The Maze Task Mobile: Using a Psycholinguistic Experimental Technique as a Pedagogical Tool for Language Learning [1]

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Abstract

This study presents a mobile application of the maze task as a complementary activity for second language learning. The application facilitates conducting linguistic training sessions with the maze task for both pedagogical and experimental purposes. We designed the Maze Task Mobile, used it in English classes with native speakers of Brazilian Portuguese, and analyzed students' perceptions through an attitude survey. Besides presenting the application in detail, we discuss the results from the survey and from participants' accuracy in the task, highlighting the benefits of this first mobile version of the maze task as well as improvements needed for future development.

Keywords: maze task; pedagogical tool; mobile application. linguistic training; second language learning.

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O Maze Task Mobile: Utilizando uma técnica experimental da Psicolinguística como ferramenta pedagógica para a aprendizagem de línguas

Resumo

Este estudo apresenta um aplicativo móvel da tarefa labirinto como atividade complementar para o aprendizado de segunda língua. O aplicativo facilita a realização de sessões de treinamento linguístico com a tarefa de labirinto tanto para fins pedagógicos como experimentais. Projetamos o Maze Task Mobile, utilizamo-lo em aulas de inglês com falantes nativos do português brasileiro e analisamos as percepções dos alunos por meio de uma pesquisa de atitude. Além de apresentar o aplicativo em detalhes, discutimos os resultados da pesquisa e da precisão dos participantes na tarefa, destacando os benefícios desta primeira versão móvel da tarefa do labirinto, bem como as melhorias necessárias para o desenvolvimento futuro.

Palavras-chave: tarefa labirinto; ferramenta pedagógica; aplicativo móvel; treinamento linguístico; aprendizagem de segunda língua.

INTRODUCTION

Mobile learning, or m-learning, is the ability to generate knowledge and acquire information through a portable digital device. This phenomenon has gained relevance in Brazil, where there are 230 million smartphones, according to the 30th Annual Survey of the FGVcia (MEIRELLES, 2019). This paper presents a mobile application of the maze task, a pedagogical tool proposed by Enkin and Forster (2014) as a complementary activity for second language (L2) learning, and the results of an attitude questionnaire in which learners evaluate their experiences with the application.

The maze task is used in psycholinguistics to measure the processing cost imposed by different linguistic structures (FORSTER *et al*., 2009; WITZEL *et al*., 2012; OLIVEIRA, 2020; OLIVEIRA *et al*., 2022). Using a computer, participants must form sentences, word by word or chunk by chunk, by selecting one of two options present on the screen. There is usually only one correct option for each piece of the sentence, and the other is either a nonword or an ungrammatical sentence sequence (WITZEL *et al*., 2012). FIG. 1 illustrates how the sentence "Samuel lives in Brazil" could be displayed in a maze with ungrammatical options as distractors.

Figure 1: Visual representation of a sentence displayed in a Maze Task

Source: Adapted from Oliveira *et al*. (2022).

Grammar instruction is limited by different psycholinguistic factors, but non-traditional methods may play beneficial roles in helping learners speed up their L2 development process, as discussed by Benati and Schwieter (2019). Some key characteristics of the maze task indicate its potential to be one such method. First, participants receive feedback for each part of the sentence. When they choose the incorrect option, they receive an "incorrect" message, and a new sentence starts. When the correct option is chosen, the sentence continues, unless it is its last word; in this case, a "correct" message appears. This immediate feedback helps participants pay attention to the task and their performance. Moreover, according to Enkin and Forster (2014), maze task training can invoke both production and comprehension processes without causing anxiety in interactions with other students. Forster (2010) also suggests that the maze task allows learners to practice converting declarative memory into procedural representations, which is key in reaching high levels of L2 proficiency. Thus, the maze task offers extra language practice complementing the learner's experience in the classroom, which usually involves interactions and explicit grammar learning.

Another possible advantage of the maze task is that it can be used for a sort of input flooding, which is an input enhancement

intervention by which learners read (or listen to) multiple examples of a structure (cf. SMITH, 1993; BENATI, 2016). This technique encourages participants to form and process various sentences with the same structure in an engaging manner. This ample exposure to different instances of a structure makes it more salient, helping learners direct their attention to linguistic forms. This strategy is in line with many theories in Second Language Acquisition that suggest, directly or indirectly, the beneficial role of input enhancement by frequency increase, which leads to the repeated practice of a given structure (ELLIS; WULFF, 2015; DEKEYSER, 2015; VAN PATTEN, 2015; GASS; MACKEY, 2015).

To our knowledge, only two studies have explored this pedagogical use of the maze task for second language learning: Enkin and Forster (2014) and Oliveira *et al*. (2020a). The former investigated native speakers of English who were learning Spanish, and the latter investigated native speakers of Brazilian Portuguese who were learning English. The participants in each study belonged to the same language course, with low levels of proficiency. In both studies, learners performed maze task training on computers to practice linguistic structures that were L2-specific. In Enkin and Forster (op. cit.), participants used the DMDX software. They performed three training sessions, one per week, at home and at their own convenience, whereas in Oliveira *et al*. (op. cit.) participants used the Psytoolkit software, and had all training sessions in one day in a computer laboratory. In both studies, the control groups performed the maze task training without L2-specific sentences.

Enkin and Forster (2014) suggest that participants exposed to specific L2 structures in training sessions show improvement

in tasks involving both procedural and declarative knowledge. More specifically, they had better results than the control group in a maze task with new sentences, a grammaticality judgment test, and a fill-in-the-blank test, which was the only task with a pre/post-test design. Oliveira *et al*. (2020a) collected data using an acceptability judgment test and a maze task with sentences different from those used in the training, both with a pre/post-test design. The results showed improvement in participants' reaction time and acceptability judgment. However, compared with the control group, no significant difference was observed.

Both studies had limitations that could have been circumvented using a maze task designed for mobile phones. In Enkin and Forster (2014), the training sessions may have been performed differently by participants as they decided where and when to do them. To control the setting of the intervention, Oliveira *et al*. (2020a) opted for a one-day session that included pre-tests, interventions, and post-tests. This strategy may have resulted in a learning effect from pre-test to post-test in the control group, which also showed better performance in the post-tests. A mobile version would make it easier to control the environment and intervals of participants' linguistic training in a longitudinal study.

The maze task for mobile phones may facilitate not only the process of conducting multiple experimental training sessions over a longer period in a controlled setting but also, more importantly, its use for language learning. Enkin and Forster (2014) argue that developing a more "video game-like" version of this task either through the Internet or smartphones could be the future of the maze task as a pedagogical tool. To examine this possibility, we developed the Maze Task Mobile

application, used it in English classes with native speakers of Brazilian Portuguese, and conducted an attitude questionnaire based on Enkin and Forster (2014), in which students were asked about their perceptions of the application and its use for language learning. Based on this previous study, we expected both the novelty and fast-paced nature of the task to foster participants' enthusiasm. The following section describes the proposed application.

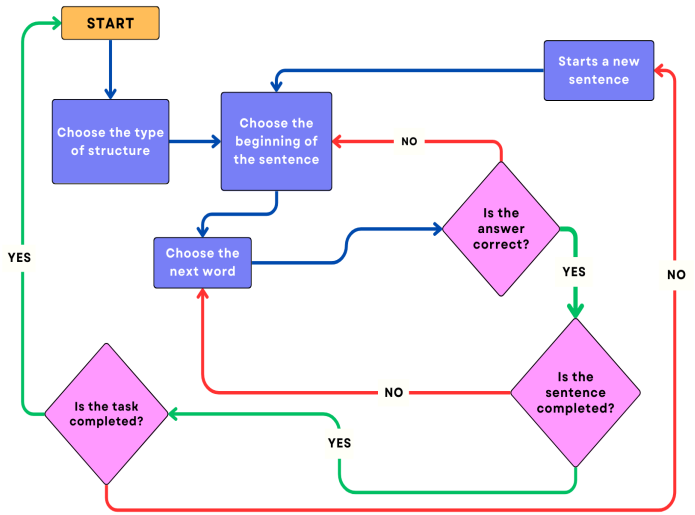
THE MAZE TASK MOBILE

The Maze Task Mobile is an application that transforms the psycholinguistic method into a pedagogical tool, in which students can practice building sentences with the maze task structure. Before presenting the application, it is necessary to first explain some concepts associated with software development, namely, the Integral Development Environment (IDE), back-end, and front-end.

We developed the application in the Android Studio IDE, an IDE where Android applications can be coded. There are many ways to code Android applications, but Android Studio uses a package with several directories for building them. The most important files are XML and Java. The XML files correspond to the front-end, which represents the visual aspects of the application such as colors and fonts. Java files correspond to the back-end and logical code constructed using the programming language Java. They are responsible for all the workflows, so any change to the interval between tasks, the number of items, and their randomization or repetition requires you to go to the Java files and change the codes.

To improve the understanding of the application, we developed the flowchart in FIG.2.

Figure 2: The representation flowchart of the Maze Task Mobile algorithm



Source: Made by the authors.

The flowchart (FIG. 2) represents the algorithm and how it works. All symbols represent the state of the application: the squares represent data manipulation (if X, then Y), and the lines represent the flux of the states. Note that some lines are oriented to a loop, which means that only when the student chooses a different path or finishes the task will he or she move on to the next part. Finally, the diamonds are the choices (or "ifs"), and the rounded rectangle represents the beginning and end of each usage.

When a student starts the application, he or she can choose one of the maze task activities. As noted in the introduction,

participants will see two words (or larger linguistic units), and will select the one that best continues the sentence being formed. If the participant gets it right, options for the next segment will appear, but if he or she gets it wrong, the sentence starts over. As the maze task is being used as a pedagogical instrument, redoing the sentence in which the participant made a mistake would be more fruitful. When the student finishes each sentence, the next sentence starts. When the task is over, a button to close the task pops up.

Regarding the visual aspects of the application, we created a screen that could fit the words used to build sentences and the messages guiding them during the exercise. In FIG. 3, we can see an example of the main screen, where we have the name of the application at the top, words to choose from in the middle, how many sentences to finish at the bottom and the feedback in the last screen when the sentence is formed correctly.

Figure 3: Visual representation of the sentence "My friends eat fruits and vegetables" displayed in Maze Task Mobile[1] when all the choices are correct

Source: Made by the authors.

1 The functioning of the application can be seen at the following link: https://youtube.com/shorts/CWqYrWOpl3E?feature=share.

One issue needing consideration in the process of developing this application was the different smartphone architectures, particularly their memory capacity. However, various applications today are directly connected to the cloud, where all data are saved in databases, allowing more people to use those applications. With this in mind, we developed an application that is not heavy for smartphones, and saves selected data in local memory.

A database (DB) was used to save all information obtained from the task. The DB received all the information encrypted with keys, to help us recognize it. The main keys were student and task information. Student information included age, classroom, self-reported proficiency level, and a code that was randomly encrypted to preserve participants' identities. As for task information, each part of the task was classified according to the type of segment (e.g., subject, verb, complement), classification of the structure (e.g., third-person present), and task identification (e.g., activity 1).

The teacher, experimenter, or designer can (i) choose the type and number of sentences in each activity, (ii) randomize the sentences, and (iii) allow repetition of each sentence or activity. All these specifications can be modified by reprogramming the code. Sentences must be built together with the incorrect options that accompany each part. FIG. 4 shows how the sentences are structured in the Java file: In the first string, we have the main sentences (*primeiroGrupo*), and in the second string, we have incorrect options (*distratores*).

Figure 4: Example of coded phrases in the application's language

```
public String[][] primeiroGrupo = {{"I lend", "Bob pencils", "and pens", "at class"},
    {"She'll buy", "a black", "mini IPad", "next monday"},
    {"I heard", "that Malcom", "wants to", "travel more"},
    {"What dessert", "are we", "going to", "eat later?"},
    {"This", "task is","very easy", "for me"},
    {"You show", "Mark pictures", "from Brazil", "after school"},
    {"I'll buy", "a brown", "hiking boot", "in Peru"},
    {"I notice", "that she", "goes home", "at night"},
    {"What instrument", "is he", "going to", "learn now?"},
    {"I am", "prepared to", "start this", "language test"}};

public String [][] distratores = {{"XXXX", "go blue", "East region", "tall trees"},
    {"XXXX", "was before", "his name", "drive her"},
    {"XXXX", "loving them", "swim too", "a raindrop"},
    {"XXXX", "she is", "big door", "very old?"},
    {"XXXX", "some people", "study English", "beautiful day"},
    {"XXXX", "with good", "give her", "when did"},
    {"XXXX", "no clue", "things as", "three dogs"},
    {"XXXX", "city where", "work at", "one movie"},
    {"XXXX", "you are", "so long", "before leave?"},
    {"XXXX", "paint the", "sisters see", "your name"}};
```

Source: Made by the authors.

FIG. 5 shows the algorithm used to check whether students were allowed to perform the activity. Every time a student clicked on a test, the function called onClick checked if it was already conducted, or if another test was conducted on that day. This is an important function for experimental studies because it prevents participants from redoing tasks and changing the results. However, it may not be necessary when used as a pedagogical tool, and so the "if (tipo.equals("1") && CurrentDate.equals(data))" can be erased.

Figure 5: Function to check if any tasks have been completed that day

```
@Override
protected void onActivityResult(int requestCode, int resultCode, Intent Data) {
    super.onActivityResult(requestCode, resultCode, Data);
    if (requestCode == 1) {
        if (resultCode == Activity.RESULT_OK) {
            String result = Data.getStringExtra("result");
            final String tipo = Data.getStringExtra("tipo");
            final String data = Data.getStringExtra("data");

            atividade1.setOnClickListener(new View.OnClickListener() {
                @Override
                public void onClick(View view) {
                    if (tipo.equals("1") && CurrentDate.equals(data)) {
                        AlertDialog.Builder builder = new AlertDialog.Builder(selecaoAtividades.this);
                        builder.setMessage("Esta atividade já foi feita hoje!\n Parabens!\n :)")
                        .setNegativeButton("OK", new DialogInterface.OnClickListener() {
                            public void onClick(DialogInterface dialog, int which) {
                                finish();
                                return;
                            }
                        });
                    builder.create().show();
                    } else {
                        atividade = new Intent(selecaoAtividades.this, telaPrincipal.class);
                        atividade.putExtra("tipo", 1);
                        startActivityForResult(atividade, 1);
                    }
                }
            });
```

Source: Made by the authors.

Another function that can be modified is the "SetTextPosition" (see FIG. 6). This function is used to randomize structure position on the screen so that the words are never positioned on the same side. This randomization is important to ensure the students choose words according to their linguistic knowledge, and not according to where specific parts of the sentences are displayed.

Figure 6: Randomization of structure positions in the application

```
public void SetTextPosition (TextView estrutural, TextView estrutura2, int i, int j){
    int random = (int) (Math.random() * 50);
    if(random%2 == 0){
        estrutural.setText(primeiroGrupo[i][j]);
        estrutura2.setText(distratores[i][j]);
        posicaoCorreta = 1;
    }
    else {
        estrutura2.setText(primeiroGrupo[i][j]);
        estrutural.setText(distratores[i][j]);
        posicaoCorreta = 2;
    }
}
```

Source: Made by the authors.

In summary, the Maze Task Mobile application can be used to create experiments or pedagogical reading activities in the maze task style. An important limitation of the application is that it does not record the reaction time for each part of the sentence, which is the main data in psycholinguistic studies with this method. In other words, the Maze Task Mobile cannot be used as an alternative to the self-paced reading technique, but it can be used for linguistic training and for data collection about the accuracy in each segment and the time taken to perform an activity. Moreover, the application is flexible in terms of sentence quantity, randomization, and repetition. We tested the application with Brazilian vocational high school students and asked them to evaluate this pedagogical instrument using the attitude questionnaire presented in the next section.

METHODOLOGY

Participants

The participants were vocational high school students from the Federal Center for Technological Education of Minas Gerais in Contagem, with ages ranging from 14 to 17 years. These participants constitute a so-called convenience sample since their English teacher was the first author of the present paper. They filled out the Terms of Informed Consent form approved by the CEP/CONEP (CAAE 46886921.8.0000.8507). We invited all students from the first year of all three courses offered by the aforementioned institute (environmental control, informatics, and electronics), but only 46 (approximately 50%) took part in the linguistic training with the maze task. After this period, they

were invited to voluntarily respond to our attitude questionnaire, which was completed by only 20 out of the 46 students who performed the task.

Maze Task training sessions

The training sessions for the maze task were conducted during students' online English classes. Owing to the COVID-19 pandemic, all classes were virtual at that time. Each student had two English classes per week during this period, and they used the Maze Task Mobile in five consecutive classes. As mentioned earlier, the maze task was flexible in terms of randomization and repetition rules. In our training sessions, the participants could only move to the next sentence after correctly forming the previous one. Moreover, each student received a different order of sentences, preventing them from getting together in groups to perform the exercises, and allowing us to obtain more reliable data regarding their performance. As we wanted to analyze how they performed in the task, we did not allow them to redo an activity, but the application was flexible in that matter.

In our version of the application, students practiced the third-person singular present morpheme {-s}; each activity had 30 sentences in which they had to choose between inflected or uninflected verbs (e.g., likes or love) in the second segment of the sentences, as shown in FIG. 3. Given recent evidence suggesting that Brazilian learners of English have a harder time noticing when the inflection morpheme is missing than when it is being oversupplied (CARNEIRO, 2017; OLIVEIRA *et al*., 2020b; OLIVEIRA; OLIVEIRA, 2023; FONTOURA *et al.,* no prelo), we decided to use 20 third-person singular present sentences and 10 third-person plural present sentences. FIG. 7 illustrates some of the target sentences. Based on previous

studies, we predicted that in the first session of the maze task, there would be a higher number of mistakes for third-person singular present sentences than for other ones. We analyzed their performance in the verb segment during the first maze task training session. We also planned to analyze their performance in the last session; however, only 11 students completed all five sessions. Participation in virtual classes was a problem during the pandemic, which also affected our study. Thus, we only analyzed the data from the first time each of the 46 participants underwent the maze task training.

Figure 7: Target sentences in Java Structure

Third-person singular

```
1. {{"The father", "watches", "movies", "on", "weekends."},
2. {"The teacher", "speaks", "French", "and", "Italian."},
3. {"My brother", "eats", "fruit", "at", "night."},
4. {"The chef", "cooks", "chicken", "with", "potato."},
5. {"The kid", "feels", "sad", "and", "lonely."},
6. {"Uncle John", "loves", "music", "and", "poetry."},
7. {"My wife", "drinks", "coffee", "and", "tea."},
```

Third-person plural

```
1. {"The boys", "love", "movies", "and", "games."},
2. {"My parents", "have", "lunch", "with", "me."},
3. {"My friends", "eat", "fruits", "and", "vegetables."},
4. {"The teachers", "drink", "coffee", "and", "tea."},
5. {"The students", "do", "homework", "at", "home."},
6. {"My friends", "hate", "soccer", "and", "tennis."},
7. {"The students", "learn", "math", "and", "physics."},
```

Source: Made by the authors.

Attitude Questionnaire

Our attitude questionnaire was based on Enkin and Forster (2014). After running sessions of maze task training, they asked

the students 11 questions to examine whether they found the maze task useful, helpful, motivating, interesting, or fun. Participants rated their answers on a scale from 1 (strong no) to 5 (strong yes). The average score for the questions was 4.3, and the results indicated that participants felt motivated, enjoyed the task, and found it fun and helpful. Learners also pointed out that the maze task would be a good addition to their language curriculum.

The questionnaire was developed using six 5-point Likert scale (LIKERT, 1932) questions, and multiple-choice questions. It was run on the Google Forms platform. The first question, "How satisfactory was your experience?," intended to evaluate how much users liked doing the training using the application. The second question aimed to measure how helpful/effective the process was for participants' learning.

The third question asked participants their preference between Maze Task and common paper-based exercises, which helped us measure any improvement in participants' interest in the learning process from using our application. In this way, we could evaluate the gaming characteristics of this technique as well. The fourth question focused on participants' motivation: "Did you feel motivated to study using the Maze Task?," which we expected to be enhanced by gamification.

The fifth question, "Do you think that Maze Task made your English learning easier?," aimed to evaluate the task's helpfulness in learning English. The last Likert-scale question was "What is your opinion on Maze Task becoming a recognized teaching tool?," measuring the task's helpfulness in the teaching process.

In addition to these Likert-scale questions, two multiple-choice questions were included in the questionnaire, in which participants could choose more than one option. One was related

to the positive features of the application, whereas the other was related to its negative features. The positive feature options were intuitive interface (easy to use), enabling new ways of learning, improved English learning, good interactivity, enabling the learning of various structures of English, appropriate content for the classroom, Maze Task motivated you to learn, game principles that make it fun to use, and relevant to what is proposed. The negative feature options were unintuitive interface (hard to use), does not allow new ways of learning, difficulty in learning English, no interactivity, does not allow learning various structures of English, inappropriate content for the classroom, Maze Task did not motivate you to learn, game principles that make use boring, and not relevant to what is proposed. All options were presented to better understand the rating values of former questions, in which students could indicate application flaws and advantages regarding to helpfulness, usefulness, likeability, and gamification features.

RESULTS

This section presents the results concerning the accuracy of the maze task in the first training session, and the results of the attitude questionnaire.

Maze task

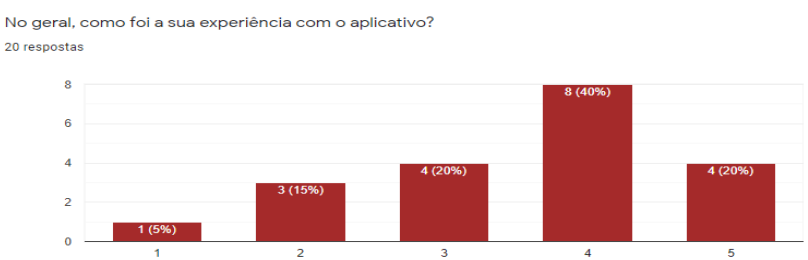
We analyzed the participants' performance on the maze task for verb selection (inflected vs. uninflected verbs). For the third-person singular present sentences in which inflected verbs were expected, the rate of correct answers was 73.8%, whereas for the third-person plural sentences in which uninflected verbs were

expected, the rate of correct answers was 63.2%. We adjusted the logistic regression with verb choice as the response variable, verb inflection as a fixed effect, and random intercepts for participants and items. The contrast of the fixed effect levels (with and without {~s}) was performed using dummy coding with the correct answer as the reference level. A comparison with nested models indicated that conjugation contributes significantly to the model ($\chi 2 = 4.1658$, $p < 0.05$). The best-fit model indicated that the probability of success was higher for third-person singular present sentences than other present sentences ($\beta = -0.5404$, $p < 0.05$). Thus, in contrast to our expectations, participants performed better on third-person singular present sentences.

Attitude questionnaire

In evaluating the questionnaire data, we observed (as shown in FIG. 8) that 60% of participants liked using the application, grading their experience as 4/5 or 5/5. Conversely, 20% (four participants) did not like the training application experience, grading it as 1 or 2, and another 20% rated their experience with an intermediate value of 3.

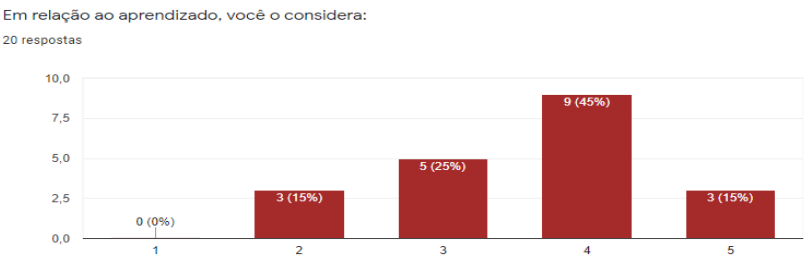
Figure 8: Answers to "How satisfactory was your experience using the app?" on a 5-point Likert Scale, from 1 unsatisfactory to 5 very satisfactory



Source: Made by the authors.

Regarding the application being effective in the learning process, 12 participants, 60%, chose 4 and 5 on the Likert scale, while 3 participants, 15%, viewed the application as not so effective, selecting 2. The last 5 participants (25%) chose 3, the middle value of the scale (see FIG. 9).

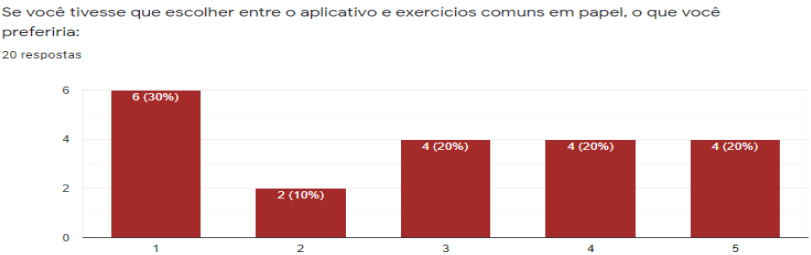
Figure 9: Answers to "Regarding your learning, do you consider it" on a 5-point Likert Scale, from 1 ineffective to 5 very effective



Source: Made by the authors.

Participants' answers to "If you had to choose between Maze Task and common paper-based exercises, which would you prefer?" were not what we expected; there was a tie between common paper-based exercises and Maze Task training, 40%–40%, demonstrating that participants saw explicit value in both learning processes, as shown in FIG. 10.

Figure 10: Answers to "If you had to choose between Maze Task and common paper-based exercises, which would you prefer?" on a 5-point Likert Scale, from 1 common paper-based exercises to 5 Maze Task training



Source: Made by the authors.

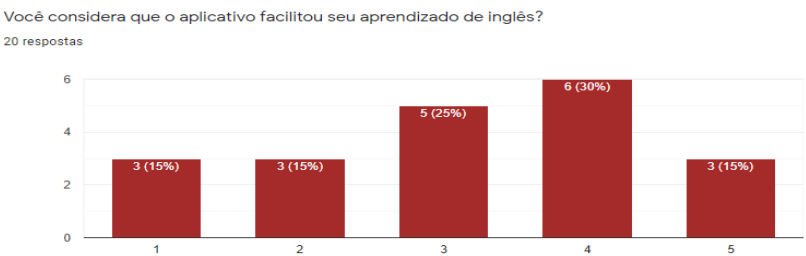
The fourth question aimed to understand how students' motivation was enhanced by the application. In fact, this did not seem to occur, as only 35% of the participants, 7, responded to gaining motivation from the application (choosing 4 on the 5-point scale), while 35% did not show motivation (choosing 1 and 2). 6 students (30%) chose the middle value of 3 (see FIG. 11).

Figure 11: Answers to "Did you feel motivated to study using the Maze Task?" on a 5-point Likert Scale, from 1 little motivated to 5 very motivated

Source: Made by the authors.

With regard to the training application making their English learning easier, 45% of participants chose responses of 4 and 5, whereas 30% (6 participants), said it did not. In addition, 25% of the students, 5, chose 3, the intermediate point on the scale, as shown in FIG. 12.

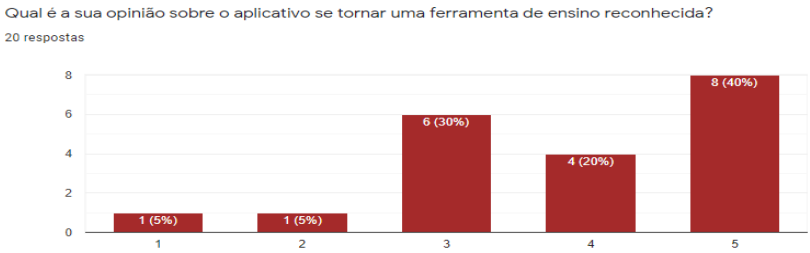
Figure 12: Answers to "Do you think that Maze Task made your English learning easier?" on a 5-point Likert Scale, from 1 it did not facilitate to 5 it made it a lot easier



Source: Made by the authors.

The last Likert-scale question, "What is your opinion on Maze Task becoming a recognized teaching tool?" had 60% of participants (12) responding in favor of the task being a teaching tool, showing once again the application's helpfulness. However, 30% of the students (6) chose the middle response of 3, while 10%, 2, said they were against it becoming a recognized teaching tool (see FIG. 13).

Figure 13: Answers to "What is your opinion on Maze Task becoming a recognized teaching tool?" in a 5-point Likert Scale, 1 being totally against to 5 all in favor



Source: Made by the authors.

The positive and negative feature question results are presented in Tables 1 and 2, respectively. These questions were not mandatory, given that they were asking about characteristics explored previously. Nineteen students answered the positive feature question, while 11 answered the negative one. The least positive feature with a score of 21.1% was "Maze Task motivated you to learn," confirming the results found in the Likert-scale question "Did you feel motivated to study using the Maze Task?." Meanwhile, the best features were found to be "Interface intuitive (easy to use)" and "Enables new ways of learning," scoring 73.7%. Negative features received fewer answers in general, with a total of 23 answers, compared with 97 answers for positive features. Overall, the application was hence seen as having more positive than negative features. The most voted negative feature was "The Maze Task did not motivate you to learn," with nine votes, which is congruent to the positive features chosen and to the previous questions.

Table 1: Answers to multiple-choice questions: Positive aspects

Which aspects do you consider positive?	Answer percentage (19 participants)	Number of answers
Interface intuitive (easy to use)	73.7%	14
Enables new ways of learning	73.7%	14
Improved your English learning	47.4%	9
Good interactivity	63.2%	12
Allows you to learn different structures of English	52.6%	10
Appropriate content for the classroom	57.9%	11
The Maze Task motivated you to learn	21.1%	4
Game principles that make playing fun	52.6%	10
Relevant to what is proposed	68.4%	13

Source: Made by the authors.

Table 2: Answers to multiple-choice questions: Negative aspects

Which aspects do you consider negative?	Answer's percentage (11 participants)	Number of answers
Interface non-intuitive (difficult to use)	54.5%	6
Does not enable new ways of learning	9.1%	1
Made it difficult for you to learn English	0%	0
Without interactivity	36.4%	4
Does not allow you to learn different structures of English	18.2%	2
Inappropriate content for the classroom	0%	0
The Maze Task did not motivate you to learn	81.8%	9
Game principles that make playing boring	9.1%	1
Not relevant to what it is proposed	0%	0

Source: Made by the authors.

DISCUSSION

Conducting an experimental study in an L2 classroom is challenging in itself (POLIO; LEE, 2019), but this first test with the Maze Task Mobile was even more difficult in the context of the COVID-19 pandemic. The fact that the classes were being held virtually impacted students' overall participation and engagement; only half of them did at least one of the maze task activities, and only half of those responded to our attitude questionnaire. A replication of this study in a more controlled and in-person setting would be relevant to analyze whether these methodological issues influenced the results. Nevertheless, this study provides important data that can guide the development of the application as well as future research.

Participants' performance on our target structure (inflected and uninflected verbs in the present tense) differed from our predictions. Previous research indicates that Brazilian learners of English find it harder to notice that the inflection morpheme is missing than that it is being oversupplied (CARNEIRO, 2017; OLIVEIRA *et al*., 2020b; OLIVEIRA; OLIVEIRA, 2023; FONTOURA *et al*., no prelo). Consequently, we expected students to perform better in sentences that did not require inflected verbs, even though we used more third-person singular present sentences (20/30), than third-person plural present sentences (10/30). However, the higher number of the former type of sentences seemed to have led participants to overgeneralize the use of inflected verbs, which resulted in a higher number of correct answers for singular sentences (74%) than for the plural sentences (63%), at odds with our hypothesis. Thus, future studies should consider using a more balanced number of sentences for

each condition. Most importantly, we hope that future studies will analyze participants' improvement throughout the sessions. Unfortunately, inconsistent student participation during the study period prevented us from performing such an analysis.

Future research should also investigate the use of incorrect inflections as distractors in the maze task. The fast nature of the task and the low salience of inflection morphemes, such as the third-person singular present one {~s}, may lead participants to choose the first word they see instead of determining which word agrees with the subject of the sentence being formed. In this case, the mistakes we observed might indicate, not that participants chose the wrong morpheme agreement option, but that they did not direct their attention to the morphemes. In other words, participants may not have perceived the agreement morphemes that accompanied the verbs in some of our target sentences.

To the best of our knowledge, this is the first attempt to create a mobile version of the maze task, which, according to Enkin and Forster (2014), could be a future pedagogical tool for this technique. Our application allows teachers to flexibly create maze task activities with different (i) types of structures, (ii) number of sentences, and (iii) strategies such as sentence repetition and randomization. Moreover, the data collected by the application also enables its use for scientific purposes, since experimenters can collect data about the accuracy and time to complete a sentence.

The first version of the application received positive feedback from most participants who responded to the attitude questionnaire. The Likert-scale questions yielded an intermediate mean value of 3.3, and the multiple-choice questions yielded 97 positive and 23 negative answers. The positive features that stood

out in the questionnaire were the application's intuitiveness, interactivity, and innovation. The multiple-choice questions with the highest rates concerned the appropriateness and effectiveness of the maze task as a pedagogical tool. In addition, in multiple-choice questions regarding the negative aspects of the task, none of the participants said that the application was inappropriate or that it made learning difficult. We interpret these results as an indication that this first version of the maze task application got off to a good start.

Despite the overall positive evaluation, some students included the application's usability and interactivity as negative aspects, which we saw as an indication of room for improvement. We planned for the first version of the Maze Task Mobile to be used with the support of the teacher, which may have led some participants to think that the application lacked intuitive and interactive features. To circumvent this problem, the application should be less dependent on external instructions, and should provide participants with all the information required to perform the task. Furthermore, because the maze task requires a type of reading that is not common in other activities, we suggest that the next version of the application offer participants a larger set of didactic examples regarding the manner in which sentences should be formed. As for interactivity, we suggest that the next version include features that stimulate more senses. More specifically, adding images and sounds to the maze task may increase users' feelings of engagement and interactivity. In a more advanced version of the application, it would be interesting to test the use of images related to each part of a sentence, as well as the use of a voice to speak the words chosen by the participants.

Our findings suggest that new procedures should be tested when using a maze task. The participants rated their motivation while performing the task as very low. Although we think that the overall context of online classes during the pandemic had an impact on these results, we understand that changes in the application can impact students' motivation. As we wanted participants to practice the structures in the maze task in a more implicit manner, we did not tell them what structures were being coached. In a future version of the application, we suggest that participants should be aware of the structures being practiced, in order to provide them with a clearer goal in the task. We believe that this strategy, together with more interactive features, will have a positive impact on users' motivation to perform tasks.

We hope that the findings reported in the present study can contribute to the use of this psycholinguistic method as a pedagogical tool, and that the Maze Task Mobile can encourage future studies and future versions of the application. After this first experience, we agree with Forster (2010) that maze task activities, as the ones reported in Enkin & Forster (2014), as well as the ones we reported in the present paper have the potential to give learners complementary linguistic practice that can help them convert the declarative memory acquired in the classroom into procedural representations. However, further development and investigation are still necessary to clarify that potential.

References

BENATI, A. *Input manipulation, enhancement, and processing*: Theoretical views and empirical research. Studies in Second Language Learning and Teaching, v. 6. n. 1. p. 65-88, 2016.

BENATI, A.; SCHWIETER, J. Pedagogical Interventions to L2 Grammar Instruction. *In*: SCHWIETER, J. and BENATI, A. (Eds.) *The Cambridge Handbook of Language Learning* (Cambridge Handbooks in Language and Linguistics). Cambridge: Cambridge University Press, 2019, p. 477-499.

CARNEIRO, M. *Investigating bilinguals' sensitivity to English regular past morphology*: A self-paced reading experiment with Brazilian learners. Revista Brasileira de Linguística Aplicada, v. 17. n. 3. p. 483-507, 2017.

DEKEYSER, R. M. Skill Acquisition Theory. *In*: VANPATTEN, B. and WILLIAMS, J. (Eds.), *Theories in Second Language Acquisition*: An Introduction. New York: Routledge, 2015, p. 94-113.

ELLIS, N. C; WULFF, S. Usage-based approaches to SLA. *In*: VANPATTEN, B. and WILLIAMS, J. (Eds.), *Second language acquisition research series*: Theories in second language acquisition. New York: Routledge, 2015, p. 75-94.

ENKIN, E.; FORSTER, K. *The Maze Task*: Examining the Training Effect of Using a Psycholinguistic Experimental Technique for Second Language Learning. Journal of Linguistics and Language Teaching, v. 5. n. 2. p. 161-180, 2014.

FONTOURA, B; OLIVEIRA, C.; SOUZA, R. *Implicit linguistic processing of inflection morphemes*: a self-paced reading task with Brazilian Portuguese-English learners. Letrônica, v. 16. n. 1. no prelo.

FORSTER, K. *Using a maze task to track lexical and sentence processing*. The Mental Lexicon, v. 5. n. 3. p. 347-357, 2010.

FORSTER, K.; GUERRERA, C.; ELLIOT, L. **The maze task**: Measuring forced incremental. Behavior Research Methods, v. 41. n. 1. p. 163-171, 2009.

GASS, S. M.; MACKEY, A. Input, interaction, and output in second language acquisition. *In*: VANPATTEN, B. and

WILLIAMS, J. (Eds.), *Theories in second language acquisition*. 2.ed. New York: Routledge, 2015, p. 180-206.

LIKERT, R. *A technique for the measurements of attitudes*. Archives of Psychology, v. 140. n. 22. p. 5-55, 1932.

MEIRELLES, F. *Pesquisa Anual do Uso de TI nas Empresas*. Escola de Administração de Empresas - São Paulo: Fundação Getulio Vargas, 2019. Pesquisa anual. Disponível em: https://eaesp.fgv.br/sites/eaesp.fgv.br/files/pesti2019fgvciappt_2019.pdf. Acesso em: 11 abr. 2023.

OLIVEIRA, C. *Métodos on-line em psicolinguística*: a tarefa labirinto (maze task). Caderno de Tradução, v. 40. n. 2. p. 217-248, 2020.

OLIVEIRA, C.; COSTA, E.; CANABRAVA, K.; BARROS, N. *Examining the use of an online version of the maze task as a pedagogical tool for second language learning*. Veredas Revista de Estudos Linguísticos, v. 24. n. 1. p. 361-388, 2020a.

OLIVEIRA, C.; FONTOURA, B.; SOUZA, R. *The challenges imposed by L2 inflectional morphology*: evidence from speeded acceptability judgment tasks with Brazilian Portuguese-English bilinguals. Veredas: Revista de Estudos Linguísticos, v. 24. n. 1. p. 317-339, 2020b.

OLIVEIRA, C.; MARCILESE, M.; LEITÃO, M. Leitura Autocadenciada (com e sem labirinto): histórico e reflexões metodológicas. *In*: SÁ, T.; OLIVEIRA, C. *Métodos experimentais em psicolinguística.* 1ed. São Paulo: Pá de Palavra, 2022, p. 40-54.

OLIVEIRA, K.; OLIVEIRA, C. *Salience and learned attention: a study on the perception of uninflected verbs by Brazilian Portuguese-English bilinguals.* Studies in English Language Teaching, v. 11, n. 2, p. 188-204, 2023.

POLIO, C.; LEE, J. Experimental Studies in L2 Classrooms. *In*: SCHWIETER, J. and BENATI, A. (Eds.). *The Cambridge Handbook of Language Learning* (Cambridge Handbooks in Language and Linguistics). Cambridge: Cambridge University Press, 2019, p. 137-165.

SMITH, M. *Input Enhancement in Instructed SLA*: Theoretical Bases. Studies in Second Language Acquisition, v. 15. n. 2. p. 165-179, 1993.

VANPATTEN, B. Input processing in adult SLA. *In*: VANPATTEN, B. and WILLIAMS, J. (Eds.)*, Theories in second language acquisition*. 2nd ed. New York: Routledge, 2015, p. 113-135.

WITZEL, N.; WITZEL, J.; FORSTER, K. *Comparisons of online reading paradigms*: Eye tracking, moving-window, and maze. Journal of Psycholinguistic Research, v. 41. n. 2. p. 105-128, 2012.