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Disclosure Statement

The authors of the present study are the same authors that designed and registered the App. This App is freely available (https://www.ucm.es/clinicalogopedia/investigacion) and there is no commercial nor ethical conflict of interest to declare.

Assessing vocabulary acquisition using a Fast Mapping Task in an Android Application: A Pilot Study

Abstract

Purpose: The aim of this study was to explore whether a fast mapping task embedded in an Android application (FastMApp) is a valid tool to assess referent selection abilities in Spanish-speaking children aged between 18 and 30 months. Traditional assessment tools for lexical development use static quantitative methods that assign children a final score to represent their overall vocabulary level. These methods fail to provide insights into the learning process, despite their potential relevance for clinical and educational purposes.

Method: Sixty Spanish-speaking children participated in this study. They completed the FastMApp (a 22-trials' fast mapping noun task including 4 and 5 pictures trials, with one unknown object), and their caregivers rated their child's vocabulary on a parent-rated vocabulary inventory measure.

Result: The data show a high percentage of responses to the task, indicating that the children were actively complied with the task. The scores for known labels are significantly higher compared to unknown labels, and the scores for 4-item trials are significantly higher compared to 5-item trials. We observed a strong and significant relationship between the scores in this task and the scores on the parent-rated vocabulary inventory measure.

Conclusion: The results suggest that FastMApp is suitable for assessing early vocabulary acquisition in Spanish language.

Key words: App; Fast mapping; Lexical development; Vocabulary assessment, Child language.

Introduction

The assessment of children's early lexical development is crucial as low levels of vocabulary are related to other difficulties during lexical and grammatical development (Lee, 2011). Most of the assessment tools suitable for children under two years of age are parent-reported and focused on their lexical knowledge of a set list of items, while the scores obtained with these tools provide no information about the processes involved in word learning (see Eriksson, 2022; for a critical review of two of these instruments). Given the high variability observed in the rates at which each child incorporates new words into their lexicon (Fernald et al., 2013; Hirsh-Pasek & Golinkoff, 2019), it would be beneficial both for teachers and early intervention services to track children's developmental trajectories by evaluating the mechanisms that are responsible for their early representations of lexical items (Jackson et al., 2023). Previous research has shown that fast mapping (FM) tasks are useful for analysing children's disambiguating abilities, that is, their abilities to identify the referent of a new label among several possible candidates (Carey, 2010; Golinkoff et al., 1992). Moreover, these tasks are sensitive to differences in the level of vocabulary of very young children (Rujas et al., 2019). The aim of this paper was to report data from a FM task incorporated into a new assessment tool that uses touchscreen technology for 18- to 30-month-old Spanish-speaking children. We present a study carried out with an application developed for Android displayed in tablets (*The FastMApp*).

The process of FM operates during early language acquisition: typically developing children start incorporating new words at a very low rate, soon mapping new labels into their referents and retaining them after just a few encounters (Carey, 2010). Carey and Bartlett (1978) developed the essentials of this task for assessing children's FM abilities.

The procedure is typically as follows: children are shown a set of objects or images that depict objects or actions, one of which is unknown to the children. The adult produces an unknown label (a pseudoword) and the children are asked to identify the referent of this label (the unknown object or action) by pointing at it (Poulin-Dubois & Forbes, 2002). With this procedure, it is possible to analyse the role of different variables needed to successfully identify the referent, such as the number of label repetitions (Carey, 2010), the time-lapse between the presentation of each stimulus (Swingley, 2010) and the level of familiarisation with the referents (Kucker et al., 2020). This procedure normally includes a second step in which children are asked to generalise the new learned label to a different exemplar that may vary in shape, size, or colour (Pulverman et al., 2006). For example, children are asked to extend a recent mapped label of an action word to a different agent (Golinkoff et al., 1996). It is thus possible to examine not only to what extent children are linking a new word with a new referent but also the feasibility of creating semantic representations. Research has found that early lexical representations are narrowly defined and context-specific, which prevents children from easily generalising new learned labels (Poulin-Dubois & Forbes, 2006) and that there is a slow-learning process (Bion et al., 2013; Munro et al., 2012). The strength of the relationships established between the new learned word and its referent is also measured by production tasks (Jackson et al., 2016).

Lexical assessment of young children can assist in the early detection of language difficulties. However, this lexical assessment poses several challenges. On the one hand, there are few suitable assessment tools for children under 4 years of age. Although there are standardised tests, such as the PPVT-5 (Dunn, 2019) or the Preschool Language Scale (PLS-5, Zimmerman et al., 2011), most are adapted in a limited range of languages.

Other measures, such as parental reports, provide a reliable measure of children's early vocabulary at very early ages (see, for example, MacArthur CDI, Fenson et al., 1993). However, they provide indirect measures of vocabulary development. Furthermore, the typical standardised assessment tools are not easily applied to bilingual children or children from culturally diverse backgrounds because they are frequently normed with monolingual, middle-income children from Western cultures (Byers-Heinlein et al., 2013). In addition, besides the evaluator's expertise, it is critical that the materials and procedures help maintain the child's attention to the task, such that the loss of interest does not mask the real performance in vocabulary. In fact, research has shown differences in attention to visual and complex stimuli across different ages (see Richards, 2010).

On the other hand, most of the lexical assessment instruments have a similar approach to assessing the vocabulary level, since they take the number of labels that a child can identify or produce as vocabulary scores. Therefore, vocabulary level is equivalent to a quantitative measure of a pre-established list of words. Despite its relevance for clinical and educational purposes, quantitative measures of vocabulary provide no information about the processes involved in word learning, nor do they account for the reasons why a child is able or not to reach a specific level of vocabulary. All these challenges can be partially tackled by taking advantage of procedures developed in research contexts and making use of developments in mobile technology.

FM tasks have been used in many different languages and in bilingual populations, showing that the children that perform better in this task are those who score better on a standardised vocabulary measurement (e.g. Alt & Plante, 2006; Arias-Trejo, et al., 2014; Asadi et al., 2021; Bedore & Leonard, 2000; Jackson et al., 2023; Kan, & Kohnert, 2008; Majorano et al., 2017; Torkildsen et al., 2008). Research has also shown that late-talking children show a poorer performance in FM tasks compared to typically developing

children (e.g., Cheung et al., 2022; Rujas et al., 2019; Weismer et al., 2013). Due to performance in FM not depending on the child's expressive vocabulary level, FM tasks can be suitable for very young children as well as for children from culturally diverse backgrounds that are not sufficiently proficient in the assessment language (Dale et al., 2003; Rescorla & Schwartz, 1990). Furthermore, implementing an FM task in an App for a tablet could make the task attractive for children, facilitating involvement and sustained attention. Additionally, FM tasks allow for a dynamic assessment of lexical development. That is, they emphasise the evaluation of the processes involved in lexical development, since they allow us to measure the number of cues given to the child to enable them to complete the task. Previous research has found that those children who need less cueing achieve higher scores than those who need more repetitions (Spicer-Cain et al., 2023). Thus, these types of tasks consider not only the number of words recognised or produced at a specific moment, but also the child's learning ability.

Moreover, implementing the FM task in a format for use on a tablet allows for collection of different types of information related to the number of prompts needed to solve the task. Based on this evidence, it seems reasonable to advocate the use of the FM tasks beyond the experimental context and introduce them in the protocols of schools and clinical practice with young children, providing practitioners with information related to vocabulary development beyond mere quantification. To our knowledge, no FM task in the Spanish language has been developed to be run in an Android App.

We chose an App for tablets for various reasons (see Smolak et al., 2021). First, because the use of tablets captures the attention of children much better and during longer periods of time than the use of other displays (Jackson et al., 2023; Lo et al., 2021). Second, because by using an App, the presentation of the stimuli is homogenised, given that the audiovisual information is audio-recorded, and the stimuli are not subject to the

specific characteristics of researchers or clinicians. This is even more important given that a potential application of the present study is to disseminate this App among Spanish speaking professionals worldwide. The third reason is that the App allows for the automatic processing of results, eliminating the possibility of human mistakes and saving a considerable amount of time. Furthermore, it is possible to register the number of prompts needed before the selection of the target referent.

In addition, the typical design and procedure of the fast mapping tasks allow for an assessment of children's linguistic skills that is more dynamic than usual fast mapping tasks, since they receive feedback on their initial choices, which, in some way, guides the selection of the next item. Although this procedure may not be considered a dynamic assessment in itself (Peña et al., 2001, Spicer-Cain et al., 2023), it is beyond the static evaluation of lexical knowledge and allows for the evaluation of the processes involved during the earliest stages of lexical development. In fact, previous research with French-speaking children has shown an increase in children's accuracy in fast mapping tasks that included three trials with feedback on their performance (MacLeod & Glaspey, 2021).

In this study, we developed an FM Android App task (the FastMApp) to be used on a tablet. We hypothesised that (a) the FastMApp would be suitable for children from 18 to 30 months. Following Lo et al. (2021), the number of trials in which a child attempts to tap an item, regardless of whether the response is correct or not, could be used as a measure of children's motivation to follow the task. In their study, they found that the average number of responses was 40 items of 50. Therefore, we hypothesised that the percentage of non-responses would be under 20%, indicating good compliance with the task; (b) the performance in the FastMApp would be sensitive to children's age, with higher scores for older than for younger children, considering both the number of correct responses and the number of prompts needed to select the target; (c) the performance

would be sensitive to the lexical status of the targets, with better performance in the identification of known referents compared to unknown referents (d) the performance in trials with a four item array would be better than that in trials with five items; (e) the FastMApp would show construct validity, with children' scores positively correlating with the vocabulary level in the MacArthur-Bates Communicative Development Inventory (MCDI) (López-Ornat et al., 2005), which acts as an independent measure of lexical development based on parent report.

Method

Participants

The study was approved by the Research Ethics Committee of the Autónoma University of Madrid. Families were contacted through nurseries in the city of Madrid and were asked to fill in the Spanish (European Spanish) version of the MCDI (López-Ornat et al., 2005). Once scored, we offered the families a brief report that included vocabulary and morphological complexity percentiles.

The pilot study was conducted (between November 2022 and July 2023) with a total of 60 children aged between 18 and 30 months (30 girls; 30 boys). The mean age was 24.53 months (SD= 3.4). They all spoke Spanish as their first language and attended monolingual nurseries. Children exposed to other languages were not excluded from this sample. As reported by parents in the demographic section of the Spanish version of the MCDI (López-Ornat et al., 2005), only two children were exposed to other languages apart from Spanish, varying between 20 and 40 hours per week. One was exposed to Ukrainian, and the other to English.

Parents and teachers also reported that they all followed typical development, having no history of hearing loss and no referral to speech or language therapy services. Children were all full-term infants from uncomplicated pregnancies and normal deliveries.

Stimuli

The task includes a total of 22 trials. The first two are training trials and the rest are test trials. Training trials include two pictures, while test trials include four (first ten test trials) or five (last ten test trials) pictures. Four picture trials include three known pictures and one unknown picture (see Figure 1). Five picture trials include four known pictures and one unknown picture (see Figure 2). The order presentation of the trials remains constant for all participants.

(insert Figure 1 around here)

(insert Figure 2 around here)

We selected the known labels from the most frequent words chosen by the participants in the adaptation of the MCDI to European Spanish (López-Ornat et al., 2005). We selected object labels that were chosen by, at least, 50% of the participants in the study, considering that it was possible to represent the labels in recognisable pictures. Since the task includes 10 trials with 4 items and 10 with 5 items (only one was unknown), we selected 70 known words of object labels (including body parts and animals). Known words include one-, two- and three-syllable items (e.g. *sol* -sun, *coche* -car, *pelota* -ball), since there are insufficient disyllabic object labels among the 50% most frequent words known by the children from the MCDI database. Their high frequency ensured that they were known items, regardless of the number of syllables. Unknown words were disyllabic and followed a consonant-vowel structure e.g., *fepo* (unknown label but phonologically

permissible in Spanish language). All syllables were part of known and frequent words, so the unknown labels were built mixing two frequent consonant-vowel syllables that did not coincide with a real word or were not similar (for example, we discarded unknown labels like *cote* because of its similarity to the real, frequent word *coche* – car). Appendix A presents a list of the known and unknown labels included in the task.

The voice of the FastMApp was recorded by a female researcher, using child-directed speech. Visual stimuli were pictures specifically drawn for this task by a professional designer. They included colour images representing both known labels (known objects) and unknown labels (unknown objects). The unknown pictures consisted of parts of mechanical tools, technical equipment and other objects rarely used in children's homes. Despite their all being inanimate objects, many of them were built on the basis of several different objects, so they could not belong to any special category. We presented all the pictures to 15 adults and asked them to name each of them. All the adults identified all the known objects with a single label, and described the unknown objects with several words, showing there is no single, frequent word to identify the object.

The arrangement of the trials with four and five items was as shown in Figures 1 and 2. The unknown object was located in different parts of each trial. We thus ensured that the target item did not have the same location (up-left, up-right, down-left, down-right).

Procedure

Participants were recruited from childcare and municipal nursery schools in Madrid (Spain). Two trained researchers administered the FastMApp to the children. The

participants left the classroom with one of their two teachers and accompanied the researcher to a quiet, empty area to complete the task.

The children sat on a chair in front of a table, close enough to the tablet to tap the images displayed in a "picture game". Their reference teacher accompanied them and was instructed not to participate in any way during the application of the FM task, which lasted less than 10 minutes.

The task was divided into two different phases (see Table 1).

(insert Table 1 around here)

Initially the audio recording presented the instructions, as follows: *¡Hola! ¿Te gustan los dibujos? ¡Vamos a jugar!* (Hi! Do you like pictures? Let's play!).

Then, the two training trials showed a picture of a girl and a picture of a banana. The audio recording played the instruction *¿Ves a la niña? Toca a la niña*. (Can you see the girl? Tap the girl.). When the participant successfully chose the right item (tapping the corresponding picture), they were congratulated (*¡Estupendo!*) (Fantastic!).

In these practice trials, the experimenter was allowed to help the children by repeating the instruction or even by touching the picture themselves or guiding the child's finger. The aim was for the children to understand the instructions and the procedure of the task.

The training phase did not end until the child had successfully pressed both training items when asked. Then, the audio recording encouraged them to continue (*¡Vamos a seguir jugando! Mira estos dibujos*.) (Let's keep playing! Look at these drawings!).

After ensuring that the child could follow the procedure, the test trials started. First, the trials with four pictures were sequentially displayed. Four pictures (three known, one unknown) were displayed on the screen. In each trial, the child was requested to identify one of the items: *Mira, un pan*. *¿Ves el pan? Dale al pan* (Look, bread! Can you see the bread? Tap the bread).

If the child succeeded in the first attempt, then the picture was highlighted in a green box (visual feedback) while the audio recording congratulated the child on their performance (auditory feedback) ("*¡Genial!*") ("Fantastic!"). Then, the task automatically moved to the next label: the unknown.

If the child's answer was incorrect at the first attempt, the FastMApp encouraged the child to keep trying: *Venga, busca el pan*. (Come on! Find the bread.). If the child answered incorrectly a second time, the FastMApp offered further encouragement: *Fíjate bien, toca el pan*. (Pay attention. Tap the bread). If the child responded incorrectly a third time, the correct picture was highlighted in a green box while the audio recording signaled the right answer: *Este es el pan*. (This is the bread.). In the event of the child not tapping the screen in three seconds, the FastMApp encouraged the child to keep trying, up to two more times: (1) *Venga, busca el pan*. (Come on! Find the bread.; (2*) Fíjate bien, toca el pan*. (Pay attention. Tap the bread). That is, for each label/picture, each participant had up to three opportunities to choose the right item. The procedure just described for known labels was also followed for the unknown labels.

Once the first trial had been completed (successfully or unsuccessfully), the task moved on to the next trial and the procedure was repeated: first the known picture, then the unknown one. The task included up to three attempts before moving to the next trial because the child might not have been paying attention, or they might have been struggling to find the referent of the label, requiring more repetitions to respond correctly.

Furthermore, given that the child-directed speech was very repetitive (Alam et al., 2021; Casla et al., 2021), the child had more opportunities to find the word. As will be discussed later, the number of attempts provides important information about the processes involved in referent selection. The task did not include further attempts because the number of items was large enough to inform about the children's referent selection, and so the task was neither too long nor too short.

After completing the ten four-picture test trials, the task moved on to the ten five-picture test trials (four known pictures and one unknown picture). The procedure was the same as in the case of the four-picture test trials.

Children were requested to identify first known labels and then unknown ones. It was possible to tap any of the drawings that were on the screen, regardless they were known or unknown. Therefore, although tapping the known item in the first place reduced the possibilities to three (or four) items, children still had all the pictures in front of them, simulating naturalistic situations in which known and unknown objects are present.

The FastMApp has a pause button for any unexpected need. The FastMApp can be freely downloaded at this link: https://www.ucm.es/clinicalogopedia/investigacion.

Coding and data analysis.

Immediately after the end of the task, a window with a summary of the results automatically appeared with the total number of correct responses and the time taken (see Figure 3).

(insert Figure 3 around here)

In addition to this screen with the summary, the App automatically created a database in an Excel spreadsheet in which several variables were coded. For example, it shows the total number of correct responses for the entire task (minimum 0 maximum 40) as well as for each trial, including the number of attempts required to reach the right response. The results include information concerning the time required to reach a response for each trial and for the whole task (see Appendix B with an example).

Results

First, we examined participants' compliance with the task. We calculated the percentage of non-responses throughout the task. That is, we considered as a non-response those instances in which participants did not tap the screen, even after three opportunities. We divided the sample into two age groups, each consisting of 30 participants: those aged 18 to 23 months (Group 1) and those aged 24 to 30 months (Group 2). We obtained less than 11% of non-responses throughout the task (10.71%). As hypothesised, overall, the number of non-responses was lower than 20%, and thus the responsiveness was good and sufficient to indicate that children comply with the task. The number of non-responses in Group 1 was significantly higher compared to Group 2 ($t(58) = 3.85$; $p = .001$). Results are shown in Table 2.

(insert Table 2 around here)

In addition, we examined the percentages of correct responses and found neither ceiling nor floor effects. In the case of the known labels, the range of correct responses was from 56 to 96% (trials 6 and 10 respectively) and, in the case of the unknown labels, the range was between 35 and 72% (trials 6 and 7 respectively). Only six of the 60 participants correctly responded to all the known labels (five children in Group 2 and one

child in Group 1). Regarding the unknown labels, no child correctly responded to all the trials (range 5 - 90%). We also found that the mean number of non-responses was higher for the unknown labels than for the known labels (see Table 2). This difference was significant (t (118) = -2.541; p = .006).

In addition, to analyse the role of feedback and the attempts on the responses, we calculated the differences between the number of correct responses at the first, second and third attempt. All the children tapped the right picture at the second or third attempt at least once. The mean number of correct responses at the second or third attempt was 9.26 (*SD* = 3.55; range 2 to 17). In particular, the mean number of correct responses at the second attempt was 5.5 (*SD*= 2.93) and at the third attempt 3.76 (*SD*= 2.24).

In order to analyse the role of age in performance, we conducted an ANOVA in which age was the between-subjects factor (with 2 levels, Group1 -18-23 months- and Group 2 -24-30 months-) and label (with two levels; known and unknown) and number (with two levels; 4- and 5-item trials) were within-subjects factors. The dependent variable was the number of correct responses. The results showed a higher number of correct responses for children between 24 and 30 months ($\bar{X}$ = 29.37, SD 7.14) than for children between 18 and 23 months ($\bar{X}$ = 21.81m SD 6.79). These differences were significant (F(1, 58) = 22.55, p < .001, η^2 = .28, 1-β=.997).

We also found significant differences between the known and unknown labels (F(1,58)= 263.39, p < .001, η^2=.82, 1-β = .1). The children's performance with the known labels ($\bar{X}$ = 16.08, SD = 1.9) was higher compared to that with the unknown ones ($\bar{X}$ = 9.53, SD = 2.42).

In addition, we found a main effect of the number of items included in the task (F(1,58) = 7.94, p < .007, η^2=.121, 1-β =.792) and an interaction between lexical status

(label) and number of items ($F(1,58) = 8.59$, $p < .005$, $\eta^2 = .129$, $1-\beta = .822$). Planned comparisons showed that the differences between the 4- and 5-item trials were not significant for known labels ($p > .5$), but were for the unknown labels ($p < .001$), being harder to respond the 5-item trials. The triple interaction between age, label and number did not reach significance.

Regarding the construct validity, we expected to find a significant correlation between the scores for the FastMApp and the vocabulary raw scores on the McArthur Communicative Development Inventory (CDI) (López-Ornat et al., 2005). We carried out bivariate (Pearson) correlations and found a significant positive correlation between both variables ($r(60) = .50$, $p < .01$). The correlations were also significant separately for the known labels ($r(60) = .49$, $p < .01$) and for the unknown labels ($r(60) = .43$, $p < .01$). We also found positive significant correlations between the vocabulary raw scores at the MCDI and the mean number of correct responses in Group 1 (18- 23 months) ($r(60) = .369$, $p = .045$) and in Group 2 (24- 30 months) ($r(60) = .439$, $p = .015$).

To further assess the relationship between the scores on the MCDI and the results in our App, we carried out some additional correlations. We correlated the vocabulary level (total number of words produced by each child according to the MCDI) with the total responses reached in the first, second and third chance, and with the non-responses. We found: (a) a significant and positive correlation between the vocabulary level and the number of correct responses at first chance ($r(60) = .511$, $p < .01$) (b) a non-significant correlation between the vocabulary level and the number of correct responses at second chance ($r(60) = .05$, $p < .8$), and (c) a negative and significant correlation between the vocabulary level and the number of responses at third chance ($r(60) = -.35$, $p = .006$). In addition, we found a negative and significant correlation between the vocabulary level and the number of non-responses throughout the task ($r(60) = -.27$, $p = .033$).

Discussion

The aim of this study was to explore whether the FastMApp developed is an appropriate tool to assess referent selection abilities related to vocabulary development in Spanish-speaking children aged between 18 and 30 months. Previous evidence in experimental settings supports the use of FM tasks with young children (Asadi et al., 2021; Bion et al., 2013; Horst & Samuelson, 2008; Jackson et al., 2019; Kan & Kohnert, 2008; Majorano et al., 2017; Spiegel & Halberda, 2011; Torkildsen et al., 2008). To our knowledge, researchers are yet to develop an App to test fast mapping abilities in children under 30 months of age in the Spanish language. Referent selection abilities are crucial for children to incorporate new words during lexical development. Early difficulties to identify the referent of new words may underlie lower levels of vocabulary that are related to other difficulties during lexical and grammatical development (Bion et al., 2023). Thus, it is essential to assess these abilities by speech-language pathologists in clinical and educational settings, especially with very young children.

We first explored the general functioning of the FastMApp. We found that children from 18 months complied with the task, as the percentage of non-responses was found to be low (less than 11% of non-responses). That is, the FastMApp not only captures their attention (Lo et al., 2021) but also allows a dynamic assessment of the abilities related to the selection of the referent of new words. Children seemed to understand that they were requested to tap a picture during the task, and a considerable proportion of younger children continued searching during a second and third attempt, even if they failed; we did not reach ceiling effects with known words. Furthermore, they received feedback according to their responses and this guided their following attempts. Thus, this dynamic assessment facilitates an evaluation of incipient abilities related to lexical development.

We observed neither floor nor ceiling effects, and none of the participants achieved a percentage of correct responses below 17% or above 97%. The range of correct responses, including both known and unknown labels, varied from 5 to 97%, and participants found some items easier than others. Only six of the 60 children successfully identified all the known labels and none of the participants were able to successfully identify all the unknown labels. This suggests that, when the task requires the identification of known labels, children's performance increases, compared to when they have to identify unknown ones. More importantly, the proportion of correct identifications of known labels being high confirms that typically developing children can identify the referent of familiar and frequent labels in the FastMApp.

The fact that the responses to known items did not reach ceiling effects (especially among younger children), even considering that these items have been identified as the most frequent words according to parental reports (López-Ornat et al., 2005), suggests that the task could be helpful for identifying different levels of lexical knowledge. The 20 familiar items could thus act as a control test for the assessment of lexical knowledge. Meanwhile, the fact that children present more difficulties identifying unknown labels than known ones is not surprising and suggests that the identification of the unknown labels is assessing emerging abilities needed to incorporate new words in the lexicon. In our view, these overall results suggest that the task and the items are suitable for assessing children of this young age. We consider that this task completes the information provided by other tasks focused on receptive vocabulary, allowing for scores that classify each child according to a very specific ability that is needed to develop their vocabulary.

Our findings concur with previous results from studies of fast mapping abilities (Asadi et al., 2021; Bedore & Leonard, 2000; Jackson et al., 2019; Kan & Kohnert, 2008). In terms of the age of the participants, we found that younger children's performance

(between 18 and 23 months of age) was lower compared to older children (between 24 and 30 months). This result was expected considering that typically developing trajectories involve better performance with age (Rujas et al., 2019). Nevertheless, it shows the FastMApp to be an appropriate assessment tool that is age sensitive. Once again, this information is very important to design interventions adapted to age and the level of the referent selection abilities of each child. For example, in educational contexts practitioners could consider specific difficulties of a given child and give greater salience to the pairing of new words with their referent, especially in those contexts that are usually related to the use of new and sophisticated vocabulary (Hindman et al., 2021).

Considering the number of items included in each trial, the results showed that performance in 4-item trials was better compared to 5-item trials. However, the interaction between lexical status and number of items is more interesting. Children were shown to be accurate in the identification of known labels (in both 4- and 5-item trials). Nonetheless, when they are required to associate new referents with unknown labels, 5-item trials seem to be harder compared to 4-item ones. This means that identifying known referents is a relatively easy task, regardless of the number of distractors. However, as discussed, identifying unknown labels is more difficult, and so adding new competitors, even if they are known referents, makes the task especially difficult for children. This result is interesting because it allows for the assessment of the processes involved during lexical development, and, as such, it will help in tracing atypical trajectories of the abilities needed for the first stages of lexical development. Jackson et al. (2023) reduced the number of items from their pilot study from three to two (the referent and a distractor) because the task was too difficult for some 2-year-olds. Nevertheless, they acknowledged that research has traditionally included four items (the target and three distractors) at the identification phase, and their study shows that the difficulties are not at this phase but at

the extension phase and depending on the basis of the generalisation (colour, size, orientation). Thus, the results obtained with this task will allow children to be identified whose lower vocabulary levels are related to difficulties mapping referents to labels, even if those stimuli have already a label. Therefore, it would be possible to design interventions for those children whose scores are especially lower with 5 items, creating other situations in which there are fewer competitors or in which the referents are more salient.

Lastly, the results show that the number of words that a child produces (measured using the Spanish version of the MCDI) is related to the performance on the task (Bion et al., 2013; Kalashnikova et al., 2018), since moderate, albeit significant correlations, were found between children's vocabularies and the identification of known and unknown words. Although previous studies have found stronger correlations (e.g., Kalashnikova et al., 2016), our view is that this result supports the notion that our fast mapping App is sensitive to vocabulary level.

Overall, the correlation indicates that the larger the child's expressive vocabulary is, the easier they find the task.

In addition, this expressive vocabulary level is also related to the number of attempts a child needs before giving the correct answer. Specifically, a more extensive expressive vocabulary is positively and significantly related to a higher mean number of responses at the first attempt. At the same time, these children with broader vocabularies barely used up the three attempts they were offered. Although the correlations were moderate, they were all significant, which is a noteworthy result, given that some studies failed to find such correlations (Kucker et al., 2020). The results once again support the idea that the FastMApp is a suitable tool for the assessment of lexical development and is sensitive to children's vocabulary level.

These findings corroborate previous research stating that vocabulary level and referent selection abilities are intertwined (Bion et al., 2013). However, the role of vocabulary size in fast mapping abilities should be studied further, as findings have not always been consistent (Kucker et al., 2020). We consider that the FastMApp has several characteristics that could be highly useful for speech-language pathologists, given the scarcity of time and resources in these settings. First, it allows mechanisms involved in lexical development that go beyond the mere quantification of vocabulary to be tested. Second, it is a quick and efficient tool to test referent selection abilities in children aged under 30 months and has the benefit of providing automatic and immediate results. Overall, we consider that our task includes some aspects of dynamic assessment that are applied to the receptive vocabulary. This is so, because children are not only provided with three attempts but also receive feedback on the result of their attempts. Importantly, as already mentioned the task goes beyond the mere quantification of vocabulary exploring the processes involved to increase vocabulary. Therefore, it is highly useful as a receptive vocabulary tool, which is a general ability that has been found to be a strong predictor of language abilities for children with atypical developmental trajectories, such as children with autism or late talkers (Spicer-Cain et al., 2023).

However, there is still further work to be done. An interesting option to further assess and exploit this App is to increase the sample and provide a scale. This scale would allow professionals to place children's abilities in relation to a reference group. In addition, to examine not only referent selection abilities but also retention abilities, it is necessary to develop a second phase (retention or generalisation phase). Previous research has shown that the ability to extend the "new learned" label to other members of the same category is needed to construct stable representations of the lexical items, especially during the emerging stages of word learning (Carey, 2010; Golinkoff et al., 1996; Jackson

et al., 2023; Kucker et al., 2020). Including an extension phase in the FastMApp would allow for the identification of those children that do not present difficulties linking new labels to new referents but who may need more repetitions to generalise the meaning of new word-referent pairings.

Furthermore, the FastMApp must be tested with children with language and learning difficulties to determine whether it is sensitive to these differences. Although two of the children were exposed to other languages, their mean scores did not differ from those of the rest of the sample. However, given the small numbers in each sample, it was not possible to statistically compare monolingual children with the small group of children that were exposed to other languages. We acknowledge that, for clinical and educational contexts, it would be important to assess cultural and linguistic differences (Spicer-Cain et al., 2023). Finally, fast mapping tasks are related to receptive language and do not evaluate the phonological processes involved in word learning. There are many difficulties involved in assessing very young children's abilities to produce new words and there are complex relationships between the processes involved in this task and the phonological abilities required for production (see, for example, MacLeold & Glaspey, 2021). In our task, we used only disyllabic unknown words to homogenise the difficulty of the unknown items; nevertheless, it would be interesting to include items that vary their complexity from the phonological point of view. Nevertheless, the lack of standardised measures for children under 3 years of age (Jackson et al., 2023) justifies the need to continue developing these kinds of tools.

Finally, as limitations of the present study, it is important to mention different issues. First, it is not possible to completely rule out that children were influenced by the novelty of the unknown stimuli. In other words, as unknown drawings were matched with known drawings of similar semantic categories, it is possible to argue that there is a bias

that shapes responses to novelty. This potential bias could have played a role in our results collected.

Second, we acknowledge that fast mapping tasks with research purposes usually control the order of presentation of the stimuli. However, since the aim of our work was to develop an assessment tool that generates scores in clinical and educational contexts, our task presented the stimuli in the same order for all participants.

Lastly, we acknowledge that there is a need for future psychometric assessment of the App, including diagnostic accuracy. Gathering more participants would be a requirement for this new study. This goal constitutes a future step for the assessment of this App.

Conclusions

Early lexical assessment is crucial to prevent and detect language difficulties. The FastMapp is a valid tool for assessing the processes involved in lexical development. This study contributes a new way of measuring Spanish-speaking children early lexical abilities: it provides information related to the number of repetitions each child needs to incorporate new words, which is a supplementary measure to the traditional quantification of vocabulary. In addition, the FastMapp could be easily adapted to other dialectal variations of the Spanish language and has the potential to be employed in clinical and educational contexts.

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Tables and Figures

Table 1.

Phases and trials included in the FM task.

Phase	Trials
Introduction and training phase.	Two training trials (girl and banana).
Test phase.	Ten four-picture test trials. Ten five-picture test trials.

Table 2.

Percentage of non-responses throughout the task.

Participants	Known labels	Unknown labels	Total
Both groups. n=60	86 (7.16%)	171 (14.25%)	257 (10.71%)
Group 1; n=30 (18 to 23 months old)	76 (12.66%)	127 (21.16%)	203 (16.91%)
Group 2; n=30 (24 to 30 months old)	10 (1.66%)	44 (7.3%)	54 (4.5%)

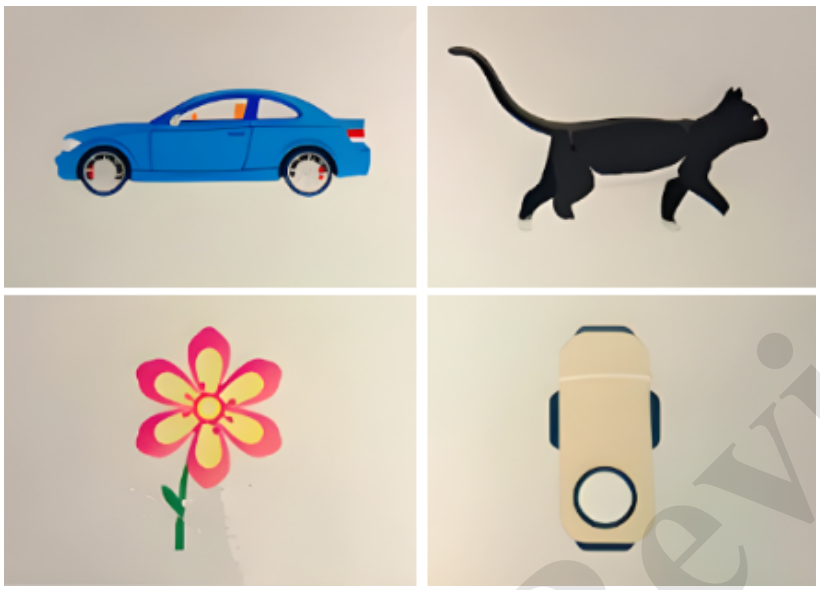

Figure 1. *Example of trial including 4 pictures.*

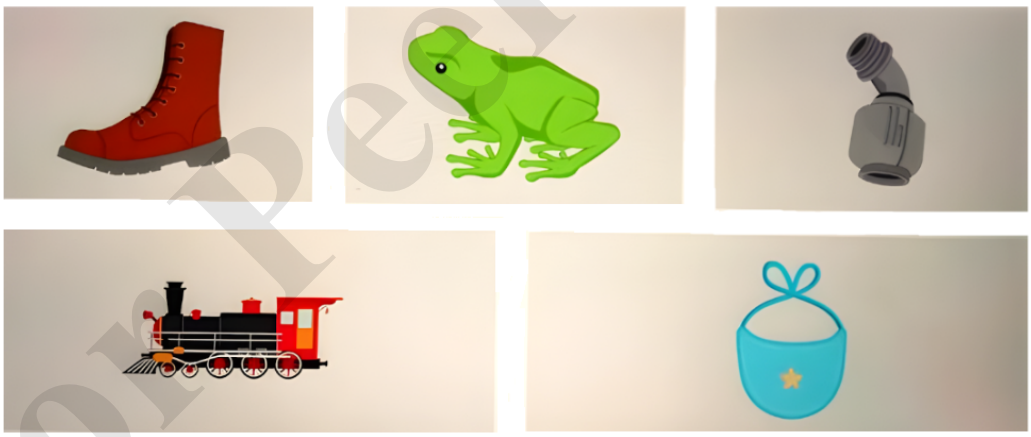

Figure 2. *Example of trial including 5 pictures.*

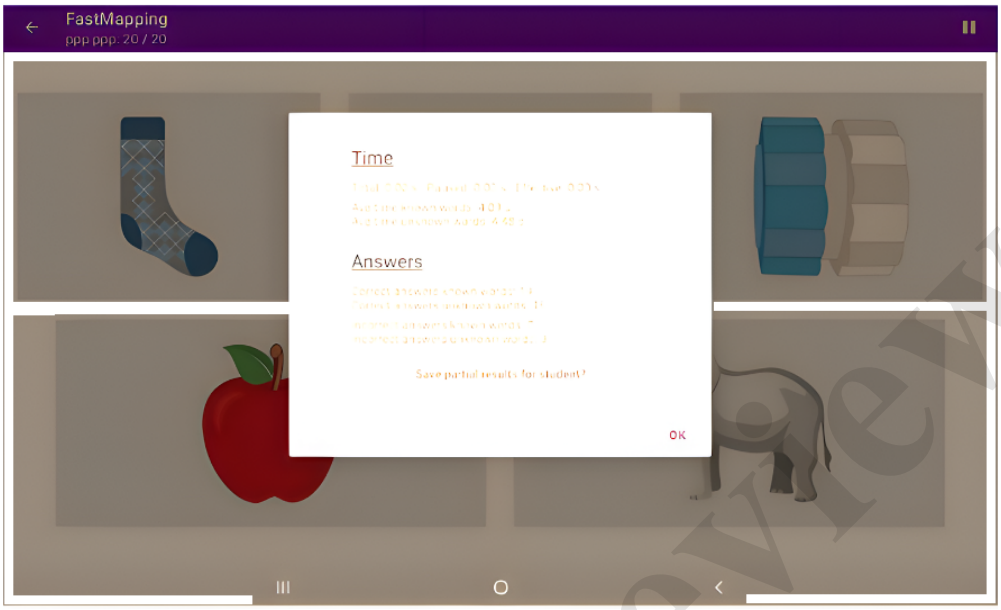

Figure 3. Final *window with the summary of the results for each participant (related to the time and number of correct and incorrect answers).*

Dear editor,

we have addressed the two comments you raised in the last revision. We hope the paper is now suitable for publication.

Best regards

Conclusion (abstract) - please include that the app is for spanish speakers.

We have added this information

Conclusion: "In addition, the FastMapp could be easily adapted to other dialectal variations of the Spanish language and employed in clinical and educational contexts". Please change this to: "In addition, the FastMapp could be easily adapted to other dialectal variations of the Spanish language and has the potential to be employed in clinical and educational contexts".

We have changed the text as requested.