REVISTA CEDOTIC ISSN Online: 2539-1518
Vol. 8. No. 2. Julio-Dic/2023

Processing Instruction effects on moment-by-moment language processing in Spanish Second Language Acquisition

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Abstract

Due to a lack of research between the fields of Computer Assisted Language Learning (CALL) and Second Language Acquisition (SLA) (Ortega, 2017; Zeigler et al., 2017; Parmaxi & Zaphiris, 2017), the present study seeks to combine these two fields by looking at Input Processing through the use of Processing Instruction (VanPatten, 2015) when implemented on the computer. With a total of 62 participants, 3rd year Spanish language learners from a high school in Florida performed a Self-Paced Reading (SPR) test after going through structured input. This study will compare the data from a pretest and posttest SPR to see if the information learned on the structured input was able to have an overall effect on the minute-to-minute way learners process input. Results showed that participants from the referential activities group were able to show exhibit a change in their processing. Therefore, when creating SLA activities on the computer incorporating referential type activities will help learners change the way they process the input.

Keywords

Computer Assisted Language Learning, Second Language Acquisition, Input Processing, Processing Instruction, and Self-Paced Reading

Recibido 5/09/2023 – Aceptado 17/11/2023

REVISTA CEDOTIC ISSN Online: 2539-1518
Vol. 8. No. 2. Julio-Dic/2023

Efectos de la instrucción de procesamiento en el lenguaje, momento a momento, en la adquisición del español como segunda lengua.

Resumen

Debido a la falta de investigación entre los campos del Aprendizaje de Idiomas Asistido por Computadora (CALL) y la Adquisición de una Segunda Lengua (SLA) (Ortega, 2017; Zeigler *et al*., 2017; Parmaxi & Zaphiris, 2017), el presente estudio busca combinar estos dos campos observando el procesamiento de entrada mediante el uso de instrucciones de procesamiento (VanPatten, 2015) cuando se implementan en la computadora. Con un total de 62 participantes, estudiantes de tercer año de español de una escuela secundaria en Florida realizaron una prueba de lectura a su propio ritmo (SPR) después de recibir información estructurada. Este estudio comparará los datos de una SPR previa y posterior a la prueba para ver si la información aprendida en la entrada estructurada pudo tener un efecto general en la forma en que los alumnos procesan la entrada, minuto a minuto. Los resultados mostraron que los participantes del grupo de actividades referenciales pudieron mostrar un cambio en su procesamiento. Por lo tanto, al crear actividades SLA en la computadora, e incorporar actividades de tipo referencial ayudará a los estudiantes a cambiar la forma en que procesan la entrada.

Palabras clave

Aprendizaje de idiomas asistido por computadora, adquisición de un segundo idioma, procesamiento de entradas, instrucción de procesamiento y lectura a su propio ritmo

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Efeitos da instrução de processamento de linguagem momento a momento na aquisição do espanhol como segunda língua.

Resumo

Devido à falta de pesquisas entre as áreas de Aprendizagem de Línguas Assistida por Computador (CALL) e Aquisição de Segunda Língua (SLA) (Ortega, 2017; Zeigler et al., 2017; Parmaxi & Zaphiris, 2017), o presente estudo busca combinar essas dois campos observando o Processamento de Entrada por meio do uso de Instrução de Processamento (VanPatten, 2015) quando implementado no computador. Com um total de 62 participantes, alunos do 3º ano de espanhol de uma escola secundária na Flórida realizaram um teste de leitura individualizada (SPR) após passarem por informações estruturadas. Este estudo comparará os dados de um SPR pré-teste e pós-teste para ver se as informações aprendidas na entrada estruturada foram capazes de ter um efeito geral na maneira como os alunos processam a entrada minuto a minuto. Os resultados mostraram que os participantes do grupo de atividades referenciais conseguiram demonstrar uma mudança em seu processamento. Portanto, ao criar atividades de SLA no computador, incorporar atividades do tipo referencial ajudará os alunos a mudar a maneira como processam as informações.

Palabra Chave

Aprendizagem de línguas assistida por computador, aquisição de uma segunda língua, processamento de entrada, instrução de processamento e leitura individualizada

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1. Introduction

The field of Second Language Acquisition (SLA) is about how learners acquire languages. Computer Assisted Language Learning (CALL) is somewhat difficult to define or shape. However, loosely defined, it's how the computer can aid in language teaching and learning (Beatty, 2013; Levy, 1997; Alvarez-Marinelli et al., 2016). So, for effective language learning to occur, it would be good to know how learners acquire languages first. Then, based on that information, computers can be an effective tool in delivering instruction. Without the "how" it is simply a tool that may or may not render results. One of the complaints in the literature is that there is an absence of SLA theory driving the technology (Parmaxi & Zaphiris, 2017; Ziegler et al., 2017; Ortega, 2017; Hegelheimer & Chapelle, 2000; Chappell, 2007; Doughty, 1987).

In a computer driven classroom, a learner's responses will be more prescribed than in the face-to-face classroom, as that is what a computer can react to. It cannot react to the spontaneous conversation and offer feedback like a teacher in a classroom can. This shows how SLA can inform on instructional materials that can be delivered electronically to language learners. SLA can improve CALL by informing how learners process input, which can then affect how CALL delivers the language input. In this way, CALL can provide the necessary feedback and interaction for the students to continue to negotiate for meaning in the target language even if it is not spontaneous. This is why CALL and SLA need to be more connected in the literature to have a bigger impact on language theory and acquisition.

To say that language acquisition is input driven means that learners construct an implicit linguistic system by comprehending messages in the target language. Input Processing (IP) looks at the moment-to-moment parsing of sentences and the connecting of formal features of a language with meaning during comprehension. Because not all input becomes intake and makes it in to be processed by the learner, IP looks at why this may be. It is designed to describe different types of forms that learners focus on during comprehension which are more likely to get processed and explain why other types might not (VanPatten, 2015). VanPatten (2015) describes three main principles of Input Processing which outline how learners grasp meaning from the input during comprehension (p. 95). Of particular interest to this study is the First Noun Principle. The First

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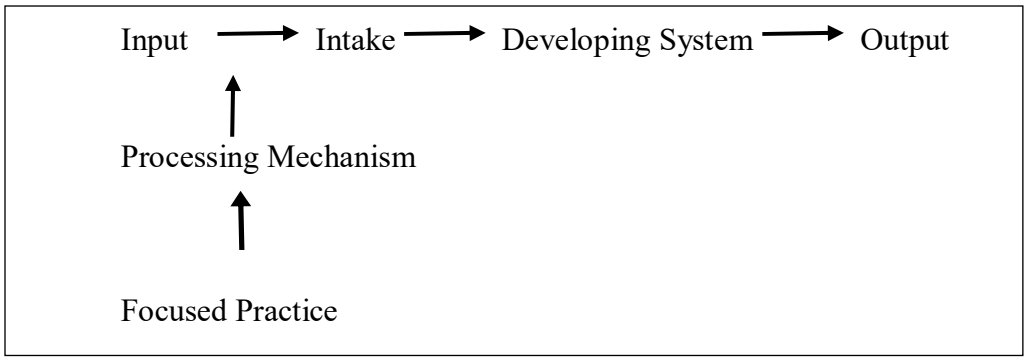
Noun Principle (FNP) states that learners tend to process the first (pro)noun of a sentence as the subject/agent

PI, which is informed by the SLA theory of IP, is the bridge between theory and classroom practice. "If processing is the linking of form with meaning, then a fundamental consideration in L2 research should be the strategies guiding or constraining how learners link form with meaning. This should inform a pedagogical intervention" (VanPatten, 2015, p.94). Knowing what learners are doing with the input during comprehension and how they are processing it can inform on how to teach grammar. PI is able to show if learners are attending to the grammatical information and making these form-meaning connections. Figure 1 shows how PI can directly impact instruction.

Figure 1

Processing Instruction Within Input Processing



Source: Lee & VanPatten (2003), p.142

By knowing which aspects of input learners are less likely to process and why, PI can be an important instructional intervention to amplify the amount of input that gets converted to intake. For example, knowing that learners often misinterpret object-first utterances due to the first noun principle this can guide (and has already guided) the creation of PI materials so that learners are more likely to understand "who does what to whom. When getting at the underlying problem that can change how input is processed, this allows communicative skill to be developed better in the target language as can be seen in (Cadierno, 1995; VanPatten & Cadierno, 1993; Benati, 2001). If instruction is to have an effect on the developing system, VanPatten & Cadierno (1993) state, "that rather than manipulate learner output to effect change in the developing system, instruction might

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seek to change the way that input is perceived and processed by the learner" (p. 227). It is for this reason that this study works with PI.

Literature Review. Sanz & Morgan-Short (2004), when initially putting PI into practice on the computer, found that only task-essential practice through Structured Input (SI) is what was necessary to affect change to processing input for the learners. Fernández (2008), along with Lee & Benati (2007), discovered that PI and more specifically Structured Input (SI) changes input processing in learners better when it's identifying a single form over assigning different grammatical roles in sentences. Finally, Henry (2015) showed how PI can be effective for altering how all input is processed but the data for this was marginal and overshadowed by the larger group.

In Henry's (2015) dissertation, he incorporated on-line processing through use of a Self-Paced Reading (SPR) exercise to look at reading times. "SPR is the most fundamental experimental measure employed by psycholinguists interested in processing at or above the level of the sentence. SPR was also the first on-line (i.e., real-time) method to be applied in non-native sentence processing research" (Jegerski & VanPatten, 2014, p.20). However, this seems to be the first time that SPR is being applied directly to a PI study. In this study, Henry is looking at how prosodic cues can impact the acquisition of morphosyntactic forms. He is looking again at the first noun principle with the nominative/accusative case marking on definite articles as the structure.

Since psycholinguistic measures like an SPR task measure how the learners are processing the input in each moment at each region, this is a different glimpse of how learners comprehend the input when compared to the sentence interpretation task. In the sentence interpretation task learners are being tested on their overall comprehension of the entire sentence. Therefore, adding in a psycholinguistic measure adds in another aspect of how leaners comprehend and process language. Henry's (2015) dissertation had a few participants who showed this restructuring but ultimately, their results were masked by the bigger group. If this is what PI advocates for: a change in processing input, then shouldn't this apply to all input and not just the structured input? Therefore, more learners should be showing a change in processing when applied to other input rather than just with the structured input. It is for this reason, that the present study implements a SPR task to test the learners' ability to process input and see if what the learners gain through PI can be applied to other input or if PI is limited in helping to change input processing only when applied to structured input activities.

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Research Questions. How can SLA theory inform on CALL so that it can be designed effectively and purposefully to benefit language acquisition? CALL has great potential in aiding language acquisition through its ability to provide an instant wealth of authentic language input. The question though, is what are the most effective practices of CALL for delivering this input in such a way that the input gets processed and has a chance to become intake? Therefore, the purpose of this study is to investigate how CALL can be tied to SLA pedagogy and theory. Does activity type: referential or affective activities in PI, when placed in a CALL environment affect L2 processing is the overall question driving this study. Specifically, this study looked at if there were any observable effects of activity type limited to the sentence-level interpretation task or if there were also effects seen on a moment-by-moment processing measure like SPR? Through using a Self-Paced Reading pre and post task, with structured input treatment on the computer via Qualtrics, a change in how learners are processing the input was investigated.

2. Methodology

Participants. The participants for this study were recruited from a public high school third-year Spanish class. Because all of the participants were drawn from the same level of Spanish, a standardize proficiency exam was not included in this experiment. However, a vocabulary test was administered to the participants at the end of the study for two reasons. First, anyone who made below 70% was eliminated from the study altogether. Secondly, it did provide an added measure of proficiency, along with self-reported proficiency ratings, to ensure that there were no differences among the groups. A One-way ANOVA was conducted to compare the effect of the four different groups on the vocabulary comprehension test. The ANOVA did not reveal a main effect for group for word order, $F(3, 58) = .973$, $p = .412$. The results of the vocabulary comprehension test can be seen in Table 1.

Table 1

Means for Vocabulary Measures for Word Order and Morphology Groups

Activity Group	Ref	Aff	R+A	Control
Variable (Range of Possible Scores)	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*
Word Order	87.38 (7.29)	88.79 (7.52)	89.65 (6.85)	85.53 (7.16)

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Standard Deviations in Parenthesis, Ref = Referential, Aff = Affective, and R+A = Referential Affective

All students in the third-year course had to have passed Spanish 2 with a grade of 70% or higher. Individuals were recruited from the Spanish 3 classes by offering them classwork participation points for each day they participated in the study. They were also given an alternate opportunity to receive classwork participation points by doing online workbook pages each day of the study.

The participants were divided into one of four groups: referential only (REF), affective only (AFF), referential plus affective (R+A), and a control group. There were 72 participants in total (N = 72). However, 1 person decided not to continue with the experiment after the first day, 4 more participants did not complete the language history questionnaire (LHQ) and vocabulary survey, so their data was also eliminated from the study. Of the 67 participants that were left, 3 more participants scored below the 70% on the vocabulary survey and were eliminated from the study as well. Finally, data from two additional participants were excluded. One person reported having English as their second language, and one more did not complete all of the tasks. This left a total of 62 participants for the Word Order study (N = 62). Each group contained the following number of participants: 1) Group R (n = 16), 2) Group A (n = 14), 3) Group RA (n = 17), and 4) Control Group (n = 15).

All participants filled out a consent form before participating, a language history questionnaire and a debriefing survey after completing all tasks. In order for a participant's data to be considered for this study, all of the following criteria had to be met and was evaluated per their language history questionnaire.

- They were a native speaker of English
- They did not speak more than 50% of another language at home other than English
- They attended every session and completed all required tasks (pretests, treatment, and posttests).
- They scored less than 80% on the interpretive pretest
- They scored 70% or higher on the vocabulary sheet

The reasons for each of these conditions was so that this study would be consistent with previous studies and therefore be able to compare the results with other research.

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Language History Questionnaire. The results of a 4 × 4 ANOVA showed that there was no effect for Group, $F(3, 58) = 1.68$, $p = .181$, nor was there a significant Skills × Group interaction, $F(9, 174) = .80$, $p = .609$. However, there was an effect for Skills, $F(3, 174) = 8.23$, $p < .001$. When analyzing the data further for this effect, it revealed that Group R rated their reading skill significantly higher than the other three skills in the language, ($.025 < p < .044$). Therefore, Group R felt more confident in their reading abilities than their writing, speaking, or listening abilities in the target language. The Control Group also rated their ability to read and write in the target language higher than their ability to speak, ($p = .046$). The results of this information can be found in Table 2.

Table 2

Means for Proficiency Measures for Word Order Task

Activity Group	Ref	Aff	R+A	Control
Variable (Range of Possible Scores)	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*
Self-rating: Reading Proficiency	3.28 (.85)	3.21 (.69)	3.52 (.71)	3.20 (.77)
Self-rating: Writing Proficiency	2.69 (.87)	2.79 (.69)	3.00 (.70)	3.20 (.67)
Self-rating: Speaking Proficiency	2.50 (.81)	2.92 (.61)	2.97 (.75)	2.53 (.83)
Self-rating: Listening Proficiency	2.38 (1.02)	2.71 (1.06)	2.82 (1.01)	2.87 (.74)

Standard Deviations in Parenthesis, Ref = Referential, Aff = Affective, and R+A = Referential Affective

Self-Paced Reading Task. The Self-Paced Reading (SPR) task used in this experiment was conducted using computers at the high school. Due to limitations and restrictions within the school district for software, this experiment was conducted with Qualtrics since it could time the participants response times in order to assess the participants' real-time processing behavior of SVO and OVS sentences. This study utilized a noncumulative format where only one word or phrase was visible at a time. Before each sentence, the participants saw a screen that instructed them to click on an arrow at the bottom right-hand side of the screen. This screen was not timed and was put after each sentence to help the participants refocus for the next sentence. As soon as the participant clicked the arrow, the first word or phrase would appear in the sentence. The word would then disappear as the participant moved on to another word. In using Qualtrics, the words

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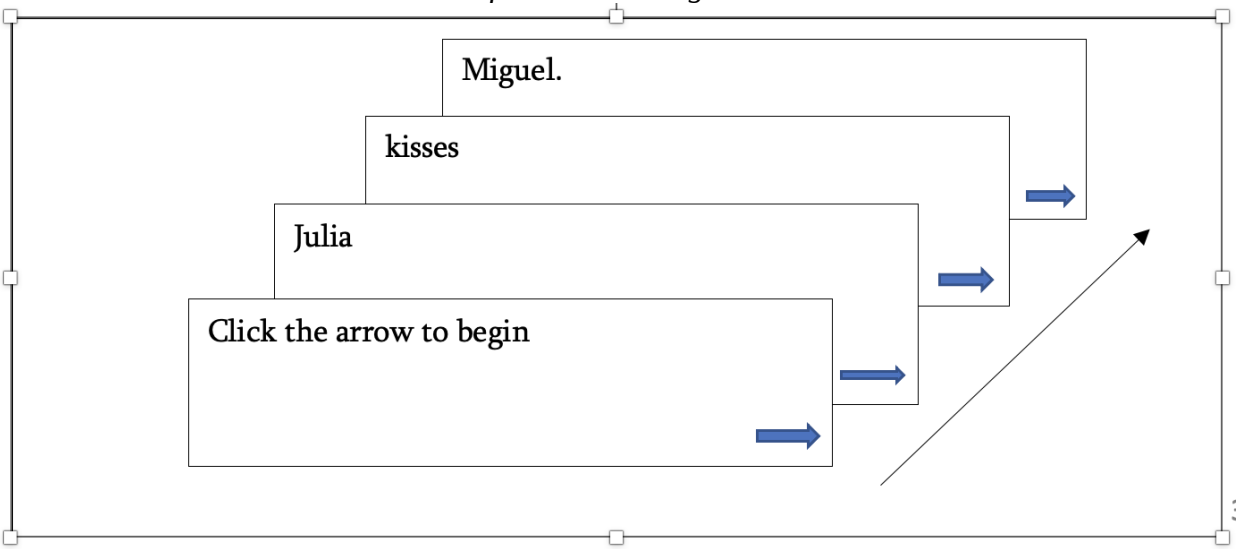
did not show up linearly in that they moved from left to right as in a sentence. All words showed up at the left-hand side of the screen and then the students would click an arrow on the right-hand side of the screen to advance to the next section. In this way, the participants would individually click an arrow to move from word to word in order to read through the whole sentence. See Figure 2 for an example.

Figure 2
Self-Paced Reading Task



While doing this task, the computer would record how much time each participant spent parsing the sentence at each region measured in milliseconds. The goal behind using a SPR task is to look at the cognitive processing that is going on while a learner is parsing a sentence. "Relatively longer reading times are taken as indications of processing difficulty, while faster reading times are interpreted as a sign that facilitation occurred" (Jegerski, 2014, p.24). Therefore, in this study, if there has been a change in processing for either structure, this should be displayed through longer reading times at specific regions. As participants become aware of different structures in the Spanish language, they would show sensitivity to different time marking morphemes and object markers by taking longer to process them. However, if there is no time difference between the two tests, then it can be assumed that the participants' processing has not been altered and they have not noticed the different structures.

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After each sentence a comprehension question would appear to make sure they had understood the meaning of the sentence. Not every sentence had a comprehension question afterwards so that the participants would pay attention and not develop patterns for the comprehension questions. An example of this can be seen in examples (1a) and (1b). The participants first completed 4 practice sentences with comprehension questions and then advanced to the main experiment. Sentences from each experimental and filler conditions were pseudo randomized so that the participants did not see a sentence from the same category two times in a row.

(1a) WO Sentence: SOV with object pronoun

David ve que / **Julia lo besa** / *en la tienda* / a *las cinco*.
David sees that Julia$_{NOM}$ him$_{ACC}$ kisses in the store at 5 o'clock.
David sees that Julia kisses him in the store at 5 o'clock.

(1b) WO Comprehension Question: *¿David besa a Julia?* (Does David kiss Julia?)

The word order task was a hard task since the learners had to maintain the entire sentence in their working memory in order to comprehend who did what to whom in the sentence. Also, the learners only saw parts of the sentence at a time and could not review the sentence which makes it more difficult to retain the information in the working memory. Jegerski (2014) comments on the point of comprehension questions after stimuli and says, "the purpose of this post stimulus task is to give participants a clear purpose for reading the stimuli so that they pay attention to them for the duration of the experimental session" (p.10). She goes on to say that that participants believe that the comprehension questions are the primary measure of interest. Therefore, they do not realize that what is being looked at while they are reading the sentences is of any interest. This is why it is good to keep the participants focused on the sentences. Due to this, the types of questions being asked for each target form are different.

During the SPR task, participants saw a total of 54 sentences. Eighteen experimental sentences that pertained to the word order structure, 18 experimental sentences that pertained to the past versus present tense morphemes, and 18 sentences were fillers. There were 4 sentences that the participants saw at the beginning to practice with. As participants become aware of different structures in the Spanish language, they would show sensitivity to different time marking morphemes and object markers by taking longer to process them. However, if there is no time difference between the two tests, then it can be assumed that the participants' processing has not

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been altered and they have not noticed the different structures. A complete list of all of the SPR sentences can be found in Appendix A.

Experimental Sentences OVS. There were 18 experimental sentences that targeted word order. Each target sentence contained a NP-V-NP sequence to manipulate the location of the object in the sentence. So that the target region did not come at the beginning, each sentence was introduced by a prepositional phrase that led into the target region but did not provide any context as to what the sentence would be about. Also, the object pronouns were used to add emphasis to the object as another way to show flexible word order. Each NP-V-NP sequence was then followed by one or two prepositional phrases to avoid sentence wrap up effects at the end of the sentences on the target region. These sentences were then divided into 4 regions. All sentences had region 2 as the critical region and regions 3 and 4 as the spill over/wrap up regions. According to Jegerski (2014), the end of the sentences can reflect later comprehension and processing difficulty. Due to this, region 3 was the spill over region and region 4 was also considered an important region to look at as well being the wrap up effects region. In example (2) the slash marks represent how the sentence is divided up into regions, bold-faced type indicates the critical regions and the italicized parts indicate the spillover areas.

(2a) SOV with object pronoun

David ve que **/ Julia lo besa** / *en la tienda* / a *las cinco*.
David sees that Julia$_{NOM}$ him$_{ACC}$ kisses in the store at 5 o'clock.
David sees that Julia kisses him in the store at 5 o'clock.

(2b) OVS with object pronoun
David ve que **/ lo besa Julia** / *en la tienda* / *a las cinco*.
David sees that him$_{ACC}$ kisses Julia$_{NOM}$ in the store at 5 o'clock.
David sees that Julia kisses him in the store at 5 o'clock.

(2c) *SVO with object pronoun
*David ve que **/ Julia besa lo** / *en la tienda* / a *las cinco*.
David sees that Julia$_{NOM}$ kisses him$_{ACC}$ in the store at 5 o'clock.
David sees that Julia kisses him in the store at 5 o'clock.

These stimuli were divided up into 3 counterbalanced lists so that the participants only saw one version of each sentence. Therefore, each participant saw 6 sentences from each of the previously described conditions. After each sentence, the participants had to answer a

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comprehension question in Spanish. The questions were presented in Spanish to check for understanding of the information as well as to minimize any cross linguistic influence between the two languages since these are less fluent participants (Talamas et al., 1999). The participants clicked "Sí" or "No" to respond to each question. Half of the answers were "sí" and half of the answers were "no". Most of the words in the target regions were common verbs that can be found in many Spanish 1 textbooks and are recycled many times when learning in a classroom environment. Also, several cognates were used to help facilitate comprehension since it has been seen that bilinguals recognize cognates more quickly (Dijkstra et al., 1999). Some comprehension questions were related to who does what to whom and others were related to where the action took place. This way the participants did not develop a pattern for what they were going to be asked but had to read for comprehension so that they could respond to any part of the sentence. By using meaning-based comprehension questions, the participants were having to pay attention to the whole sentence and therefore this task could examine the implicit knowledge gained rather than the explicit knowledge of a grammatical rule application. Finally, these types of questions are going to be more taxing on the working memory of the participants since they will have to retain the whole sentence in order to answer the question correctly.

Procedure. The participants were asked to do the consent form before arriving. Then, when they arrived on the first day, they were asked to look over a vocabulary sheet before they performed the self-paced reading (SPR) task. After the SPR task they moved into the treatment phase for the second and third days. The second and third days were very similar. The participants started with a sentence interpretation task as a pretest and then did the treatment. During the treatment, the participants were working with structured input material. Finally, right after the treatment, they took the immediate posttest which was the sentence interpretation task again. A week later, the participants returned and completed a delayed posttest on the sentence interpretation task for word order. They also took the SPR task again. Afterwards, they completed a vocabulary survey to demonstrate knowledge of the words, they completed their language history questionnaire, as well as a debriefing survey. This was all done at the end to make sure we were within time constraints for the class since the participants completed all tasks during their normal Spanish class hour throughout the day.

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Scoring Methods. For the vocabulary sheet each participant received 1 point for every word they checked saying that they knew and 0 points for every word they checked saying that they did not know. This gave them a maximum total of 100 points. Everyone who scored 70% or higher was included in this experiment.

Data Analyses. For the SPR task, this gave an offline test of comprehension with an online test of processing time. The comprehension scores were scored as either correct or incorrect. Then, for all of the questions answered correctly amongst the experimental items, the times for the critical regions and spillover regions were compared using a mixed effects model. This was to examine if longer times had been spent in processing from the first to the second time in which the participants took the test.

3. Results

To see the full results for the interpretation task, refer to Author's dissertation for the complete study. Overall, groups R and RA showed significant gains on the interpretation task. Group A and the Control group showed no improvement. For the SPR task for this study, reading times (RTs) for each region of the sentence were analyzed as well as the participant's responses to comprehension questions using SPSS. Therefore, both an online measure of processing speed was calculated as well as an offline measure of accuracy. The accuracy results will be presented first, followed by the RT results.

Accuracy Results for Word Order Sentences. Table 3 displays the comprehension accuracy of the word order sentences. Overall, the comprehension accuracy is quite low for all groups. This is because for Word Order, the participants had to maintain the entire sentence in their working memory in order to figure out who did what to whom. A 2 × 4 ANOVA revealed that there was no effect for Test, $F(1, 58) = .00$, $p = .960$, nor an interaction for Test × Group, $F(3, 58) = 1.25$, $p = .299$. However, there was a main effect for Word Order, $F(2, 116) = 160.43$, $p < .001$, a main effect for Group $F(3, 58) = 2.94$, $p = .041$, a significant Word Order × Group interaction, $F(6, 116) = 2.15$, $p = .052$, a significant Word Order × Test interaction, $F(2, 116) = 43.48$, $p < .001$, and finally a three way interaction that was approaching significance for Word Order × Test × Group, $F(6, 116) = 1.92$, $p = .082$. For the Word Order × Group interaction, the pairwise comparison with the Bonferroni adjustment for multiple comparisons revealed that all groups performed better on the pretest with SVO sentences, ($.001 \leq ps \leq .028$) ranging from a small to a large effect size (.78

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$\leq d \leq 1.75$). All groups also performed better on the posttest for SOV sentences ($.001 \leq p \leq .034$). Cohen's *d* for all groups range from ($.76 \leq d \leq 1.76$) revealing a small to large effect size for all groups. Lastly, in looking at the OVS sentences the groups differ. Referential is the only group that performed better on the posttest with these sentences, ($p = .055$), producing a small effect size of ($d = .57$). All other groups did better on the pretest with OVS ($.022 \leq ps \leq .875$), reaching significance only for the Control group with a small effect size for this group, $d = .65$. In looking closer at the pairwise comparison, it shows that the Referential Group is significantly different from the Affective and Control groups with the OVS structures on the posttest, ($.002 \leq ps \leq .052$) which produced a medium to large effect for both groups ($1.07 \leq d \leq 1.67$). The Referential Affective group also reached significance on the OVS structures on the posttest when compared to the Affective group, $p = .017$. This produced a medium effect size, ($d = 1.15$). Table 3 exhibits the mean accuracy scores for the different word order sentences along with the standard deviations.

Table 3

Accuracy Results for Word Order Sentences with Means, Standard Deviations in Parentheses.

Sentence Type	SVO		SOV		OVS	
Measure	Pre	Post	Pre	Post	Pre	Post
Groups	*M* *SD*	*M* *SD*	*M* *SD*	*M* *SD*		
Referential	.32 (.05)	.27 (.05)	.18 (.06)	.23 (.07)	.12 (.06)	.17 (.07)
Affective	.32 (.04)	.25(.05)	.17 (.04)	.25 (.05)	.10 (.07)	.06 (.06)
Ref Aff	.32 (.04)	.26 (.10)	.19 (.05)	.29 (.12)	.15 (.06)	.15 (.09)
Control	.32 (.04)	.25 (.04)	.20 (.06)	.27 (.04)	.15 (.09)	.10 (.06)

SVO=Subject Verb Object, SOV=Subject Object Verb, OVS=Object Verb Subject, Pre=Pretest, Post=Posttest, and Ref Aff=Referential Affective Group.

RT Results for Sentences Targeting Word Order. Unlike L1 and L2 psycholinguistic research that only considers reading times for sentences for which the comprehension question was answered, all sentences were included in the analyses for the following reasons. First, the low accuracy on the comprehension questions would result in the exclusion of 30 to 40% of the data. Second, the present study is examining overall processing behavior before and after an instructional treatment. If participants were correctly answering most of the prompts correctly on

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the pretest, then they would not be in need of instruction. Because of the low accuracy results, the decision was made not to exclude sentences for which the comprehension question was answered incorrectly.

Prior to statistical analysis, reading times below 200 milliseconds or great than 5000 milliseconds for each sentence region were treated as outliers and excluded from analyses. This affected 8.1% of the data. RTs were log10 transformed to reduce the positive skew that is typical of reaction time data, as suggested by Larson-Hall (2015) and Tabachnick and Fidell (2001). Then I converted everything back into milliseconds to be comparable with other research in the field. Alpha was set at .05 for all analyses. All data were analyzed via linear mixed effects models using SPSS version 25. The final model included the fixed factors group, test, and grammaticality, and a random intercept for subject. Random slopes did not improve the model fit.

Of particular interest in the reading time analyses are significant Test × Group × Grammaticality interactions. To explore these interactions, pairwise comparisons were conducted that focused on the following: (a) between group differences by grammaticality condition on the posttest, and (b) differences between grammatical and ungrammatical sentences by group at each test.

For the sentences targeting word order, each sentence was divided into 4 regions. An example is shown in (4a-c).

(4) a. Los padres ven que / los ayuda Roberto / en la puerta / de su casa.

b. Los padres ven que / Roberto los ayuda / en la puerta / de su casa.

c. *Los padres ven que / Roberto ayuda los / en la puerta / de su casa.

1 2 3 4

As can be seen, Region 2 is the target region with regions 3 and 4 being the spill over and wrap up effect regions. Regions 3 and 4 are prepositional phrases to check for delayed reactions from the participants. Thus, the regions of interest for word order sentences were regions 2, 3, and 4. Therefore, Table 4 presents the descriptive statistics for the mean RTs in milliseconds.

Table 4

Descriptive Statistics of Mean Reading Times (in milliseconds) and Standard Deviations (in Parentheses) for Word Order by Region and Condition

Region	2	3	4

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Test	Pre	Post	Pre	Post	Pre	Post
Condition						
Group R						
Grammatical	1778	1023	977	602	851	524
	(.16)	(.16)	(.16)	(.16)	(.12)	(.12)
Ungrammatical	1513	1071	977	676	891	645
	(.20)	(.20)	(.16)	(.16)	(.16)	(.16)
Group A						
Grammatical	1584	977	954	691	870	537
	(.18)	(.14)	(.14)	(.14)	(.14)	(.11)
Ungrammatical	1584	912	1000	549	870	588
	(.18)	(.18)	(.14)	(.18)	(.14)	(.14)
Group RA						
Grammatical	1949	1202	977	707	831	562
	(.16)	(.16)	(.16)	(.16)	(.12)	(.12)
Ungrammatical	1819	1096	977	660	870	588
	(.20)	(.20)	(.16)	(.16)	(.16)	(.16)
Group C						
Grammatical	1905	1737	1047	851	870	741
	(.15)	(.15)	(.15)	(.15)	(.11)	(.11)
Ungrammatical	1949	1548	1096	851	977	812
	(.19)	(.19)	(.15)	(.19)	(.15)	(.15)

Group R=Referential, Group A=Affective, Group RA=Referential and Affective, Group C=Control

The results of the linear mixed model for Region 2, the target region, revealed a marginally significant effect for Group, $F(3, 63) = 2.47$, $p = .069$, and Grammaticality $F(1, 1280) = 3.34$, $p = .068$. There was a significant main effect for Test, $F(1, 1032) = 173.94$, $p < .001$, and a significant Group × Test × Grammaticality interaction, $F(10, 1046) = 3.53$, $p < .001$. To explore this

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interaction, pairwise comparisons with a Bonferroni adjustment for multiple comparisons revealed the following. For between group differences by grammaticality and test, pairwise comparisons revealed that Groups R and A were significantly faster than the control group for grammatical sentences on the posttest ($.002 \leq ps \leq .005$). Group A was significantly faster than the control group for ungrammatical sentences on the posttest ($ps < .019$). All three of these between group differences obtained large effect sizes ($1.21 \leq d \leq 1.72$). For differences between grammatical and ungrammatical sentences, pairwise comparisons revealed that Group R read ungrammatical sentences faster than grammatical sentences on the pretest ($p = .049$), which resulted in a small effect size ($d = .38$). No other significant differences were found between grammaticality conditions for the other groups on either test ($ps > .172$). Tables 5 and 6 summarize the main findings of the pairwise comparisons for the Group × Test × Grammaticality interaction.

Table 5

Group Pairwise Comparisons for Word Order Sentences in Region 2 (Target Region)

Finding	Test	Condition	*Mean Difference*	*SE*	*df*	Cohen's *d*
Referential < Control	2	Grammatical	.22**	.06	81.94	1.48
Affective < Control	2	Grammatical	.24**	.06	81.11	1.72
Affective < Control	2	Ungrammatical	.22**	.07	118.11	1.21

*$p < .05$, **$p < .01$

Table 6

Grammaticality Pairwise Comparisons for Word Order Sentences in Region 2 (Target Region)

Finding	Test	Group	*Mean Difference*	*SE*	*df*	Cohen's *d*
Ungram < Gram	1	Referential	.07*	.03	845.00	.38

*$p < .05$.

For Region 3, which is the spill over region when participants can start to process the errors they have just seen. The results of the linear mixed model revealed no effect for Group, $F(3, 64) = 1.51$, $p = .218$ nor for Grammaticality, $F(1, 1905) = .13$, $p = .711$. However, there was a significant effect for Test, $F(1, 1576) = 138.64$, $p < .001$, and a significant Group × Test ×

Grammaticality interaction, $F(10, 1650) = 2.06$, $p = .024$. A pairwise comparisons with a Bonferroni adjustment for multiple comparisons was used to explore further the interaction. For between group differences by grammaticality and test, pairwise comparisons showed the following differences: when compared to the Control group, Group R processed faster the grammatical items on the posttest ($p = .030$) and Group A processed faster the ungrammatical items on the posttest ($p = .011$). For both groups this was a medium size effect according to Plonsky & Oswald (2014), ($.96 \leq d \leq 1.02$). Finally, in this region, a pairwise comparison revealed for grammaticality that Group A processed ungrammatical items faster than grammatical ones on the posttest. The effect size was small ($d = .62$). Finally, no other groups revealed any significant effects ($ps > .193$) for this region. Tables 7 and 8 presents the results for region 3.

Table 7

Group Pairwise Comparisons for Word Order Sentences in Region 3 (1st Spill Over Region)

Finding	Test	Condition	*Mean Difference*	*SE*	*df*	Cohen's *d*
Referential < Control	2	Grammatical	.15*	.05	96.81	.96
Affective < Control	2	Ungrammatical	.19**	.06	168.53	1.02

*$p < .05$, **$p < .01$

Table 8

Grammaticality Pairwise Comparisons for Word Order Sentences in Region 3 (1st Spill Over Region)

Finding	Test	Condition	*Mean Difference*	*SE*	*df*	Cohen's *d*
Ungram < Gram	2	Affective	.10**	.41	1413.04	.62

*$p < .05.$, **$p < .01$

According to the results of the linear mixed model for Region 4, the wrap-up effects region, there was no effect for Group $F(3, 64) = 1.98$, $p = .124$. However it did reveal a significant effect for Test, $F(1, 1635) = 143.80$, $p < .001$, and Grammaticality $F(1, 1911) = 7.44$, $p = .006$ as well as a significant Group × Test × Grammaticality interaction, $F(10, 1752) = 2.35$, $p = .009$. Pairwise comparisons for between group differences by grammaticality and test indicated the following

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differences: All 3 treatment groups, Groups R, A and RA (.006 ≤ *p*s ≤ .037), processed the grammatical items faster on the posttest when compared to the control group. These were all medium size effects (1.03 ≤ *d* ≤ 1.30). Also, there is a marginal effect for the processing of ungrammatical items on the posttest for Groups A and RA (.065 ≤ *p*s ≤ .067) when compared to the control group. Even though it is approaching significance, it resulted in a small size effect (.90 ≤ *d* ≤ .96). When looking at the grammaticality, the pairwise comparisons revealed that Group R read grammatical sentences faster than ungrammatical ones on the posttest (*p* = .016), which resulted in a small effect size (*d* = .63). There were no other effects found for the other groups concerning grammaticality (*p*s > .257). Tables 9 and 10 present the findings from region 4.

Table 9

Group Pairwise Comparisons for Word Order Sentences in Region 4 (2nd Spill Over Region)

Finding	Test	Condition	*Mean Difference*	*SE*	*df*	Cohen's *d*
Referential < Control	2	Grammatical	.15**	.04	107.79	1.30
Affective < Control	2	Grammatical	.14**	.04	106.78	1.27
Referential Affective < Control	2	Grammatical	.12*	.04	104.23	1.03
Affective < Control	2	Ungrammatical	.14	.05	208.33	.96
Referential Affective < Control	2	Ungrammatical	.13	.05	193.72	.90

*p < .05, **p < .01

Table 10

Grammaticality Pairwise Comparisons for Word Order Sentences in Region 4 (2nd Spill Over Region)

Finding	Test	Condition	*Mean Difference*	*SE*	*df*	Cohen's *d*
Gram < Ungram	2	Referential	.02**	.03	1426.39	.63

*p < .05., **p < .01

Summary of Results for Word Order.

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- Group R was reading faster than the Control group the grammatical items in regions 2, 3, and 4 on the posttest.
- Group A was significantly reading faster than the Control group the ungrammatical items in regions 2 and 3 on the posttest. Group A read marginally faster than the Control group the ungrammatical items in region 4 on the posttest as well.
- In region 3, Group A read the ungrammatical sentences faster than the grammatical ones for a medium effect on the posttest.
- In region 4 all three treatment groups R, A, and RA read the grammatical sentences faster than the Control group on the posttest.
- In region 4 on the posttest, Group R read the grammatical sentences faster than the ungrammatical ones for a small effect.

4. Conclusion

Self-Paced Reading: Word Order Accuracy Results. The SPR was designed so that when participants read a sentence directly related to the FNP they would then have to answer a comprehension question to check their processing. These questions were performed in Spanish to diminish language interference since the L1 was still active. The accuracy scores for word order showed that all participant groups did slightly worse on the posttest with SVO sentences (32% on pretest for all groups, 25-27% on posttest). Also, all groups improved on the posttest with SOV sentences (18% pretest ≤ 23% posttest). This could be since the first noun is still the subject first just like in SVO sentences. Therefore, a gain in these sentences is not a complete switch since the participants are still presented with subject first then object. They can rely on the FNP for these sentences and get them correct. Finally, on the posttest for OVS sentences, only group R improved (12% pretest, 17 % posttest). Group A (10% pretest, 6 % posttest) and Control (15% pretest, 10 % posttest) did worse. Group RA maintained its scores (15% both tests). Group RA experienced the most improvement with the sentence interpretation task, yet only showed improvement with accuracy on the SOV sentences in the SPR. In looking at these results, it is apparent that they were not able apply the changes from the sentence level interpretation task to the SPR task.

Another aspect to this study that arose from the results were the lower accuracy scores for the word order. The first thing to keep in mind is that for word order, the questions were about the target item. To answer them correctly, the participants had to maintain the whole sentence in

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their working memory and understand syntactical information to know who did what to whom. Not only was this a hard task, but there were other task demands the participants had to engage in as well like taxing their working memory. In Spanish, not only are the learners having to process syntactic knowledge for the FNP to figure out who is the subject/object, but they are also reassigning meaning for words that they have already learned as articles. Figure 3 illustrates the shared forms between articles and object pronouns.

Figure 3
Shared Forms Between Articles and Object Pronouns in Spanish

Gender	Articles		Object Pronouns	
	Singular	Plural	Singular	Plural
Masculine	el	los	lo	los
Feminine	la	las	la	las

This involves the One-to-One Principle developed by Anderson (1984) where learners assign one meaning with one form. As mentioned earlier, the FNP creates more difficulty within this task as learners are not only processing syntactic information for assigning agent/patient roles, but also processing form and reassign meaning between articles and object pronouns. Finally, the learners must process other syntactic information within the sentence to correctly interpret with whom the object pronoun is associated with in the sentence. This shows that learners are now asked to tax their memory stores, reassign meaning to other forms and process syntactic information correctly. VanPatten et al. (2013) also found evidence of the One-to-One principle for the Spanish portion of their study with the FNP.

Implications for Second Language Instruction. Levy et al. (2015) comment that "CALL design is about constructing CALL environments purposefully such that learning does not occur by accident, but through an understanding of the key factors or variables that impact upon it" (p. 3-4). Using CALL to do a PI study has helped provide the theory and support for what works best when implementing second language instruction into a CALL environment. The results of this study suggest that using referential questions with specific right or wrong feedback is essential to helping learners process input. Not only do they get immediate feedback on how they are processing the input, it also helps them apply what they are learning to other types of input that they encounter. This was seen with the results on the SPR test. The referential group was able to

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make a change in the way they were processing the input for the word order study. Referential activities help learners focus on the form within a meaningful context.

With CALL that is unlike a classroom, students can just click through the questions and make guess work with the answers without having to really pay attention to anything. This does nothing for them gaining more intake into their linguistic systems. There were at least 8 participants that admitted to doing just that during this experiment. This can be a negative aspect to CALL design. However, there are some functions to CALL that can be implemented to help avert this issue, like putting a timer on the page so that students cannot just click through but are presented with the information for a certain amount of time. This prevents the students from clicking through the page but cannot force them to utilize the time to read through the information presented. Using graphics and staying away from having heavy text slides could provide more motivation in having the learners read through the information on the screen. For lower learners that might feel frustrated with the language, using more highly frequent vocabulary items to encourage them to read through the materials is also recommended.

A comment from the debriefing surveys was that when learners didn't know all the vocabulary in the text, they would just skip the question. This emphasizes the point that early in the language journey, learners are more dependent upon lexical-level associations rather than conceptually mediated associations as proposed in the Revised hierarchical model (Kroll & Stewart, 1994; Talamas, et al., 1999). The learners are dependent upon the lexical connection between the L1 and L2 and therefore, if they don't know some of the words, instead of trying to figure them out as some will do, several will go ahead and just click an answer to move on to the next question. Therefore, in designing questions in CALL, keep in mind the lexical vocabulary that the students have and use more known words to help facilitate learner engagement so that they won't just click to move on to the next question.

Limitations and Future Research. The main limitation to this study was the small number of participants that participated in this study. This limits the effects that can be found and the generalizability of the findings to the SLA field at large. If there had been more participants, perhaps this result would have been more significant. This shows how more robust findings could be provided with more participants. Therefore, it would be good to replicate this study with more participants to corroborate the results obtained. As this was a first trial for my doctoral research,

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there are plans to verify it in the future with more participants. In replicating the SPR task in the future I would like to up the amount of the target items that the participants see. This study only included 50 items for each group to stay consistent with other PI studies like VanPatten et al. (2013). However, by increasing this amount to 100 or 150 items to see if that could affect a greater change in processing on a SPR task. This would also be worthwhile to investigate. Finally, this study did not immediately test the learners right after the treatment with the SPR. It would be interesting to see if there were any changes to the processing of input right after receiving the treatment compared with what was shown a week later.

In this study, I investigated the effectiveness of the different activity types of PI when presented within a CALL setting. Based on the results of this study, the following was revealed: activity type does affect L2 processing. There was emerging data that shows referential activities were starting to enact a change in processing of all data and not just the structured input based on the SPR results. Affective activities by themselves provide no significant gains in the target language. Referential activities help learners apply this knowledge to other input and not just the structured input they have seen in the treatment. Incorporating an Input Processing study with CALL and the use of psycholinguistic tests helps bring an understanding of how the input learners are exposed to, becomes intake. Knowing that there is a lack of research tying CALL to SLA (Ortega, 2017; Zeigler et al., 2017; Parmaxi & Zaphiris, 2017), I sought to link these two fields together through investigating how learners process input. Taking into consideration these different findings, it can shed some light on how best to design CALL activities in SLA environments in order to best help the learners process the input and incorporate more input into their intake.

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APPENDIX A

SELF-PACED READING TASK

SPR Sentences for Word Order

1. * Valeria dice que/ Esteban besa la/ en el jardín / apasionadamente. ¿Esteban besa a Valeria en el jardín? Yes
2. Miguel dice que / Julia lo espera / en la tienda / a las cinco. ¿Miguel espera a Julia? No
3. Los padres ven que / los ayuda Roberto / en la puerta / de su casa. ¿Roberto ayuda a sus padres? Yes
4. *Mi hija ve que / los maestros hablan me / en la escuela / por una hora. ¿Los maestros hablan por dos horas? No
5. Los tíos dicen que / María los busca / para hablar / de su viaje. ¿María busca a sus tíos? Yes
6. El tío sabe que / te visitan los amigos / para una fiesta / de cumpleaños. ¿Tú visitas a los amigos? No
7. * Un amigo dice que / tú invitas lo / para cenar / en el restaurante. ¿Tú invitas a un amigo para cenar? Yes
8. Eva dice que / la maestra nos busca / para practicar / el español. ¿Nosotros buscamos a la maestra? No
9. Su madre ve que / la escucho yo / llamando a su hija / por teléfono. ¿Yo escucho a la madre? Yes
10. * Juan dice que / sus padres no comprenden lo / cuando / canta en chino. ¿Los padres no comprenden a Juan cuando canta en inglés? No
11. Mateo dice que / la esposa lo busca / del trabajo / en la tarde. ¿La esposa busca a Mateo? Yes
12. Nicolás dice que / lo llaman los padres / desde/ el dormitorio. ¿Nicolás llama a sus padres? No
13. * Lucia dice que / la señora pide me/ mudarme / de casa. ¿La señora me pide mudarme de casa? Yes
14. Rita dice que/ nosotros la escuchamos / cantar/ en español. ¿Nosotros escuchamos a Rita tocar música en español? No
15. En navidad/ me sorprende mi mamá / con/ un regalo caro. ¿Mi mamá me sorprende con un regalo caro? Yes
16. * En la escuela/ los abuelos visitan me / para/ una fiesta. ¿Los abuelos me visitan para asistir un concierto? No

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17. En el examen/ la amiga te copia / para sacar / una buena nota.
18. La chica dice que / la saludo yo/ en la escuela/ por la mañana.

Morphology Sentences

19. Ahora\ Pedro\ toma\ un refresco\ en\ el salón. ¿Pedro toma un refresco en la tienda? False
20. *Ayer\ Alejandro saca\ un libro\ de\ la mesa. ¿Alejandro saca un cuaderno de la mesa? False
21. Ayer\ Isabel \ miró\ un programa\ con\ varios amigos. ¿Isabel mira un programa con su hermano? False
22. Ahora\ Sancho\ busca\ el lápiz\ en\ el otro escritorio. ¿Sancho busca un bolígrafo en el otro escritorio? False
23. *Ayer\ Dylan \ paga\ el alquiler\ de\ este mes. ¿Dylan paga su carro este mes? False
24. Ayer\ Elena \ lavó\ el auto\ con\ los hermanos.
25. Ahora\ Rosa\ toca\ el piano\ en\ un concierto.
26. *Ayer\ Ariana \ prepara \ el pastel\ con\ sus amigos. ¿Ariana prepara el pastel con sus amigos? Cierto
27. Ayer\ Erica\ habló\ con\ los doctores. ¿Erica habla con los doctores? Cierto
28. Ahora\ Ronaldo\ juega\ videojuegos\ en\ la sala. ¿Ronaldo juega videojuegos en la sala? Cierto
29. *Adriana\ enseña\ ayer\ ciencias \ en\ otro edificio. ¿Adriana enseña ciencias en otro edificio? Cierto
30. Víctor \ bailó\ ayer\ al ritmo\ de\ mucha música. ¿Victor baila al ritmo de mucha música? Cierto
31. Diego\ comienza\ ahora\ el trabajo\ en\ la oficina. ¿Diego comienza el trabajo en la oficina? Cierto
32. *Verónica\ revisa\ ayer\ el examen\ con\ el profesor. ¿Veronica revisa el examen con el profesor? Cierto
33. David \ limpió\ ayer\ su carro \ sin\ mucha jabón. ¿David limpia su carro sin mucha jabón? Cierto
34. Richard\ compra\ ahora\ un libro\ en\ el parque central. ¿Richard compra un libro de la librería? False
35. *Valeria \ busca \ ayer\ un teléfono \ en\ varias tiendas. ¿Elías trabaja en casa? False
36. Laura \ criticó\ ayer\ el plan\ de\ muchos políticos. ¿Laura critica el plan de muchas secretarias? False

Distractor Sentences

37. Yo/ veo /un carro rojo /en/ la calle.
38. Jorge /va/ al cine /con su novia /Adriana.
39. Sofia /tiene/ tres mascotas /y quiere /una vaca/ también.
40. Durante el viaje / Jaime y Alex/ no durmieron/ pero/ leyeron novelas.
41. Los padres de Ruth/ murieron / hace dos años/ y ella/ está triste.
42. Linda / tiene que/ lavar los platos/ todos /los fines /de semana.
43. Roberto y Juan / van/ a la playa/ todos los días.
44. A Laura /le interesa jugar /al tenis/ y al golf.
45. A mí / no me gusta / tomar cursos / por internet.

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46. Mi compañera de cuarto / es/ de California/ y Senia / es/ de Alabama
47. Santiago y yo/ manejamos/ a Nueva Orleans/ durante/ el carnaval.
48. Los niños/ no/ duermen mucho/ cuando/ tienen fiebre.
49. Los estudiantes/ toman/ muchos exámenes/ durante/ el año.
50. La madre/ compró/ la comida/ ayer/ en la tienda/ para los niños.
51. Los músicos/ cantan/ en/ un concierto/ todo el día.
52. Los amigos/ salieron/ ayer/ por la noche.
53. El turista/ pagó/ treinta dólares/ por su comida.
54. Sebastián/ viajaba/ en tren/ por Europa.