

Language App Development Project, Final Report

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July 31, 2018



Acknowledgements

The research team would like to thank the 36 families that participated in this study. Thank you for giving up your time to play with Poppy and Buddy, and for coming to play with us for up to three times in a short span of time. We greatly appreciate your support, feedback, and smiles throughout this process.

We would also like to thank our stellar coding team for all of your assistance in coding the data. Angela, Justin, Gove - thank you for your dedication to our research and working hours on end to complete the data entry and coding.

Thank you also to Justin Cook for providing the app activation codes for each participant, and for your assistance when we had technology issues.

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Summary

This report summarises the procedure and results of a 6- to 8-week study conducted at the Early Learning Lab in the School of Psychology at The University of Auckland. Thirty-six 4- to 6-year-old children and their caregivers were introduced to a prototype of a second language learning app, Poppy and Buddy, and were asked to interact with the app as often as possible for 6- to 8-weeks. Children's initial language comprehension was assessed in a baseline session during which families were shown the app and asked to select their second language of choice out of three possible languages (Te Reo, South American Spanish, and German). Children were assigned to one of two conditions. In the one language book condition, the books only provided the second language whereas in the two language book condition, both the child's first and second language were displayed on each page. Children's language comprehension was assessed approximately 3- and 6-weeks after the baseline session, as was their use and enjoyment of the app. Our findings revealed that children's knowledge of words and concepts depicted in the books increased significantly for both their first and second language. Children's performance across the two book conditions did not seem to differ, although the data provided some suggestion that the two language condition might support sustained language comprehension growth in both first and second languages. Children reported that they enjoyed playing with the app. Most parents reported that their children used the app at least 5 times per week and enjoyed doing so. Parents provided several positive comments about the app including the interactive features, annunciation and highlighting features. Some suggested improvements would be to enhance functionality and increase the interactive nature of the apps. In conclusion, our findings suggest that the Poppy and Buddy app could be an enjoyable and

useful tool to support preschool-aged children's first and second language comprehension development.

Background

The goal of this project was to test the extent to which preschool-aged children's use of a prototype of the Poppy and Buddy Language Development App supports first and second language acquisition. To this end, the Early Learning Lab, under the direction of Dr. Annette Henderson, conducted a longitudinal study during which children ranging in age from 4- to 6-years of age and their parents were introduced to the Poppy and Buddy App and were asked to use the app on a regular basis for the following 6-8 weeks (procedure outlined in detail below). Children and at least one of their caregivers attended three lab sessions: baseline (first visit), midpoint (approximately 2-3 weeks after the introduction to the app) and final (approximately 6- to 8-weeks after the introduction to the app). Before coming in to the lab, half of the children were randomly assigned to the one language condition in which the books only contained the second language, whereas the other half of children were assigned to the two language condition in which the books depicted the words in both English and the second language on each page. During the first session, children and their parents were introduced to the app and were asked to select their preferred second language out of the three available languages (Te Reo Maori, South American Spanish, and German). In all three lab sessions, children completed a series of questions to assess their initial language knowledge and subsequent language development. Before leaving the lab, parents and their children were asked to interact with the app at home as often as possible. In the second and third sessions, children and parents were also asked questions surrounding the app use, enjoyment of the app, and also to provide suggestions for improvement.

This report consists of three main sections: Method, Results, and Discussion. In the Method section we provide details about who the families were who participated in this study, including the attrition rates, and then we detail the procedure that was followed for the study. In the Results section we provide both quantitative and qualitative analyses of the comprehension test data, as well as parents' and children's responses to our questions about the app, to answer the following questions:

- Which languages did the families choose?
- Did children show any change in their language knowledge of their second language relative to their first language?
- Were there any difference between conditions in children's language development?
- What did children and their parents think of the app?
- Insights from the experimenters

Please note that we have not included our analyses of the production and mimicry test questions. While we have coded all of the responses of the children for which German and Spanish were the chosen languages, we had significant difficulties finding a native Te Reo Maori speaker and did not have sufficient resources to have a broad search while also trying to run the study. We believe that we have secured a Te Reo speaker and hope to have the coding completed in a few weeks and will provide a revised report with a summary of the production data at that time. We realise that this is sub-optimal but we could not anticipate the difficulties that we experienced finding this speaker, which was compounded with several leads that fell through. We greatly appreciate your understanding regarding this issue and look forward to presenting these results as soon as we can.

We finish the report with a brief Discussion section in which we summarize the findings, offer some conclusions based on the results, and provide some points that you may want to consider in the development of the app.

Method

Participants

A total of 36 4- to 6-year-old children ($M_{age} = 48.20$ months, $SD = 5.17$, range = 32.93 to 60.43 months, 19 males, 17 females) exposed primarily to English during their waking hours ($M_{Percent\ English\ Exposure} = 98.36\%$, $SD = 2.71$, range = 90% to 100%) and their caregivers participated in the baseline session of this study. During this session parents identified their children as belonging to the following ethnicities: NZ European ($n = 28$) and more than one ethnicity ($n = 8$). See Figure 1 for detailed Child Ethnicity breakdown. Seventeen children were randomly assigned to the one language condition and nineteen to the two language condition. The estimated combined annual income of the families in the study reported by the primary caregiver was: over \$100,000 ($n = 25$), \$80,000 - \$99,999 ($n = 7$), \$60,000 - \$79,999 ($n = 1$), and less than \$60,000 ($n = 2$). One caregiver did not answer this question.

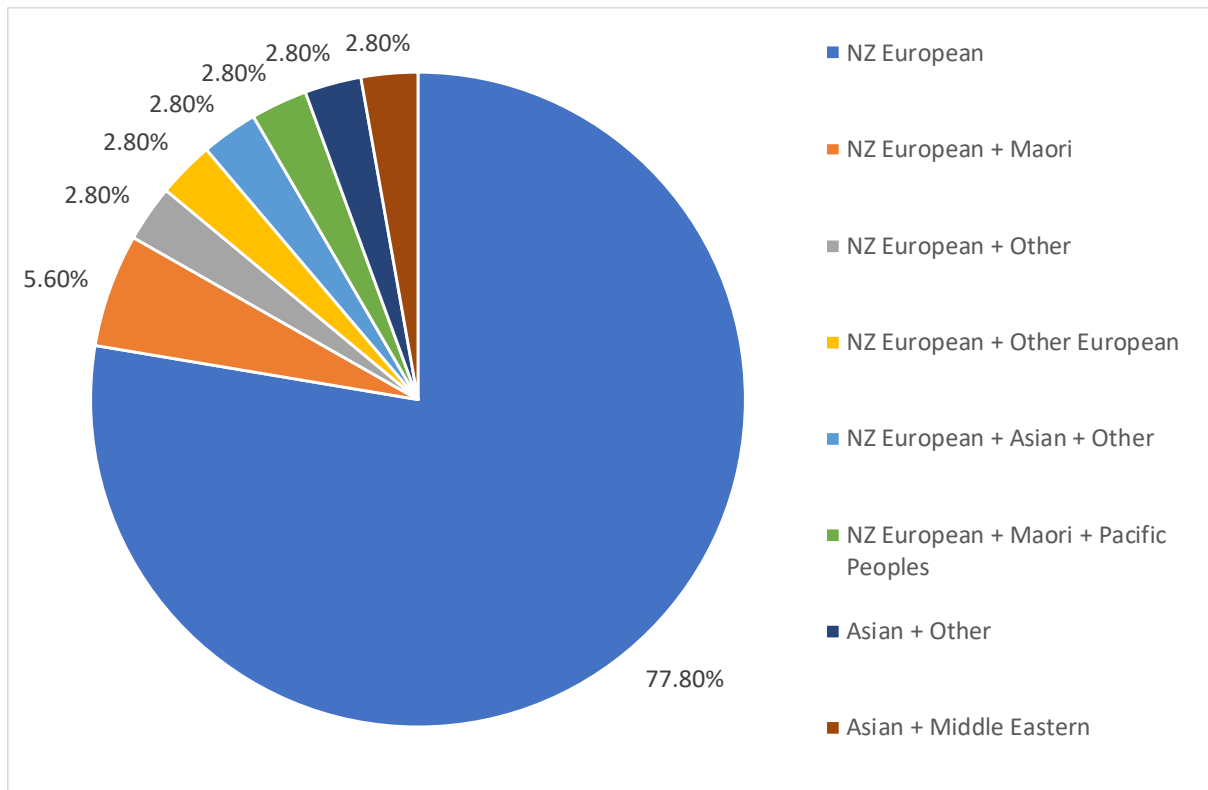


Figure 1. Percentage of total sample of children from each ethnic group (Reported by parents; $N = 36$)

A total of 29 children participated in the second session. Of the seven children who did not participate in the second session, one child participated in the third session. The parent was unable to attend the second session due to personal reasons, but we were appreciative that she was able to make the third session work. Thus, we had six families drop out of the entire study from the first visit to the second visit.

A total of 26 children participated in the final session and thus, an additional four families dropped out of the study between the second and third visit. While this attrition rate of 38% was much greater than the anticipated 10 - 15%, it was not surprising given the technical challenges (i.e., system crashes, glitches etc.) that were experienced throughout the study. Our ethics approval required us to state that participants could withdraw without

requiring them to provide a reason for doing so and thus, we do not have formal data to present regarding the reasons for participant withdrawal. However, the experimenters' informal conversations with many of the ten families who withdrew leads us to believe that most of the families withdrew because their child either did not enjoy the app from the start, or lost interest in the app during the study, and the parents could not get their child to engage with the app. One of the families had technical difficulties loading the app on their device and thus, dropped out of the study despite several attempts (from all parties) to address this issue. Although the attrition rate was not ideal, it is important for us to note that with the power of the repeated analysis design, the final sample size of 26 (12 children in the one language book condition and 14 in the two language book condition) was still large enough for us to complete statistical analyses to assess children's learning across the three phases.

Materials and Procedure

Baseline Session.

The main goals of the baseline session were to: introduce the children and parents to the app and to assess children's initial knowledge of the words and concepts that appeared in the Poppy and Buddy books.

Warm-Up and Introduction. After parking in the Science Building carpark, families were escorted by a team member to the Early Learning Lab on the City Campus of the University of Auckland. The experimenter described the study to the parent and completed the informed consent procedure. After answering any questions the parent had, the experimenter asked the parent to complete the consent form and demographic

questionnaire. While the parent was completing the forms, the experimenter played with the child to ensure that the child was comfortable with the new setting. After the forms were signed, the experimenter escorted the child to the study room where the rest of the study session was completed. The study room consisted of a small table and chair for the child to sit at, and a Dell laptop placed near the middle of the table. The entire session was recorded via two Panasonic video cameras that were on tripods and were positioned on opposite sides of the room. The laptop was used to present the images and graphics from the Poppy and Buddy app that were presented during the language knowledge test phase.

Children's language comprehension (what they know) and production (what they say) in both English and the second language were assessed in this session by completing two language comprehension tests and two language production tests (described below). The language knowledge tests were created using content from four Poppy and Buddy books. The following books were used to create the language test stimuli: Count, Art, Dance and Party. Please note that the Opposites book was not used because it was not completely functional. In the interest of time and children's attention, children were tested on two of the books (randomly assigned).

Language Comprehension Test. Children completed two language comprehension tests each consisting of ten questions. For each question of the language comprehension test, four images/graphics were displayed on the screen and children were asked to point to the correct answer (e.g., "Green"). For the Dance storybook, half of the questions displayed a solo image of Poppy or Buddy, and children were instructed to point to the correct body part. Children were given a plastic wand to use to point to their answer during the

comprehension test phase. Children's responses to the test question were coded offline by a second coder.

Language Production Test. Children also completed two language production tests, each consisting of ten questions. For each question, one static image or moving graphic was displayed on the screen, and the children were asked to say what the object, colour or action was displayed in either English or the second language. For example, the experimenter would point to a picture of the balloons from the Party storybook, and say "Can you say what that is in English?/Can you say what that is in [chosen second language]?" Children's responses to the test question were coded offline by a second coder.

Introduction to the App. After the language tests, the experimenter loaded the app onto the parent's device and set up the app with the correct settings (e.g., with the selected second language, and either showing only the second language or both English and the second language). The experimenter then explained to the parent how to operate the app.

Following this, the parent was asked to show their child how to use the Poppy and Buddy app for approximately five minutes on camera in the testing room. This concluded the end of the testing session. Additionally, the experimenter asked for the child to engage with the app for on average five minutes a day between the first session and the second session.

Second Session.

The main goals of the second session were to: assess changes (if any) in children's knowledge of either language (English or their second language) and gauge parents' and children's interest and use of the app. The procedure for the second session was nearly

identical to that of the first with the following exceptions: the parent did not need to be introduced to the app, but instead, completed a questionnaire about their experience and the child's (and their) use of the app thus far. For the language knowledge test, children were asked which two books were their favourite and those books were subsequently used for the language tests. Using the child's two favourite books would increase the chances that children had come across the content before and thus, gave them the best opportunity to showcase their knowledge.

After the child completed the language tests, the experimenter asked an extra set of questions focusing on the child's opinion of the app. The experimenter asked the child how much they enjoyed the app by asking the child to select the face that corresponded to how they felt when they played with the app (see Figure 2). Then the experimenter asked the child what they liked most about the app, and what they liked least about the app. Children's responses are summarised in the Results section.

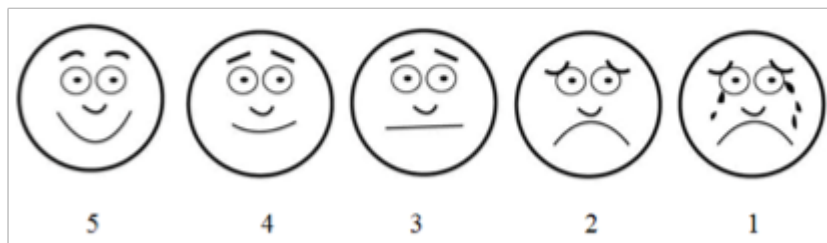


Figure 2. The face scale used to index children's enjoyment of the app.

Third Session.

The procedure for the third and final session was nearly identical to the second session, with the following main difference. We introduced a mimicry game to assess

children's ability to repeat specific words from the books. During the mimicry game, ten words or phrases were said in the second language, and the child was asked to copy what Poppy and Buddy said. The main reason for this addition was because we had noticed that production performance was quite low (possibly due to shyness) and wanted some measure of children's ability to produce the words. Thus, in this phase five games were played on the laptop; two comprehension games, two production games, and one mimicry game. As in the second session, children were tested on their two favourite books.

Results

What language did families choose as the second language?

There were three possible languages available to families: Te Reo Maori, South American Spanish, and German. The number of families selecting each language in the baseline phase were: Te Reo Maori (n = 22), South American Spanish (n = 11), and German (n = 3). Of the ten families who discontinued participation in the study, most had selected Spanish (n = 6) while four had selected Te Reo. Thus, the number of families in the final sample who had selected each language were: Te Reo Maori (n = 18), South American Spanish (n = 5), and German (n = 3). The finding that over two thirds of the sample (and 69% of the final sample) selected Te Reo Maori as their preferred second language, suggests that parents of young children being raised in New Zealand are particularly motivated to expose their children to Te Reo Maori as a second language.

Did children show an improvement in their English and second language comprehension over time?

As can be seen in Figure 3, children's language comprehension improved across time for both English and the second language. To test whether children's increased performance on the language comprehension tests was statistically significant, a 3 (testing session: baseline, second, third) x 2 (language: English, Second Language) repeated measures analysis of variance (ANOVA) on children's percent correct responses on the comprehension tests for each language (i.e., English and the Second Language) was conducted. The results revealed statistically significant main effects of language ($F(2, 48) = 24.91, p < .001, \text{partial } \eta^2 = 0.51$) and of phase ($F(1, 24) = 93.64, p < .001, \text{partial } \eta^2 = 0.80$), but not a significant interaction between language and phase. As would be expected, children performed significantly better on the English comprehension test questions than they did on the second language test questions. The main effect of phase reveals that children's comprehension scores were significantly higher at the second and third sessions than they were at the first session (p 's $< .01$). However, children's comprehension did not show statistically significant improvement between the second and third visits. These findings suggest that the app improved children's knowledge of the words and concepts depicted in the books in the second language, as well as the child's first language, which was English for the children in this study. Improvement was mostly seen within the first three weeks of app use while improvements after the second session were modest.

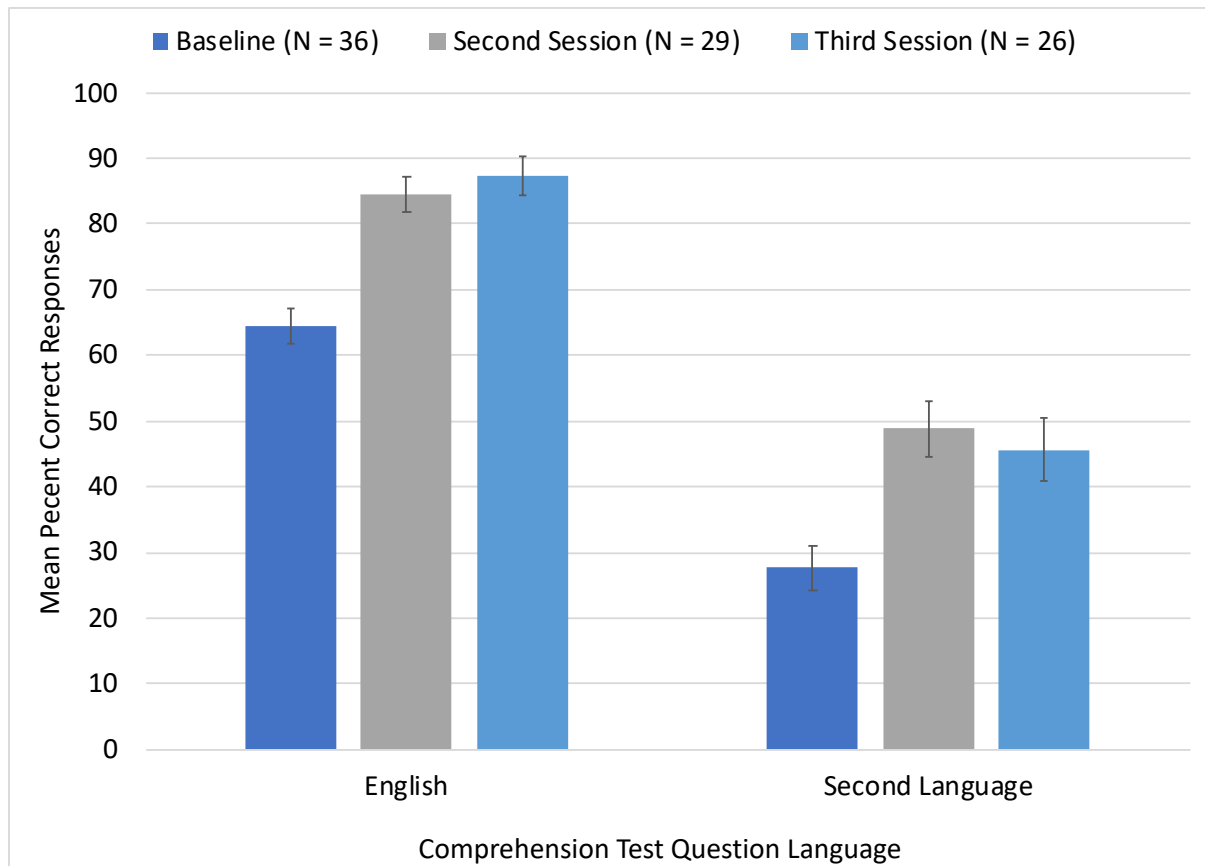


Figure 3. Mean percentage of correct responses (+/- SE) on children's comprehension for English and the second language questions across each phase collapsed across condition.

Were there any differences on children's comprehension test performance between the one vs two language book conditions?

As can be seen in Figure 4, children in both conditions showed an improvement in their second language comprehension from the baseline session. To test whether there were any statistically significant differences in performance between the two book conditions, a 3 (testing session: baseline, second, third) x 2 (book condition: one language, two languages) mixed-design ANOVA with phase as the within subjects factor was conducted on the percent correct responses on the language comprehension tests across time. The results revealed a significant main effect of phase ($F(2, 46) = 8.07, p = .001, partial$

$\eta^2 = 0.26$) and no other significant effects. Consistent with the above analyses, children's second language comprehension performance improved from the baseline session to the second and third sessions. However, children's comprehension did not improve between the second and third visits. These findings do not reveal a significant difference between the book conditions with respect to the development of children's second language word knowledge. However, it is interesting to note that only the two language condition showed continued growth in children's second language comprehension performance.

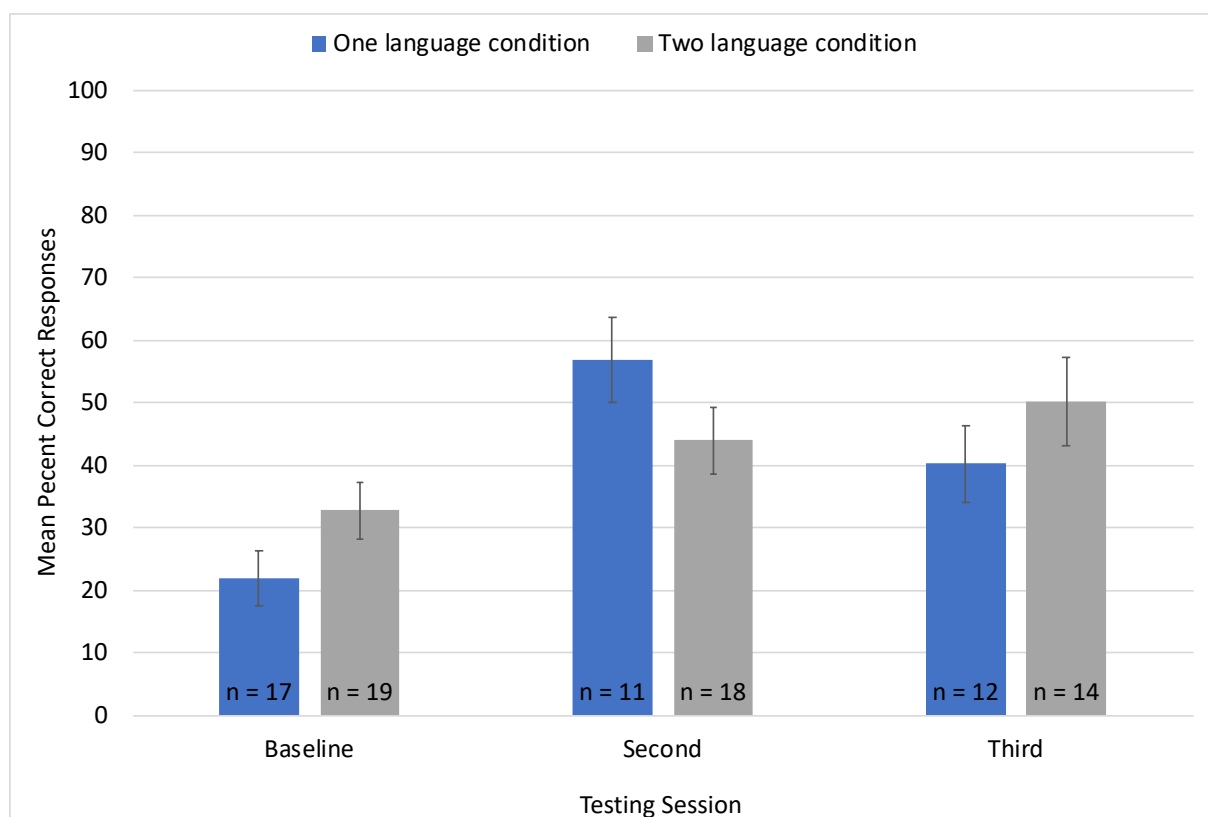


Figure 4. Mean percentage of correct responses (+/- SE) on children's second language comprehension across each phase for each book condition.

While the above analyses did not provide strong support for a difference between conditions with respect to children's second language comprehension acquisition, it is interesting to note that the book condition did seem to have an effect on children's English

comprehension development (see Figure 5). To test whether there were any differences in performance between the two book conditions, a 3 (testing session: baseline, second, third) x 2 (book condition: one language, two languages) mixed-design ANOVA with phase as the within subjects factor was conducted on the percent correct responses on children's English comprehension test performance across time. The results revealed a significant main effect of phase ($F(2, 46) = 24.21, p < .001, \text{partial } \eta^2 = 0.51$) and the interaction between phase and condition was approaching significance ($F(2, 46) = 2.82, p = .07, \text{partial } \eta^2 = 0.11$). Follow-up analyses of this approaching significance effect for each condition revealed that in the one language condition, children's English comprehension improved significantly from baseline to the third session, $t(11) = -3.58, p = .004$. In contrast, children in the two language condition, showed a statistically significant improvement in English comprehension from baseline to the second session, $t(17) = -7.07, p < .001$, as well as from baseline to the third session, $t(13) = -5.58, p < .001$. Thus, these analyses provide some evidence that the two language condition may enhance children's comprehension of the English words and concepts depicted in the Poppy and Buddy books, at least in the first few weeks of app use.

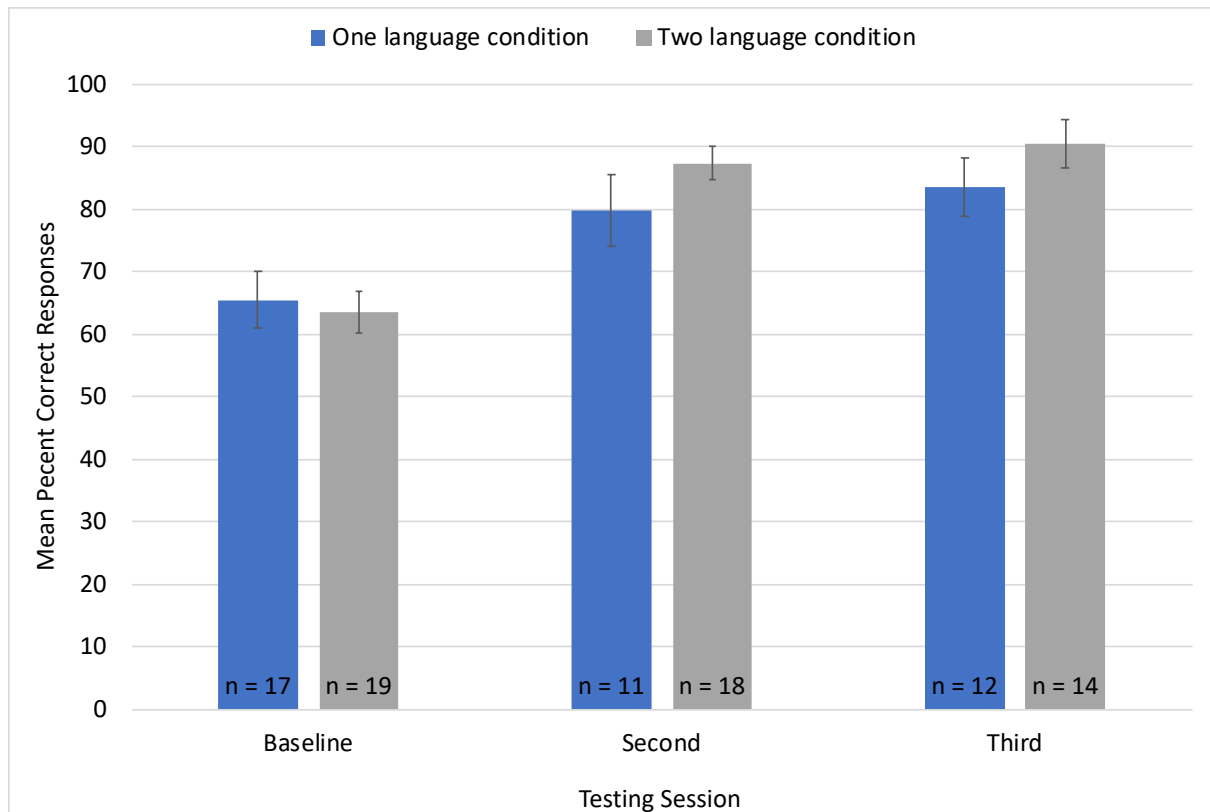


Figure 5. Mean percentage of correct responses (+/- SE) on children's English comprehension across each phase for each book condition.

What did children and their parents think of the app?

Parents' report of children's app use, engagement and enjoyment.

During the second and third sessions parents were asked several questions regarding their child's use and enjoyment of the app. Here is a summary of the key findings.

App use. In the second session, when parents were asked to indicate how many times per week their child played with the app, 55.2% of the parents reported that their child played with it 5-6 times per week and 6.9% played with it every day. Thus, children's frequency of use of the app across the first 3 weeks of the study was quite high. However, at the third visit when parents were asked to report their child's use of the app, only 26.9% of

the parents stated their child played with it 5-6 times per week. However, there was a slight increase in the percentage of children who played with it daily from the second to the third visit. Looking at the change in children's frequency of use over time, only two children showed an increase in use between the second to the third session suggesting that children may have lost interest in the app in the final few weeks of the study.

Most of the parents reported that their children attempted to speak along with the narration while playing with the app at both the second and third sessions, 71.4% and 69.2% of parents respectively. Generally, children who attempted to speak along with the narration across the first three weeks continued to do so.

At the second session most of the parents (75.9%) reported that their child needed repeated instruction on how to play with the app. However, children seemed to learn how to use the app quite rapidly because at the third session most of the parents (66.7%) reported that their child did not need repeated instructions on how to use the app.

App enjoyment and language interest. Parents were asked how much they thought their child enjoyed playing with the app. At the second session, 58.6% of the parents reported that their child enjoyed playing with the app "quite a lot" or "very much". However, at the third session only 38.5% of the parents reported that their child enjoyed playing with the app "quite a lot" or "very much". This reduction in enjoyment was statistically significant, $X^2(12) = 23.28, p = .026$. Looking at the change in enjoyment over time, only one child showed an increase in enjoyment of the app from the second to the third session. The majority of parents reported that children's engagement with the app was greater or the same when the parents were playing with their child.

Parents whose children had been assigned to the two language book condition were asked two additional questions regarding children's interest in each language. At the second session, 72.2% of the parents of children in the two language book condition stated that children focused more on the English language compared to the second language. At the third visit interest in the second language increased with only 60% of the families saying that children in the two language condition focused mostly on English. Thus, while only 27.8% of the children in the two language condition focused more on the second language across the first 3 weeks of the study, 40% of the children in the two language condition showed a greater focus on the second language across the final three weeks of the study. This suggests that children's increased focus on the second language, relative to their first language, takes time to develop.

With respect to the interest in the chosen second language that children in the dual language condition showed, 70% of the parents stated that children showed "a little" or "moderate" levels of interest in the chosen second language in general and thus, only 30% of the parents said their children showed "quite a lot" or "very much" interest in the second language. At the third session, most of the parents (58.8%) said that their children showed moderate levels of interest in the second language and only 23.5% of the parents reported their children showed "quite a lot" of interest in the second language.

Parents' participation in the app with their children. Most of the parents reported that they read along with the stories with their children at both the second and third sessions, 78.6% and 65.4% of parents respectively. These findings suggest that, in general, parents who read to their child across the first three weeks continued to do so throughout the duration of the study.

Children's enjoyment of and comments about the app.

After completing the language tests during the second and third sessions, children were asked some questions regarding how much they enjoyed the app. 47.2% of the children pointed to the happiest face and another 16.7% pointed to the second happiest face suggesting that children generally really enjoyed playing with the app after the first 3 weeks. When children were asked how much they enjoyed the app during third visit 52.8% of the children selected the happiest face and an additional 2.8% selected the second happiest face. Thus, children generally showed an increase in their enjoyment of the app over time. Indeed, only two children showed a reduction in their self-reported enjoyment of the app between the second and third sessions.

When asked to state what they liked most about the app, children's comments varied from stating that they liked specific books to particular elements of the app. Between the four books, Party was the most highly rated book amongst the stories, Count came second by a tiny margin, Art trailing behind at third most popular, and Dance being least popular. Some participants also expressed their fondness for the art and art style. Some children also expressed that they liked the whole application in general.

When asked to state what they did not like about the app, most children expressed that there was not anything that they did not like, or did not know what they did not like. Most of the items that children expressed dislike for were random things. To name a few, one participant did not like the grey walls, a small group of participants expressed that they did not like a certain language. Another child did not like the sister that was hiding under the table, in the Party story. Thus, as could be expected of children at this age, children did not provide much insight as to areas for improvement. We believe the parents' comments

outlined below will probably be more helpful with respect to what you may want to consider in future versions of the app.

Parents' open-ended comments regarding children's interest in and use of the app.

App functionality. Feedback often provided by the parents in this study surrounded the app's functionality. Some issues addressed were the games not working properly (the written words were not displayed, so they were unable to tell what each answer was), being unable to exit the game at the end of each storybook, and the changing language button was reported as hard to use, as it was too small for the parents and children to successfully switch between languages on their first attempt. Animations were also noted to not work in certain stories, most prominently the Opposites storybook (e.g., the night animation for the camping page).

The majority of the feedback surrounding the app's functionality focused on the sentences displayed in the app. Some issues were found with the highlighting of the sentences not always aligning in relation to the audio; the text would light up at different times to the speech. However, highlighting the words was noted as useful and a great idea to help pair the audio and the written word together. Another issue mentioned was that the sentences were too long. The sentences would sometimes be cut off, as the words did not always fit on the screen. This was predominantly encountered with the South American Spanish books. Following this, parents noted their belief that some of the sentences were too long for the children to be able to understand, focus and follow along. Reports of slight frustration from the children were noted by a few of the parents. Most of the children at this age are unable to read, therefore parents commented that the parent had to repeat

and reinforce the English and the second language word in order for the children to make the connection between words.

Child Interest. Some parents commented that their child lost interest with the app by the time of the third session. Parents believed that children lost interest after they had gone through all the stories after one week of interaction with the app, or parents noted that their child was easily distracted away from the app during app playing time. Several comments were made that children needed a parent to supervise the interaction with the app to increase engagement.

A few of the parents noted that their child was not really interested in learning the second language (as they only liked to listen to the English dialogue and sometimes refused to listen to the second language), and were not too interested in repeating the second language words after the app or the parent. One child stated to the parent outside of the study that they initially did not like the characters Poppy and Buddy. Unfortunately, the child did not express this in the study session and thus, we could not follow-up on why this was the case.

A significant number of parents commented that the children liked pushing the pictures that told the children what they were (e.g., pressing the cupboard picture in the Party storybook and the app saying “Cupboard”). They also liked pushing the language button to repeat the audio. Several parents also commented that the app had fantastic colours, themes, and stories, which they noted increased engagement with their child. Considering these findings, it seems as though parents and children were particularly interested in the interactive components of the books.

Miscellaneous. Other comments provided by the parents focused on aspects they enjoyed from the app. One parent commented on the amazing pronunciation of words from the app, and a few commented they liked that Poppy and Buddy demonstrated the action (e.g., stomping in the Dance storybook) to help make sense of the new words introduced for the second language. Parents also commented it was easy to use and enjoyable. They also reported that the children were making connections from the words learned on the app to other places, such as identifying colours in the second language at home. This was also found to expand to day to day conversations between the parent and child for one parent.

Parents' suggested changes.

Parents were provided with the opportunity to provide feedback surrounding the app for development consideration. Below we provide some key points that emerged in this section. Parents suggested that it could be good to incorporate a preview or title page for each book so children can see what they are about to read (as children at 4/5 years old are not all able to read the titles of the books). Common suggestions focused on adding more moving images and graphics to increase interest in the children (rather than static images).

A suggestion frequently mentioned by the parents was to include more interactive games for the children to play with, to increase their interest and help their language acquisition. A game suggested would be to ask questions, such as "Which one is one/six?" and the child having to find it on the page. This was suggested as the parent knows that this style of interaction, observed from their child engaging with other apps, is more engaging for the children. This would also increase their interaction with the words.

Another suggestion frequently mentioned in the feedback section and verbally to the experimenters was to incorporate more touch points, e.g., for there to be more objects that when touched say what they are. The inclusion of this in the second language would also be beneficial for the children to reinforce the second language words.

For functionality of the app, a suggestion provided by multiple parents would be to make the changing language option button bigger, as it is too small for the kids to touch and press. Similarly, the touch area on the pictures (e.g., in the Party storybook when you can touch the characters and some of the objects) is too small. The addition of a home or a back button in the games section at the end of the storybook would also be useful, as to exit the child has to go through all of the questions.

One parent suggested that a flashcard style might work better to reduce the long sentences for children who cannot read yet (in both English and their second language). Similarly, a few parents suggested an emphasis on spoken and picture interactions would be more effective rather than focusing on spoken sentences, or a direct word comparison between the two languages (e.g., “yellow” “kowhai”) would work better in pairing the two languages together. Another parent also suggested that the incorporation of a points system (such as accumulating stars or points from games) would increase engagement with the app.

Insights from the Experimenters

As observant researcher's, we found that on the whole, children enthusiastically engaged with the app in ways which often aided second language learning. The storybook format of the app developed and held the children's interest in the Poppy and Buddy

characters, the vocabulary and the language concepts. Children actively and thoughtfully interacted with the language presented in the books by repeating, identifying and assimilating the vocabulary.

Over the course of the participants' 6 to 8-week involvement, children often lost interest in the relatively limited variety of books and activities presented in the app – however, most still expressed enjoyment for having played the app.

Parents were very interested in exposing their children to a second language, and were thus very interested in presenting the app to their children. Parents encouraged more studious engagement in their children – parents often directed their child's attention away from the pictures and animations towards the vocabulary and language concepts, thus aiming to educate rather than entertain. Many parents expressed a desire to continue using the app after the study conclusion, and to obtain the full version on its release.

A limiting factor in the recruitment of participants was that not all families owned Apple devices, or owned an Apple device with OS 9 or higher. Many families that were approached and interested had to decline participation because of their not owning a device that was compatible with the app. Further, having the fully developed app available for Android users would be beneficial and reach more families eager to learn a second language.

An obvious and expected challenge faced during the completion of the study was the technological difficulties associated with the creation of a new app. At several points during the study, the app crashed, froze or altogether would not open, thus causing delays within the research process and slight frustration to the families. The unpredictability and

uncontrollability of the technological errors impaired timeline planning of this project, but ultimately did not greatly affect the quality of data collected.

Another challenge faced during the course of the study were the experimenters not being able to showcase the child's full knowledge that they had acquired from the app. For example, some of the children were able to say outside of the study room that where is red, or be able to count to ten in the second language that they were engaging with, but when asked this question by the experimenter during the session, we encountered a lot of "I don't know" or shrugging of shoulders, despite the children clearly being able to say this during warm up. While the mimic game was introduced in the third session, this did not truly capture the child's expanded vocabulary acquired from playing with the app. However, our coding that is in progress will be able to provide an accurate assessment of these comments.

Issues in setting up the app on the participant's device also proved to be a challenge. Sometimes this was due to the Wi-Fi not working in the lab (for unknown reasons), other times it was due to the activation code not working. Because of this, the experimenters were not always able to fully set up the app during the baseline session. As a result, a few of the participant's changed their condition from displaying just the second language to displaying both English and the second language, because we could not set it to the correct conditions ourselves. This occurred despite emailing instructions to change the format to only one language displayed.

Families who chose to withdraw from the study also posed another challenge. It seemed that families who did not enjoy working with the app withdrew from the study (at either the second or third visit) and often did not want to provide feedback on why they

chose to do so. This left us only able to assume that they did not want to continue to use the app – but this is obviously unconfirmed.

Also of note is the children's choice in which storybooks were their favourite during the testing session. Multiple parents commented after the session that they were surprised their child chose the specific two books as their favourite, as when at home the parent's observed them interacting with other stories more frequently. This may have potentially affected the results, as they may have been able to comprehend or produce more words if those storybooks had been used during the session. Overall, we believe that the experiment was a success and hope that the above results provide you with some important points to consider in the future development of the app.

Discussion

This report details the results of our study that was designed to investigate whether the Poppy and Buddy app supported preschool-aged children's second language development. A second goal of the study was to gain information about parents' and children's use and enjoyment of the app. To achieve these goals, a group of 36, 4- to 6-year-old children and their caregivers were asked to participate in a 6- to 8-week study in which they were introduced to a prototype of a new app designed to support language development called, Poppy and Buddy. Families were asked to select which language they would like to learn out of three possible languages: Te Reo Maori, South American Spanish and German. Children were randomly assigned to one of two conditions: one language book condition and two language book condition. In the one language book condition, children's app only showed the second language throughout the books. In the two language book

condition, each page of the book had the corresponding English translation for the second language. Children and their caregiver participated in three sessions and were asked to use the app as much as possible between each visit. In the first visit, families were introduced to the app and children's baseline knowledge of the words and concepts (in English and the second language) in two of the books in the app was tested. The second visit was approximately 3 weeks after the baseline and the third visit was approximately 6 weeks after the baseline. In the second and third sessions, children's language knowledge of the words and concepts in their top two books (in English and the second language) was tested. Parents' and children's use, enjoyment, and comments surrounding the app were also collected during the second and third sessions. In this section we briefly discuss the results presented above.

Which languages did the families choose?

Of the three possible languages available to our participants, Te Reo was the most popular with 61% of the initial sample selecting it as the language for the app. The second most popular language was Spanish with 30.6% of families selecting it. Interestingly however, due to attrition of the sample, the final sample consisted of 69% were in the Te Reo Maori group, 19% in Spanish and 11.5% in German. While we could have randomly assigned participants to different language groups to ensure equal numbers across language conditions, we believe that providing families with the choice of language would increase our families' motivation to use the app. Enabling families to choose the language also provided us with the invaluable opportunity to attain critical information about which (out of the three) languages available at the time of the study initiation would be of most interest to families raising young children in New Zealand. Indeed, we believe that our

finding that over two thirds of the sample selected Te Reo Maori as their preferred second language, suggests that parents of young children being raised in New Zealand are particularly motivated to expose their children to Te Reo Maori as a second language and see this as a particularly valuable tool to support Te Reo Maori development. On a global scale, our findings suggest that it would be important for the app to consider supporting the development of the app to suit particularly relevant second languages. For example, if the app were to be used in English-speaking parts of Canada, it would be particularly important/relevant to have a French-Canadian option available.

Did children show any change in their language knowledge of their second language relative to their first language?

Overall, children showed significant improvements in their language knowledge in both English and the second language across the duration of the study. With respect to children's performance on the comprehension test questions for the second language, at baseline, children provided correct answers on 28% of the questions they answered. Critically, children's performance on the second language comprehension questions increased by 40% after only 3 weeks of using the app. Thus, the findings suggest that use of the app does support the development of second language comprehension in children 4- to 6-years of age. Surprisingly, there was also a significant increase in children's performance on the language comprehension questions for their first language, English.

With respect to children's performance on the English comprehension test questions at baseline, children provided correct answers on 64.4% of the questions they answered. While this baseline performance was quite strong, it was exciting to see that children

showed a 20% increase in their performance on the English comprehension test questions at the second session, after 3 weeks of using the app. The significant increase in English performance was surprising and suggests that the use of the app is not only beneficial to second language learning, but also first language learning. We suggest that parents likely anchor their child's learning of the new second language words and concepts using the parallel words and concepts in their first language.

Given the initial improvements in children's comprehension in both languages, it was somewhat surprising that the growth did not continue across the final three weeks of the study. It is likely that needed some processing time to assimilate their new knowledge before being able to acquire an additional large amount of information. A subsequent study could examine the app use over a longer period of time to chart sustained growth. While the rate of growth was not maintained across the second and third sessions, it is important to note that children's knowledge did stay relatively consistent across these sessions and thus, children do seem to be retaining the knowledge that they acquired in the first three weeks of app use.

Were there any differences between conditions in children's language development?

Our results did not provide strong evidence of a significant difference between the two book conditions with respect to enhancing children's language development. Both versions supported the development of children's first and second language comprehension. While not statistically significant, examination of Figures 4 and 5 suggests that the two language book condition encouraged slightly more growth over time in both

children's first and second language. These findings provide some very preliminary evidence suggesting that the two language condition could be particularly beneficial in supporting children's language development.

What did children and their parents think of the app?

In general children reported that they were happy when playing with the app throughout the 6- to 8-weeks of using the app. Children stated a particular preference for two books, Party and Count. Parents' reports of their children's use and enjoyment of the app also supports this conclusion. Most of the parents reported that their child used the app between 5-7 times per week across the first three weeks of the study, but frequency of use declined across the second half of the study period. Perhaps introducing language learning tests or activities might increase children's motivation to play with the app and/or "unlocking" new books after a few weeks of play would encourage sustained use of the app beyond an initial 3-week "honeymoon period". In general, parents reported that their child's interest in the books was enhanced when they read the books with their child. Thus, providing additional parent activities/suggestions of activities may encourage parents to read the books with their child, which in turn is likely to support children's sustained interest in the app.

Parents generally were quite positive about the app noting several strengths including several positive comments about the interactive components, the pronunciation of the words, highlighting function in the app, and stressed the potential positive impact such highlighting could have on children's learning and attention. With respect to parents' suggestions for improvements to the app, most of the comments focused on improving

functionality of the app. Some families experienced sync issues in the stories. Families seemed to really like the stories that had interactive features and would have liked to have seen more interaction, especially with the second language words. The insights from the experimenters also suggested that enhancing the interactive features in the app would be one particular area for the app to further develop.

Conclusion

In conclusion, our results suggest that the Poppy and Buddy app supported the development of 4- to 6-year old children's language comprehension in both their first and second language of choice across the 6- to 8-weeks that the study was conducted. The flow-on effect of enhanced first language development is an exciting finding that we encourage the app developers to emphasize when promoting your product. The significant growth across the first three weeks of the study was generally sustained across the duration of the study. As noted above, we need to finalise the coding of the production and mimicry responses and hope that these results will provide even more information supporting the ways in which the Poppy and Buddy app can support children's first and second language development.

While we did have higher attrition than anticipated, it was not surprising given the challenges we faced during the study regarding the technology. In addition to the technical issues, informal feedback from the experimenters suggests that most of the families who withdrew did so because they could not get their child to engage with the task.

Interestingly, of the five children who withdrew between the second and third session, three children had reported that the app did not make them feel very happy (i.e., 2 and 3's

on the face scale). We did not have enjoyment information at baseline and so, cannot comment on the extent to which the children who withdrew prior to the second session enjoyed the app to begin with. Given that there are individual differences across families with respect to device uptake from the earliest stages of their child's development, it is reasonable to expect that some children are just not that interested in device use. Whether the interest is due to the app, or the device cannot be determined from our data, but could be a question for future research. Overall, we believe that there are many positive qualities of the app that likely support language learning such as the high-quality word pronunciation, colourful pictures, animations, and fun-loving characters. We suggest that more of these be incorporated throughout the books where possible so that the Poppy and Buddy app can show even greater support of second language development.