated by an automatized version of explicit knowledge since time pressure may not prevent access to explicit knowledge, especially in adults who have already received a fair amount of training and language exposure (Suzuki, 2017; Suzuki & DeKeyser, 2017; Vafaee et al., 2017). Nonetheless, test modality is one of the factors that further blurs the challenging issue of implicit knowledge measurement. There is evidence that the GJT modality affects the knowledge type accessed (R. Ellis & Roever, 2018; Kim & Nam, 2017; Loewen, 2009). Some studies have suggested that aural GJTs are more difficult than the written versions (Plonsky et al., 2020; Shiu et al., 2018), and others showed that they probably load on factors equivalent to implicit knowledge (Kim & Nam, 2017; Spada et al., 2015). This seems plausible as aural items with fleeting stimuli require real-time and online processing, particularly if the items are also timed. Therefore, this study relied on the weight of evidence considering timed aural GJTs as implicit knowledge measures.

Instructional Conditions

Generally, there is a consensual agreement that instruction enhances learners' attainment (Norris & Ortega, 2000), and the potential effect of the context of learning on language learning has been proven (Azadnia, 2023). Additionally, there have been heated arguments regarding different instructional conditions and their effectiveness, explicit/implicit being the most discussed dichotomy. Explicit and implicit approaches to instruction are differentiated by the presence of rule explanations or lack thereof, respectively (Hulstijn, 2005). In implicit conditions, learners deal with examples in meaningful contexts, while in explicit conditions, learners are presented with metalinguistic rule explanations. The comparative effectiveness of these two approaches has been investigated in previous research (e.g., Fordyce, 2014; Klapper & Rees, 2003), with explicit instruction being relatively more effective. In instructed SLA, some studies (e.g., Loewen et al., 2009; Reinders & Ellis, 2009) have investigated how various instructional conditions can foster learners' implicit and explicit knowledge. As an illustration, in an L2 implicit learning condition using a semi-artificial language, Godfroid (2016) examined the type of knowledge in German participants who were flooded with aural samples of a difficult structure in an implicit condition, using experiments and techniques of word monitoring and oral production. The findings suggested that the implicit condition of instruction affected implicit knowledge acquisition.

Due to making no assumptions regarding learner-internal processes, intentional/incidental conditions are claimed to be better descriptors of explicit/implicit conditions (Isbell & Rogers, 2020). A number of studies have examined intentional/incidental conditions (e.g., Godfroid et al., 2018; Indrarathne & Kormos, 2018; Robinson, 1997; Rogers, 2017). Learners in intentional conditions are given explicit instruction and make conscious efforts to learn, while in incidental conditions, they are not informed about the target structures, and knowledge is acquired when there is no intention. Incidental and implicit conditions are similar in the lack of conscious focus on target structures. Their major difference is that, in the implicit condition, learners memorize sentences, while in the incidental condition, learners read and understand their meanings.

Holding direct relevance for instructed SLA, research is investigating the degree to which instructional conditions can lead to the most optimal outcome for L2 learners, implicit knowledge acquisition (Long, 2017). Generally, there is a relative advantage for intentional conditions (e.g., Khezrlou et al., 2017; McManus & Marsden, 2017; Tammenga-Helmantel et al., 2014; Varnosfadrani & Basturkmen, 2009). Intentional conditions can differ with reference to the timing of directing learners' attention to language forms, a central issue in pedagogy (Doughty & Williams, 1998). In terms of the timing of directing learners' attention to form and building upon Transfer Appropriate Processing (TAP) theory, Spada and Lightbown (2008) designed Isolated and Integrated FFI. In the former, attention to form is isolated from communication-based instruction, while in the latter, focus on form is underlined in communicative-based instruction. These teacher-generated intentional conditions are in communicative, content-based classes, and their difference lies in the timing of attention to form. Isolated FFI does not exclusively focus on language structures and does not exclude communicative practice, a feature observed in the focus on formS approach (Spada & Lightbown, 2008). To date, little empirical evidence exists to examine the timing of attention to form. In one such work, Spada et al. (2014) investigated the timing of FFI in two conditions of Isolated and Integrated FFI using passive forms as the target structures, and their effects on language knowledge. Results showed that both conditions greatly improved, and the groups' differences were not statistically significant. Nevertheless, in the oral production test (as an implicit knowledge measure) and in the written grammar test (as a measure of explicit knowledge), there were some advantages for Integrated and Isolated FFI, respectively. Some studies also found that incidental learning conditions could facilitate learners' explicit and implicit knowledge (e.g., Rebuschat & Williams, 2012; Rogers et al., 2016; Ruiz et al., 2018).

Cognitive Abilities

Learner variables have been assumed to substantially predict learners' attainment (e.g., Dornyei, 2006; Kormos, 2013; Robinson, 2001). Among them, language aptitude has been documented to account for much of the inter-individual variability in language attainment (Granena, 2014; Roberts, 2012). Cognitive abilities that predict how well a person is likely to benefit from language instruction relate to a broad multi-component cognitive concept. As maintained by Li and DeKeyser (2021), recent aptitude testing includes different versions of MLAT (Carroll & Sapon, 2002) and other tests developed based on it, one of which is LLAMA (Meara, 2005). Recently, the new construct of 'implicit' aptitude has attracted scholars' attention (Granena, 2013b). Implicit aptitude involves cognitive processes classified as associative, unintentional, and automatic (Yilmaz & Granena, 2021). It is a tacit and inductive learning ability, quite relevant for learning languages in settings where patterns or regularities among language forms are to be perceived without awareness (Granena, 2016). On the other hand, explicit aptitude (traditionally represented as general language aptitude) refers to abilities that are needed for learning a language intentionally via processes of memorization, justification, etc. and requires attentional regulations.

Since there is a paucity of studies specifically researching the impact of implicit aptitudes on learners' attainment and that implicit aptitudes have recently been added to the literature (e.g., Bolibaugh & Foster, 2021; Li & Zhao, 2021), further research is required to create a robust knowledge base. Language-independent LLAMA battery includes both explicit and implicit components, which is a wise choice for researching aptitude. Selected for this study, LLAMA-F (assessing grammar inferencing ability) measures explicit aptitude, and LLAMA-D (assessing phonetic memory ability) measures implicit aptitude (Granena, 2013b, 2019). To date, some studies have employed LLAMA subtests to assess language aptitude (e.g., Li & Qian, 2021; Monteiro & Kim, 2020; Saito, 2017; Suzuki & DeKeyser, 2017). Like any aptitude battery, the language-neutral LLAMA is of a multi-component nature, and researchers may select one, some or all of its subtests. In this regard, Artieda and Muñoz (2016), in a correlational study, examined the relationship between aptitude components and two proficiency levels of beginner and intermediate learners. Using LLAMA and end-of-course official school tests at two levels to assess language skills, they showed different impacts of aptitude components at two proficiency levels, as phonemic coding aptitude affected participants at the early phases of learning and language analytic aptitude influenced all regardless of the level. They suggested that implicit learning played a key part in the initial phases of adult learning, which needed to be taken into consideration in education. In another study exploring the relationship between aptitude and high-level language proficiency (using tests of collocation and grammaticality judgment), Forsberg and Sandgren (2013) showed a significant positive relationship between collocation scores and LLAMA-D as an implicit aptitude measure. Aptitude multidimensionality has also been documented by research showing that better scores on multiple components of language aptitude contribute to learning different language components like grammar, vocabulary, pronunciation, etc., even within a learner. For example, in a correlational study, Saito (2017) found a considerable contribution of aptitude (measured through LLAMA) to several aspects of pronunciation. The findings demonstrated a multi-dimensional influence of aptitude on

Japanese EFL participants' spontaneous speech. In detail, phonemic coding ability, rote and associative memory, and grammatical inferencing ability were found to be correlated with grammatical correctness and pronunciation, grammatical complexity and articulation rate, and lexical sophistication, respectively. However, sound-sequence recognition ability predicted to measure implicit aptitude, showed no correlation with any of the measured language variables, which may be because implicit aptitude is associated with incidental and unintentional learning conditions or even may be as a result of the difference in the elicitation mode of pronunciation knowledge. In a similar study, Saito et al. (2019) revealed that in the first part of the academic year, explicit aptitude seemed to expand participants' general comprehension. Due to the influence of implicit aptitude on refining the segmental correctness, participants with a better implicit ability (that is, sound-sequence recognition) received higher scores on comprehensibility in the second half of the year, lending support to the impact of exposure. Regarding the mediating role of language aptitude using LLAMA-F, Benson and DeKeyser (2019) investigated the effect of L2 aptitude and two forms of written corrective feedback on the accuracy of present perfect and past simple verbs. They indicated that the language-analytic aptitude mediated the effects of the two forms of feedback.

WM, defined as the capacity to retain and process information, has made its way into aptitude studies as the most-commonly-studied ID predictor or mediator (Conway et al., 2005; Lado, 2017; Sáfár & Kormos, 2008; Suzuki & DeKeyser, 2015; Wen, 2019). For example, Yalçın et al. (2016) showed that WM (measured through span tests) had a significant relationship with aptitude (measured through LLAMA), although they were not substitutable or identical in any way (as shown in a principal component analysis). A multitude of studies has employed Daneman and Carpenter's (1980) Span Test as a test of auditory WM. For instance, Harrington and Sawyer (1992) revealed that participants with higher WM capacity (measured via span tests) did much better on tests of second language reading compared with participants with lower WM capacity. Additionally, Mujtaba et al. (2021) found a robust relationship between WM, other cognitive variables, and performance on L2 writing. They showed that all independent variables, except LLAMA-D as a sound-recognition ability, were related to performance in writing. They also revealed that WM, LLAMA-E, LLAMA-B, and vocabulary size strongly predicted L2 writing as the criterion variable. In another study, Pawlak and Biedroń (2021) investigated the relationship between WM (measured through a Polish version of LSPAN), phonological short-term memory (measured through a Polish nonword span test), and performance on L2 grammar with regard to explicit and implicit knowledge. Grammatical knowledge was defined as accuracy in using English passive verbs as the target structures. Phonological short-term memory was found to be associated with implicit productive knowledge, and WM was associated with explicit productive knowledge, indicating the multidimensionality of WM. Likewise, Winke (2013) examined native English participants' cognitive variables in learning Chinese. Aptitude (measured through MLAT), WM (measured through a span test) and end-of-year proficiency (as measures of learning Chinese) tests were administered. The structural equation modeling analysis revealed aptitude as a predictor of language proficiency. Among aptitude components, rote memory's contribution was the highest, and WM's contribution was the lowest.

This Study

Because ATI, as a research paradigm, examines the link between learners' aptitude strengths and demands of various instructional conditions, it can be beneficial in optimizing L2 teaching/learning (DeKeyser, 2012, 2019; Li, 2018). Conducting such research is especially significant on account of the variation in measuring aptitude with its implicit and explicit components (DeKeyser, 2012; DeKeyser & Li, 2021). In this light, as one of its aims, this study intends to examine the interaction between EFL learners' language aptitude and their acquisition of implicit grammar knowledge in Isolated FFI, Integrated FFI, and Incidental conditions. In addition, instructional conditions have proved to differentially affect learners' outcomes in different contexts (e.g., Radwan, 2005; Zhuo, 2010). In this light, the study contributes to this tradition of research by examining whether instruction makes a significant difference. The study is thought to advance the scholarship in this area as the influence of instruction, in both incidental and intentional conditions, on learners' outcomes has rarely been viewed in terms of implicit aural knowledge, which is much more challenging than its written counterpart (Clifton et al., 2013) since it requires learners to process continuous input, and more importantly cognitive strategies are not immediately available for the learners who receive the aural input, which may give rise to the lack of awareness in knowledge acquisition (Kim & Nam, 2017). Hence, the following research questions are addressed.

1. Does aptitude-treatment interaction affect EFL learners' implicit grammar knowledge?
2. Do the instructional conditions affect the implicit learning outcomes differently?

Method

Participants

Of the initial 186 Iranian university-level students (aged 20–40) who took the grammar section of a quick Web-based version of the Oxford Placement Test (Allan, 2004), 34 males and 86 females (a total of 120 participants) were found eligible for inclusion in the study, filled the consent forms, and received financial incentives at the end of the study. The criteria for inclusion were receiving scores between 28-36 out of 60 (equivalent to B1, according to the CEFR scale) and not taking English classes over the course of the study. They reported learning English in schools or private language institutions in previous years and not having lived in English-speaking countries.

Instruments

Participants took two subtests of LLAMA-v3 (LLAMA-D, and LLAMA-F) and a test of WM (LSPAN). They also took two versions of the Timed Aural Grammaticality Judgement Test (TGJT) used as the pre-test and post-test for measuring implicit knowledge of past/present simple passive verbs. All tests and treatments were online and totally lasted for five weeks. LLAMA aptitude tests developed by Meara (2005) are language-neutral and easy to administer using PCs (Granena, 2013b). LLAMA scores range from 0 to 20, which will be shown on the screen. Since LLAMA scores provided by the website (lognostics.co.uk/tools/LLAMA_3/index.htm) are not itemized and they are obtained automatically, checking their reliability is not possible. However, in an exploratory study of LLAMA, Granena (2013b) showed satisfactory reliability, with an internal consistency of 0.77, and adequate test-retest reliability.

LLAMA-D: sound recognition ability. Known as an implicit aptitude test (Godfroid & Kim, 2021; Granena, 2013b, 2019; Li & DeKeyser, 2021), it measures participants' ability to realize whether a word that they just heard is new or known. It is assumed that good language learners would be better at distinguishing words already heard (Meara, 2005). The test takes 10 min to complete, during which some words are aurally presented to the participants. They are required to choose between two options '*repeated word'* and '*new word.'*

LLAMA-F: grammatical inferencing ability. It tests participants' grammatical inferencing ability and is equivalent to the grammatical sensitivity component of MLAT. The test is based on the rationale that L2 learners are not likely to notice the difference between the order of grammatical words across their native language and other languages and expect other languages to follow the patterns of their L1. Thus, in the learning phase of the LLAMA-F, which takes five min, test takers learn about the grammar of a completely unfamiliar language (PATSI) by exploring its rules. In the testing phase, they should describe 20 pictures through the acquired grammatical rules using the words written on the buttons. Although there is no time limit for this test, it normally takes 10-15 min to complete the 10 test items. Note-taking is also allowed.

Listening Span Test. LSPAN, or the auditory version of the Reading Span Task developed by Daneman and Carpenter (1980), is a measure of auditory WM. Test takers listen to 10 sequences of 3–7 sentences, and judge the meaningfulness of the sentences by selecting either '*True* or '*False*. A letter is played to be recalled later by clicking on a letter matrix in each sequence and at the end of each sentence. The letters also range from 3 to 7 in each sequence. Two scores are reported for each test taker, based on two scoring methods of traditional 'LSPAN absolute score' and 'LSPAN total correct.' Following the lead of earlier studies (e.g., Friedman & Miyake, 2004), we used the latter. The time allocated for the test is 20 min and scores range from 0 to 75. It is worth mentioning that LSPAN scores obtained through the website (Millisecond.com) are also not itemized and checking the reliability is not possible. However, Conway et al. (2005) indicated that scores obtained from span scores have acceptable reliability, as they have been administered in numerous studies. They further added that for span scores, measures of reliability like split-half correlations and alphas are mainly around .70–.90.

Timed Grammaticality Judgement Test (TGJT). It is a temporal measure that draws on implicit knowledge (Bowles, 2011; R. Ellis, 2005; Ellis & Loewen, 2007; Ellis & Roever, 2018; Godfroid et al., 2015). In this test, performance is based on comprehension, and participants are not required to produce language. Learners are instructed to judge the grammaticality of the sentences presented to them quickly to prevent them from drawing on explicit knowledge that might be available to them (R. Ellis, 2005). This study utilized an auditory version of two counterbalanced expert-validated TGJTs (an adapted version of Spada et al., 2015) for the pre-test and post-test since, with the aural input, TGJTs measure implicit knowledge more precisely (Kim & Nam, 2017). Test takers were instructed to listen to 40 sentences (20 evenly divided grammatical and ungrammatical past/present simple passive verbs as target structures and 20 distractors) one by one, under a three-second time constraint (Kim & Nam, 2017) and judge their grammaticality. In the test briefing session, test takers were instructed to choose among *'Correct'*, *'Incorrect'*, and *'Not sure'*. To score the participants' performance, each correct response was awarded one point, but the other options received zero points. The internal consistency of the TAGJT was Cronbach's α = .76 for the pre-test and Cronbach's α = .81 for the post-test.

Test item examples:

* Several trees planted last year. (Ungrammatical)
Today, several products are made of plastic. (Grammatical)
He was running when I saw him. (Distractor)

Target Structures and Instructional Conditions

The target structures selected for this study were past/present simple passive verbs. The rationale for choosing these grammatical features as target structures was that the passive structure poses great challenges for L2 learners in both implicit and explicit knowledge (R. Ellis, 2006). Instructional content was reviewed and revised by four experienced English teachers before the treatments since uniform instructional methods are not normally followed, and contents and teaching methods can be elaborated by teachers (Amin & Rahimi, 2022). One teacher taught the materials in three Isolated FFI, Integrated FFI, and Incidental conditions through the Web-based BigBlueBotton program, which is an online teaching platform prevalent due to a quick transition to e-learning after the COVID-19 outbreak (Sharifi et al., 2023). Exposure to target structures was kept equal across all conditions. Each condition included 30 participants (divided into two classes of 15 for feasibility concerns) who were taught two one-hour sessions per week (six sessions in total). Instructional conditions were similar in structure, as all followed a sequence of pre-listening activities, listening to the same pre-selected English podcasts containing the target structures and having post-listening communicative activities. A notable feature of the Isolated FFI was the metalinguistic grammar explanation of the podcasts' contents before communicative activities. In the Integrated FFI condition, participants received aural modified input, accompanied by teacher's paralinguistic interventions, integrated with simultaneous communicative activities. In trying to focus learners' attention on the specified target structures, the teacher slightly slowed down the podcasts' speed, included a short pause before and after the target items, and used emphatic stress when uttering the exact target items. In the Incidental condition, participants were not made aware of the lesson objective (i.e., the target structures). They listened to the same English podcasts, with no rule explanations and no modifications, and did the post-listening activities in collaboration with classmates and the teacher. A clear difference between the Incidental condition and the control group was learners' engagement in communicative activities with classmates and the teacher while making use of the target structures unconsciously and with no intention of learning. The control group received no instruction at all, and participants were only asked to listen to the files by themselves and check the comprehension activities provided in a pamphlet individually. Table 1 shows the main features of the instructional conditions.

Table 1.
Features of Instructional Conditions

Instructional conditions	**Metalinguistic Rule Explanation**	**Aural Input Enhancement**	**Communication-based Activities**
Isolated FFI	+	-	+
Integrated FFI	-	+	+
Incidental	-	-	+
Control	-	-	-

Procedure

LLAMA-F, LLAMA-D, and LSPAN tests were administered after participants signed consent forms, took the placement test (Allan, 2004), and participated in the test briefing sessions. According to Meara (2005), all instructions should be translated as clearly as possible, and the whole testing procedure should be explained before administering the tests. Therefore, to orient the tests and procedures, participants received written pamphlets in Persian. The pamphlets included translated testing instructions, such as the number of items, timing, some exemplar pictures of the items, and explanations on how to answer. Participants took the Web-based tests with the help of two administrators who supervised and facilitated the whole procedure, and each test was taken on a separate day. After taking the pre-test, participants were randomly assigned to the four instructional conditions. Three days after the treatments, they took the post-test.

Data Analysis

To answer the research questions, we checked the assumptions, performed an Analysis of Covariance (ANCOVA), and ran an LSD post-hoc test using SPSS (Version 24 for Windows). This mixed between-within-subjects ANCOVA was based on a 4 (instructional conditions: Isolated FFI vs. Integrated FFI vs. Incidental vs. control; varied between subjects) × 2 (time: pre-test vs. post-test; varied within-subjects) design. Three z-standardized cognitive variables (LLAMA-D, LLAMA-F, and LSPAN) were used as covariates. The dependent variable (implicit grammar knowledge) was the aural TGJT scores after the instructional treatments.

Results

The purpose of this study was to investigate the ATI effects on aural implicit grammar knowledge under three instructional conditions. Descriptive statistics are provided in Table 2.

Table 2.
Descriptive Statistics

Variable	Treatment Conditions							
	Isolated FFI		Integrated FFI		Incidental		Control	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
LLAMA-F	12.86	4.03	11.83	2.24	11.76	2.88	13.00	2.46
LLAMA-D	11.13	3.43	10.73	2.40	11.70	3.75	11.76	1.99
LSPAN	11.46	3.36	12.86	2.31	14.86	2.52	14.23	2.34
Pre-test	7.96	3.54	5.36	2.64	6.56	2.87	7.06	2.54
Post-test	11.76	3.99	15.5	2.64	9.66	3.59	7.76	2.73

To check the assumptions, first the normality of variables was examined with the Kolmogorov-Smirnov test. According to Table 3, the normality assumption is not violated ($p > .05$).

Table 3.
Normality of the Data (Kolmogorov-Smirnov Test)

Variable	Groups	n	K-S Statistic	Sig
Post-test	Isolated FFI	30	0.104	>0.2
	Integrated FFI	30	0.158	0.053
	Implicit	30	0.104	>0.2
	Control	30	0.140	0.135

Other assumptions, i.e., the homogeneity of regression slopes ($p = .099$) and homogeneity of variances ($p = .288$), are also met.

According to Table 4, by controlling for the pre-test scores, a significant difference was observed in the implicit grammar knowledge scores ($F_{(3, 100)} = 77.62$, $p < .01$, $\eta^2 = .7$) among the experimental and control groups (Isolated FFI Condition: $M = 11.76$, $SD = 3.99$; Integrated FFI Condition: $M = 15.5$, $SD = 2.64$; Incidental Condition: $M = 9.66$, $SD = 3.59$; Control Group: $M = 7.76$, $SD = 2.73$). In detail, the three instructional conditions enhanced participants' aural implicit grammar knowledge. Regarding the interaction of treatment conditions and LLAMA-F, LLAMA-D and LSPAN, only the interaction of Condition with LSPAN was found to be significant ($F_{(3, 100)} = 3.87$, $p < .05$, $\eta^2 = .10$).

Table 4.
Results of the Analysis of Covariance

Variable	Source	Sum of Square	df	Mean Square	F	Sig	η^2	Power
Implicit Grammar Knowledge	Condition	271.55	3	90.51	77.62	0.00	0.70	1
	Pre	36.58	1	36.58	31.37	0.00	0.24	1
	LLAMA-F	9.91	1	9.91	8.49	0.00	0.08	0.82
	LLAMA-D	13.01	1	13.01	11.15	0.00	0.10	0.91
	LSPAN	97.98	1	97.98	84.03	0.00	0.46	1
	Condition*LLAMA-F	7.11	3	2.37	2.03	0.11	0.06	0.51
	Condition*LLAMA-D	4.91	3	1.63	1.40	0.24	0.04	0.36
	Condition*LSPAN	13.55	3	4.51	3.87	0.01	0.10	0.81

Furthermore, based on Table 5, the interactions of LSPAN with Isolated FFI and Incidental conditions are significant ($p < .05$), though in the Isolated FFI, the effect of LSPAN is higher ($B = 1.55$). Therefore, WM has the highest effect on implicit grammar knowledge under the Isolated FFI condition.

Table 5.
Estimating Parameters

Parameter	B	Std. Error	t	Sig.	η^2	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Intercept	3.93	.74	5.323	.000	0.22	2.465	5.394
Isolated FFI*LSPAN_Z	1.55	.46	3.316	.001	0.09	.621	2.471
Integrated FFI*LSPAN_Z	.55	.68	.811	.419	0.00	-.803	1.915
Incidental*LSPAN_Z	1.03	.48	2.119	.037	0.04	.065	1.989
Control*LSPAN_Z	0[a]	.	.	.	.	.	.

* a: this parameter is set to zero because it is redundant.

Finally, the LSD post-hoc test was used to check the pairwise differences among the conditions. As presented in Table 6, the post-test means of implicit grammar knowledge among all the conditions are significantly different ($p < .01$). However, the post-test mean in the Integrated FFI condition is higher than in other conditions.

Table 6.
LSD Post-hoc Pairwise Comparison among the Treatment Conditions

Variable	Condition i	Condition j	Mean Difference	Std. Error	Sig
Implicit Grammar Knowledge	Isolated FFI	Integrated FFI	-3.22	0.47	0.00
		Incidental	4.55	0.48	0.00
		Control	7.07	0.57	0.00
	Integrated FFI	Incidental	7.78	0.41	0.00
		Control	10.31	0.51	0.00
	Incidental	Control	2.52	0.52	0.00

Discussion

The main purpose of the present study was to check the interaction effects of cognitive variables (LLAMA-F, LLAMA-D, and LSPAN) and instructional conditions (Isolated FFI, Integrated FFI, and Incidental) on gains in aural implicit grammar knowledge. The rationale for utilizing LLAMA-F is that it is a language-inferencing aptitude and is thus compatible with the instructional contents (i.e., target structures) and the resulting knowledge. LLAMA-D is an implicit attitude that appears to involve implicit learning and knowledge (Yilmaz & Granena, 2021). LLAMA-D (a sound recognition ability measure) and LSPAN (a measure of WM) are aural tests consistent with the modality of the measure of implicit grammar knowledge in this study.

The aptitude-treatment interaction was shown to affect learners' gains in implicit grammar knowledge as elicited aurally. However, upon closer inspection, it was shown that only the interaction between LSPAN and treatment was significant. This finding is consistent with the finding reported by Godfroid (2016), who reported an effect of WM on implicit knowledge under the implicit condition. Since L2 aptitude is multi-dimensional and WM is considered a key component of it (Li, 2013; Robinson, 2002; Sáfár & Kormos, 2008), we can conclude that among all the aptitude components examined in this study, WM's effect on aural implicit grammar shows the highest interaction with instructional conditions. This is also consistent with Indrarathne and Kormos's (2018) finding, showing that in all input conditions, WM scores were most highly correlated with receptive knowledge. Additionally, since the interaction of only LSPAN with the treatment condition was significant, we further discovered that the interaction was significant in the Incidental and Isolated FFI conditions, though it was the highest in the Isolated FFI condition. This finding is consistent with Sanz et al. (2016), who examined how WM mediated the development of Latin across implicit vs. explicit conditions. They found positive associations between WM and learning in the incidental condition. Other studies (Li, 2013; Robinson, 2002, 2005; Tagarelli et al., 2015) also discovered WM as a crucial mediating variable affecting learners' ultimate attainment.

This finding, however, contrasts with the findings of Pawlak and Biedroń (2021), who found that WM capacity did not have a mediating role in implicit knowledge. It also contradicts the findings reported by Tagarelli et al. (2011), who showed that WM was not relevant to final outcomes under any instructional condition. Similarly, Winke (2013) showed that among the components of aptitude, WM contributed less than others to Chinese language learning. In these studies, WM had the lowest contribution. One justification may be that, unlike the current study, a mismatch in input and testing modality is evident in all afore-mentioned studies. As aural input is intrinsically fleeting, the resulting learning may produce outcomes that differ from those obtained through written tests. Previous studies have shown that aural input is advantageous for measuring implicit knowledge (e.g., Conway & Christiansen, 2005; Godfroid, 2016; Rogers et al., 2016; Williams, 2005). Moreover, the aural and written modes are processed differently, as they are processed in different cortical zones, and the aural cortex is more sensitive to detecting patterns, while the visual cortex is better at spatial information detection (Frost et al., 2015; Recanzone, 2009). Thus, we can conclude that modality does matter for knowledge acquisition.

It was also found that the three instructional conditions were significantly different. Previous research has investigated the comparative effectiveness of implicit and explicit approaches to instruction (Loewen et al., 2009; Norris & Ortega, 2000; Pawlak, 2021; Radwan, 2005; Tammenga-Helmantel et al., 2014; Varnosfadrani & Basturkmen, 2009; Zhuo, 2010). Yet, Integrated FFI is an in-between condition introduced in few studies. The results, as discussed above, indicate that the conditions differ from the control condition, but the Integrated FFI condition proved to be the most effective, which is in line with Spada et al.'s (2014) study, indicating that Integrated FFI seemed to be advantageous over Isolated FFI with respect to the implicit knowledge development. Teachers' paralinguistic emphasis on specified target structures in meaningful contexts, aural input modification, and communication-based practices in this condition seem to be more conducive to gains in aural implicit grammar knowledge. The Isolated FFI and Incidental conditions are the second and third most effective conditions. Comparisons reveal that the highest mean difference is seen between Integrated FFI and control, suggesting that Integrated FFI is poles apart from the control group. One interpretation of the superiority of Integrated FFI could be the timing of focus on form because this condition is advantageous in terms of "transfer-appropriate processing" (Spada et al., 2014, p. 466). Interestingly, there was a small mean difference between Isolated FFI and Integrated FFI, and they were both substantially different from other conditions. This finding is, to a certain degree, consistent with studies making use of only explicit and implicit instructional conditions, where the explicit one is superior (Ahmadian, 2020; Macaro & Masterman, 2006).

Inconsistent with predictions, gains in implicit grammar knowledge in the Incidental condition were less than in the other experimental conditions, which may be due to a host of factors such as the input and test modality, the selected target structures, learners' proficiency levels, and the measure of implicit knowledge applied. For example, simple vs. complex target structures can influence the effectiveness of instruction, and it is sensible to include them in future interactional studies. Furthermore, as Doughty (2003) rightly points out, more measures of implicit knowledge are required before drawing conclusions regarding the superiority of one instructional condition over another with reference to the implicit knowledge construction.

Conclusion

Learner variables such as aptitude, age, motivation, and WM play key roles in how learners react to instruction. Results of this study show that the effectiveness of incidental and intentional instructions can also differ for different learners. The findings imply that without considering characteristics that are likely to modulate instructional effectiveness, it would be naive to simply favor one condition over another. The findings of this study further showed that WM, in interaction with instruction, can substantially contribute to gains in the implicit knowledge of grammar. Evidence was also found for the effectiveness of Isolated FFI, Integrated FFI, and Incidental conditions, though the Integrated FFI was the most effective of all, regardless of the interactional effects. This condition is characterized by features that are more conducive to aural implicit knowledge construction. According to the findings, for grammar knowledge to be implicit, when the modality is aural, such instructional features are most effective. Considering the findings of the current study, it is advisable that teachers consider adding features of the Integrated FFI, such as input modification and enhancement to aural tasks and even include drills for boosting learners' WM. One of the implications of this study is that language teachers and curriculum developers should be made aware of the interaction between the instructional conditions and learners' cognitive characteristics, especially their WM. In so doing, tasks that boost WM may improve the effects of instruction. Therefore, instruction can be differentiated in view of knowledge types as well as learner differences.

In interpreting the results of this study, limitations should be taken into consideration. The first limitation is that we only used one test of implicit knowledge, i.e., the Timed Aural Grammaticality Judgement Test. More measures of implicit knowledge can help interpret the results better (Doughty, 2003). Furthermore, the mode of elicitation in this study was only aural, a limitation that can be removed in future studies by adding oral and written modes for purposes of comparison. Likewise, specifying simple vs. complex target structures is helpful as another mediating variable in future studies since going beyond just two interacting variables is also suggested due to its statistical power (see Cronbach & Snow, 1977), and it is more demonstrative of learning processes. Additionally, replicating the study in different contexts and with different participants could be another suggestion for future research.

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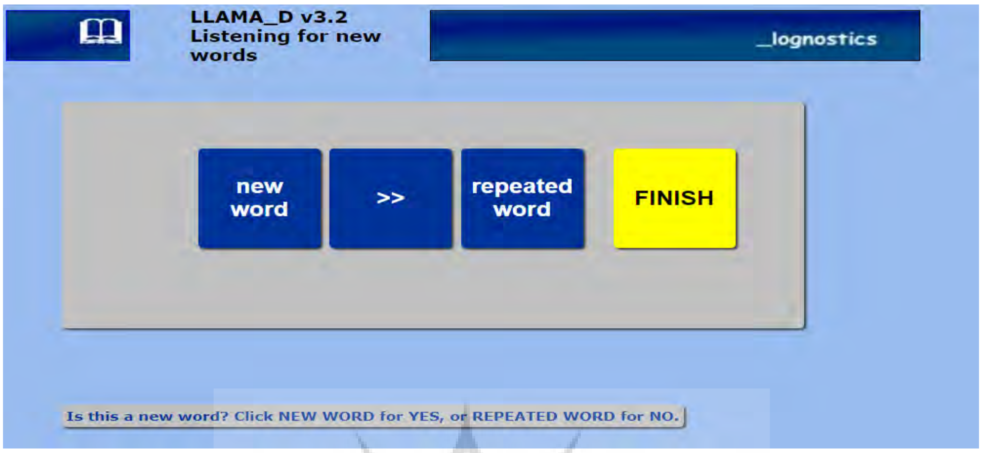
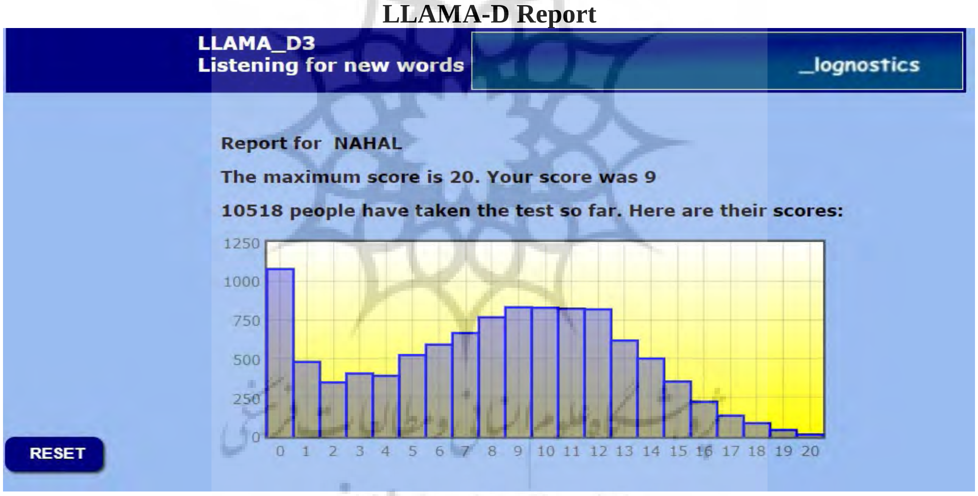
Appendix 1

LLAMA-D items

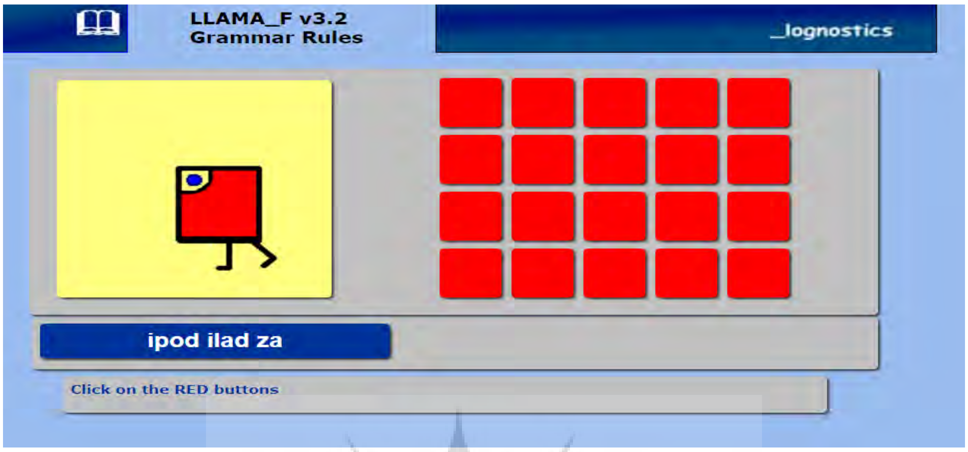


LLAMA-D Report

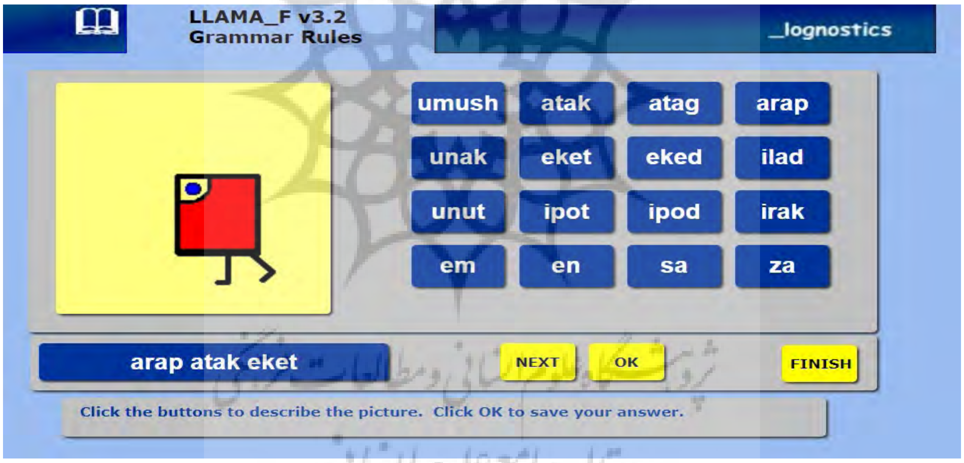


Appendix 2

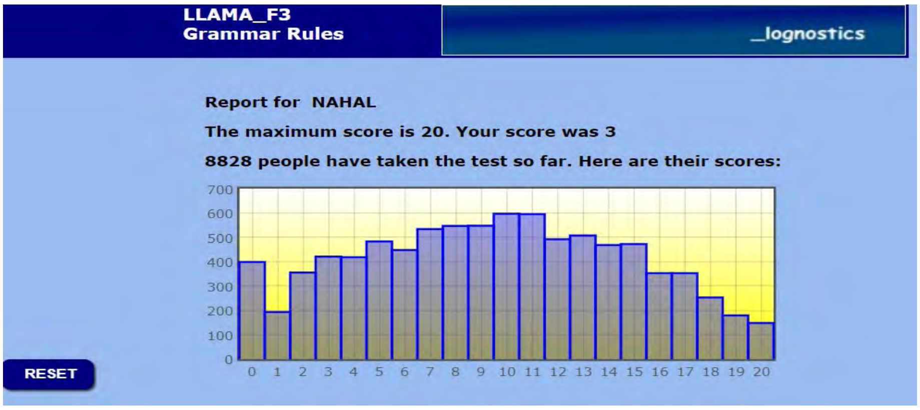
LLAMA-F (learning phase)



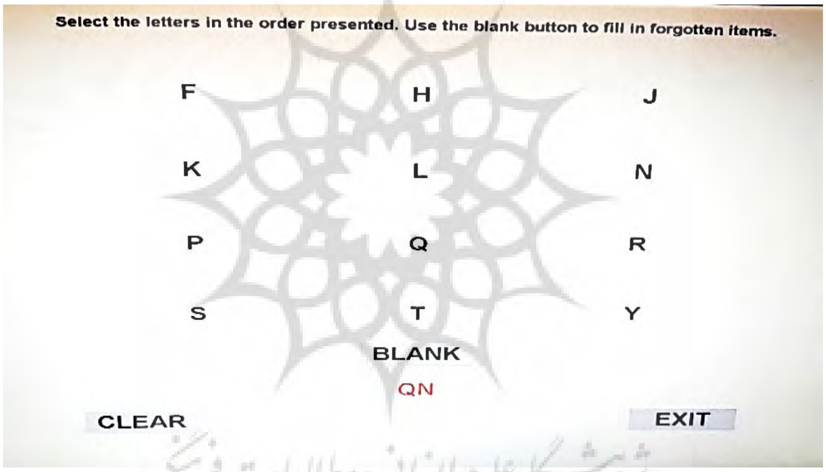
LLAMA-F (testing phase)



LLAMA-F report



Appendix 3
LSPAN (testing phase)



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LSPAN Results