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# Enhancing L2 learning through a mobile assisted spaced-repetition tool: an effective but bitter pill?

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## ABSTRACT

We tested the effectiveness of the spaced-repetition flash-card application, Anki, on improving 62 university-level learners' second language (L2) learning in a semester-long beginning Spanish course. Using effective study strategies is critical for L2 learning, but college students learning an L2 often study with strategies that are only useful for short-term performance. Prior research has shown that spaced-repetition testing increases long-term memory retention so we hypothesized that regularly studying L2 vocabulary with Anki would improve L2 learning. Participants were students enrolled in a beginning Spanish course who were assigned to study with Anki as a class requirement. The results showed a positive relationship between days studying with Anki and Spanish performance at the end of the semester even while controlling for baseline abilities and for motivation, self-efficacy, and beliefs. However, students were reluctant to use the app and reported low enjoyment. Regardless, participants also reported having higher motivation and more effort-based or incremental beliefs about learning at the end of the semester. The present study answers calls for experimental research on specific strategy interventions that also produce genuine gains in second language acquisition.

## KEYWORDS

Second language acquisition; language learning strategy; technology; motivation; self-efficacy; learner beliefs

## 1. Introduction

Gaining proficiency in a second language (L2) requires considerable time, sustained study, and active engagement with the material (e.g. Ortega, 2009; Seliger, 1977). Language learning is different from other academic subjects, in that it involves multiple modalities and necessitates acquiring underlying structures rather than facts and formulas, yet post-secondary students report using the same strategies and habits used in non-language courses (Gardner, 2007; Oxford & Nyikos, 1989; Victori &

Lockhart, 1995). Cramming, for example, which is often employed in content courses, is particularly problematic because it produces only short-term retention (Kornell, 2009), and SLA is a cumulative process that cannot be successful if previously learned material is forgotten. Ineffective study habits may be responsible for the many language students who do well on class assignments yet report feeling incompetent at the language (Graham, 2007). These feelings of low self-efficacy may cause a loss in motivation (Graham, 2007; Mercer & Ryan, 2010), which is the strongest and most consistent predictor of success in second language acquisition (SLA) (Lasagabaster, Doiz, & Sierra, 2014). In the present study, our aim was to improve L2 learning by implementing an effective study strategy that is ideal for long-term L2 acquisition, contrary to the short-term retention strategies that students typically use (Kornell, 2009). Specifically, we introduced students to a spaced-repetition testing mobile application for L2 vocabulary and tested the effect of using this strategy on L2 vocabulary and grammar learning while controlling for other critical factors that affect L2 learning such as motivation, beliefs, and self-efficacy.

## 2. Research background

### 2.1. *The importance of study strategies in SLA*

Researchers and educators have called for teaching practices that foster a growth mindset for learning, in which students' attention is focused on effort rather than ability (Yeager, Paunesku, Walton, & Dweck, 2013). It is important to note, however, that emphasizing effort can backfire if students do not use effective learning strategies (Dweck, 2015). The mere exertion of effort does not produce success—only time and energy spent on *effective* learning strategies creates positive change. Struggling language learners who believe in language giftedness can blame failure on not having an aptitude for language, rather than on insufficient or ineffective practice (Dörnyei, 2003; Graham, 2004; Horwitz, 1988, 1999; Hsieh & Schaller, 2008; Mercer & Ryan, 2010). When learners decide they do not possess a talent for languages, their self-efficacy for SLA decreases, as does their motivation to persist (Graham, 2004; Hsieh & Schaller, 2008).

In reality, SLA in adulthood requires dedicated use of effective study strategies, and there are strong associations between using better strategies, self-efficacy, and attained proficiency (Oxford & Nyikos, 1989). Successful language learners integrate multiple strategies that activate various modalities and skills (Uhl Chamot, 2005). Across multiple languages and cultures, using *more* strategies – both of greater variety and

frequency – is correlated with higher SLA self-efficacy and performance (Gholami, Abdorrahimazadeh, & Behjat, 2014; Magogwe & Oliver, 2007; Oxford & Nyikos, 1989; Yang, 1999). The observed correlations between strategies and motivation most likely reflects bidirectional influences, with motivation leading to better strategy use, and using effective strategies boosting motivation (Dörnyei, 2005; Magogwe & Oliver, 2007; Oxford & Nyikos, 1989).

Graham (2007) is one of few demonstrations of specific strategy interventions that have been conducted. He found that French learners taught techniques for improving listening comprehension later showed greater French self-efficacy and listening comprehension than a control group. In the present research, we tested the effectiveness of having students use their smartphones to engage in spaced-repetition studying, which is ideal for promoting long-term retention of L2 vocabulary. Both the particular study strategy (spaced-repetition) and medium (smartphone) were selected here based on past research showing their many benefits for L2 learners.

### ***2.1.1. Learning through spaced-repetition recall***

Research in the field of learning and memory consistently shows that people have superior long-term retention if they read information once and then try to recall it, compared with re-reading it multiple times (Roediger & Butler, 2011; Roediger & Karpicke, 2006). Long-term retention increases even more when the delay interval between each instance of recall continually lengthens, which is a method called *spaced-repetition testing* (Roediger & Butler, 2011; Wozniak, 1990). For example, when using spaced-repetition, a learner who correctly recalls information learned a day ago would not be tested again until two days later. If the learner recalls it correctly again at that time, the next test would be four days later. The interval between tests grows as long as the learner answers correctly (e.g. the next three intervals would be 10 days, two weeks, three weeks). If the learner answers incorrectly, the information is retested that day until the learner answers correctly, and then the testing interval begins to gradually lengthen again.

Flashcards are an excellent tool for recall testing, but unfortunately many language learners use flashcards ineffectively. Spaced-repetition testing improves retention both within a single act of studying (within-session spacing) and across days of studying (between-session spacing; Kornell, 2009; Underwood, 1970); yet many learners report doing the opposite when they study with flashcards: they divide their flashcards into small decks so less time passes before a card is seen again, and they cram their studying into the hours or days immediately before a test

(Kornell, 2009). These two behaviors promote short-term, but not long-term, retention and therefore they create a false feeling of knowing the material during the act of studying. Consequently, students expect to remember material better when it is studied all at once compared with when it is spaced out over time (Kornell, 2009).

In SLA, spaced-repetition testing is ideal for vocabulary acquisition. All aspects of SLA – vocabulary, grammar, speech, and listening – have inherent challenges, but in many ways vocabulary appears distinct. Adult learners show difficulty distinguishing L2 sounds (Werker, 1989), and a lifetime of producing one's native phonemes and using a particular grammatical structure create similar obstacles for accent-free speech and mastery of grammar (Author; Flege, Bohn & Jang, 1997; Wang & Liu, 2013). Many language educators do not focus on vocabulary in the classroom, thinking students can memorize vocabulary on their own (Zimmerman, 1997). While this is true, vocabulary creates more problems, errors, and frustrations for learners than grammar (Leki & Carson, 1994; Meara, 1980, 1984).

The effectiveness of spaced-repetition testing for long-term retention of L2 vocabulary has been established through experimental research (Bahrick, Bahrick, Bahrick & Bahrick, 1993; Bloom & Shuell, 1981; Ellis, 1995), yet these powerful experimental demonstrations have not resulted in classroom implementations. One important obstacle has been an already packed curriculum. This can now be circumvented thanks to mobile devices that make studying more convenient outside of the classroom, yet also more sophisticated (i.e. complex spacing algorithms can be executed with no effort on the learner's part).

## ***2.2. Language learning using smartphones***

Based on the convenience and availability of smartphones for university-level language learners, we examined smartphone applications in language learning. Kukulska-Hulme and Shield (2008) describe how mobile assisted language learning (MALL) differs from computer-assisted language learning in its use of personal, portable devices that enable new ways of learning, emphasizing continuity or spontaneity of access and interaction across different contexts of use. Even though mobile learning may belong more to learners than to teachers, most learners struggle without a teacher's guidance and studies of MALL are always teacher-led (Kukulska-Hulme, 2009). In Burston's (2013) review of the literature on MALL, he acknowledges the smartphone's capability to support learner-centered environments, but also states that we are just in the beginning stages of this research. In their study on participants' smartphone use for

language learning, Wigglesworth and Harvor (2018) confirmed that for university-level language learners, smartphones are, ‘part of the landscape of their lives’ (p. 455), and that the primary language learning activities they use smartphones for are accessing online dictionaries and chatting or texting in the target language. While there is no mention of any specific applications, it is clear from the research that smartphones are an important part of language learners’ daily activities.

Ushioda (2014) highlights the need to allow learners to autonomously try technological tools such as smartphones, and to only expect the tools to be useful for quick-learning such as for vocabulary. Leis, Tohei, and Cooke (2015) found that students who were encouraged to use their smartphones in language lessons studied more in their free time and became more autonomous. Considerable research has found that a sense of autonomy (i.e. personal control) is critical to motivation (Reeve & Deci, 1996). For example, autonomous language learners take it upon themselves to study more vocabulary, which in turn produces positive language gains (Tseng & Schmitt, 2008). Of relevance to the current study, Golonka, Bowles, Frank, Richardson, and Freynik’s (2014) review of 350 studies on technology and language learning confirmed that language students’ autonomy can be increased through smartphone-assisted language learning. Feelings of autonomy over the learning task are highly desirable because they significantly predict students’ L2 achievement (Hsieh & Kang, 2010). However, Golonka et al. (2014) note that to-date there are no studies that show increases in language abilities as a result of smartphone or technology-assisted language learning. This may be, as Nielson (2011) found, due to a high rate of attrition. In her multi-phase study on the use of a *Rosetta Stone*<sup>TM</sup> software package for self-directed language learning by US Government employees, less than half of the participants who volunteered obtained their accounts let alone used the software. Although the participants were highly motivated, one of their major complaints was that the material in the *Rosetta Stone*<sup>TM</sup> program was not geared toward their needs as learners. Also, Read and Kukulska-Hulme (2015) tested whether a listening comprehension application would motivate language learners, but only nine out of forty-five participants used the app with only three using it the entire research period.

### 2.2.1. Anki application

As stated by Ellis (1995, p. 22), ‘There is a role for sitting down and learning vocabulary, particularly in the early stages of FL [foreign language] learning,’ and we both can and should take advantage of technology to ‘structure training, practice, and testing to optimise the rate of vocabulary acquisition.’ Accounts of using different spaced-repetition

tools in language classes report that students like the technology (Librenjak, Kocijan, & Janjić, 2016; McLaren & Bettinson, 2016), but their effect on proficiency is unknown due to a lack of comparison groups and unreliable sample sizes. Chien (2015) found that participants self-reported having positive attitudes toward using online flashcard applications (Quizlet, Study Stack, and Flashcard Exchange), saying the applications motivated their vocabulary learning. Because it is so effective, spaced-repetition systems (SRS) are already integrated into many commercial language learning programs, such as DuoLingo (Settles & Meeder, 2016), Memrise (Memrise, 2012), and FluentU (FluentU, 2016). While each of these platforms offers some spaced testing, it is usually peripheral to the activities on the platform's main interface, only available to paid users, or does not follow best practices (e.g. it uses multiple-choice questions and within-session massing). The ideal tool is a platform that is both devoted to spaced-repetition testing and widely accessible to educators and students. This exists in the form of Anki, an open-source and non-commercial flashcard application available for the desktop, mobile devices, and as a website. Anki administers the user's flashcards according to a spaced-repetition algorithm (Elmes, 2018; Wozniak, 1990). Because Anki controls when learners next see a card, learners cannot unknowingly undermine their own success by dividing cards into smaller decks as they might with paper flashcards (Kornell, 2009). Anki is devoted exclusively to spaced-repetition flashcards, which increases experimental rigor because the obtained results can only be attributed to this particular strategy. Also, results should be generalizable to any method of spaced-repetition testing, regardless of the specific platform or device. Indeed, as stated by Leis et al. (2015), the world of electronics is fast-moving and articles written about specific smartphone applications may become outdated before they are published.

Some language educators have incorporated Anki into their classes and found that students enjoy using it (e.g. Altiner, 2011, Bailey & Davey, 2011), but their sample sizes were small (15 or fewer students) and they did not compare learning outcomes for students who did and did not use Anki. Prior to our present study, we conducted a pilot study of Anki's effectiveness in beginning Spanish classes by providing students with the tool and encouraging, but not requiring or incentivizing, them to use it. This pilot was valuable in shaping the design of the main intervention study.

### **2.3. Pilot study**

During the Spring 2017 semester (January to May), the researchers introduced Anki to students in three sections of a SP102 'Beginning Spanish



II' course, with another two sections serving as a control group. The first visit (Time 1) occurred during the third week of the semester, and all students attending class that day ( $n=97$ ) took a baseline Spanish vocabulary and grammar test. Students in the Anki intervention group ( $n=58$ ) were additionally introduced to Anki, given a pre-made deck of flashcards for vocabulary, verb conjugation, and expressions from all of the chapters that would be covered in the textbook that semester. The researchers returned during the second-to-last week (week 13) of the semester (Time 2), at which time 76 of the original 97 students were present to take a second vocabulary and grammar test.

The researchers had access to participants' accounts to monitor frequency of Anki usage. Because participants were only encouraged to use Anki and there was no incentive (e.g. it was not a class requirement) or encouragement from their instructors, compliance was low. Only 21 students (36%) accessed Anki at any point, with a mean usage of just 2.03 ( $SD=3.54$ ) days over the entire semester. The top three users of the app studied only 29, 15, and 13 days, respectively. On the baseline vocabulary and grammar test, these students' percentile rankings were 79, 38, and 73, respectively. On the final test, their percentile rankings were 87, 58, and 71, respectively. The average change in percentile ranking tests was 8.67, providing preliminary support for the effectiveness of studying with Anki. Because voluntary Anki usage was quite low, in the main study, we decided to include studying regularly with the app as a course requirement.

#### **2.4. The influence of motivation and other psychological factors**

The ideal scenario for evaluating the effectiveness of studying with Anki would be if all students used it to an equal degree, but we recognized that there would be natural variability in students' compliance with the course requirement. To address this, we measured and controlled for factors that might be confounded with how much students used Anki: motivation to learn Spanish, Spanish self-efficacy, epistemological beliefs, and baseline Spanish abilities.

Motivation is a complex construct, with no one theory encompassing all its facets (Dörnyei & Ryan, 2015; Gardner, 2007; Tremblay & Gardner, 1995). In general, studies have shown that motivation correlates with positive SLA outcomes (e.g. Gardner, 2006; Masgoret & Gardner, 2003; Yu & Watkins, 2008). There are multiple types of motivation, such as integrative motivation, which is learning an L2 based on the desire to belong in a group, to receive affection, and to identify with the L2 community, versus instrumental motivation, which is the utilitarian learning



of L2 for personal gain (as in, for a job, etc.) (Gardner & MacIntyre, 1993). Also of importance is the difference between intrinsic motivation, which is motivation originating from naturally fluctuating arousal and curiosity for the task, and extrinsic motivation, which is motivation derived from the desire to receive a reward or avoid punishment (Dörnyei, 2003).

Another important component of motivation in SLA is the learner's *self-efficacy*, which is whether learners think they, personally, are capable of SLA (Hsieh & Schaller, 2008). Although self-efficacy appears to be an introspective phenomenon, it is influenced in part by the person's *epistemological beliefs*, which are assumptions about the nature of learning and ability (Schommer, 1990). Dweck, Chiu, & Hong (1995) have initiated an ever-growing literature on the consequences of seeing ability as fixed or flexible (e.g. Yeager et al., 2013). These beliefs are called implicit theories. People who possess an *entity theory* believe that skills – for example, intelligence, mathematics – come from natural talent and cannot be changed, while people with an *incremental theory* believe skills can improve through effort and persistence. When entity theorists struggle, they decide they lack talent and often give up, whereas incremental theorists recognize that more practice is needed (Hong, Chiu, Dweck, Lin, & Wan, 1999). As a result, entity theorists perform worse than incremental theorists (Dweck et al., 1995; Shively & Ryan, 2013). Due to the potential impact of these factors, we measured and controlled for them at both the beginning and end of the semester.

### 3. Method

#### 3.1. Participants

Participants were 62 students (age  $M = 19.06$ ,  $SD = .90$ ) enrolled in one of five sections of the course SP102 'Beginning Spanish II' during the Fall 2017 semester (August to December) at a small liberal arts university in the northeastern United States. A total of 66 students completed the baseline measures administered by the researchers during class time the third week of the semester (Time 1). Of these, 62 students completed the post-test measures (Time 2), which were given the last week (week 15) of the semester on the same day as either exam review or one-on-one oral exams. As reported on a language background questionnaire, all 62 participants indicated that their native language was English with seven stating that they used English and another language at home, which included Spanish for four participants. One participant reported that they lived in Puerto Rico for the first five years of their life. This participant was not an outlier on any of the measures so their data were

retained in analyses. The mean age of first exposure to Spanish reported was 9.7 years ( $SD = 4.79$ ), which for many occurred in elementary school classes. The mean contact time with Spanish reported was only 3.74 hours per week ( $SD = 2.91$ ), 87% of which included class time (3.25 hours per week). Of the eleven participants who reported an interest in minoring in Spanish at Time 1, nine were still interested at Time 2. Also, six students who were initially uninterested in completing a Spanish minor wrote, ‘yes’ or ‘maybe’ at Time 2.

### 3.2. Measures

#### 3.2.1. Implicit theory of language learning

To assess beliefs about the role of effort versus natural talent in language learning, we began with the 12-item Conceptions of the Nature of Athletic Ability Questionnaire (CNAAQ) by Biddle, Wang, Chatzisarantis, and Spray (2003), which is a domain-specific measure of implicit theories, and edited the items to apply to the domain of language learning. Sample items include, ‘To be good at learning a new language, you need to be born with basic qualities that allow success,’ ‘If you put enough effort into it, you will always get better at using a new language,’ ‘When it comes to learning a new language, you have a certain level of ability and you really cannot do much to change that level,’ and ‘To reach a high level of performance in a new language, you must go through periods of learning and training.’ Participants indicated their agreement with each statement on a scale of 1 (*strongly disagree*) to 5 (*strongly agree*). The scale was reliable at both Times 1 and 2 ( $\alpha s = .85, .82$ , respectively).

#### 3.2.2. Quick-learning beliefs

Quick-learning beliefs were measured with a three-item scale by Mori (1997): ‘If I cannot understand something quickly, it usually means I will never understand it,’ ‘If I am ever going to be able to understand something, it will make sense to me the first time I hear it,’ and ‘Successful students understand things quickly.’ Participants indicated their agreement with a 1 (*strongly disagree*) to 5 (*strongly agree*) scale. Internal reliability for this scale was somewhat low (Time 1  $\alpha = .58$ ; Time 2  $\alpha = .56$ ), which may be the result of the scale consisting of only three items.

#### 3.2.3. Spanish motivation scale

Ushida’s (2003) modified version of the Attitude Motivation Test Battery (AMTB) developed by Gardner (1985) was used to measure Spanish motivation. There were 12 items, including, for example, ‘I really enjoy

learning Spanish,’ ‘I would rather spend my time on subjects other than Spanish,’ and, ‘Spanish is an important part of my education.’ Participants chose their level of agreement or disagreement based on a 1 (*strongly disagree*) to 5 (*strongly agree*) scale. The scale was reliable (Time 1  $\alpha = .91$ , Time 2  $\alpha = .93$ ).

#### **3.2.4. Spanish self-efficacy scale**

Spanish self-efficacy was measured with two items: ‘I believe I can learn Spanish well’ and ‘I think Spanish is something I am good at’ (Time 1  $\alpha = .83$ ; Time 2  $\alpha = .82$ ). Participants responded using the same 5-point agreement scale.

#### **3.2.5. Study strategies questionnaire**

First, participants rated their belief in the effectiveness of two study strategies, on a scale of 1 (*not at all effective*) to 5 (*very effective*): ‘Reading and re-reading the textbook and your notes’ and ‘Quizzing yourself on the material (e.g. flashcards).’ Next, they read, ‘If you want to remember something (e.g. material for an exam), how confident are you that you could learn it by ...’ They then rated their confidence, from 1 (*not at all confident*) to 5 (*very confident*) for two strategies: ‘re-reading it’ and ‘quizzing yourself on it.’

#### **3.2.6. Spanish vocabulary and grammar tests**

The pre- and post-tests were developed with a combination of grammar and vocabulary items from the course textbook, *Aventuras* (Blanco & Donley, 2014). There were 15 grammar items (multiple choice) and 34 vocabulary items divided into three sections of matching activities. Participants matched Spanish vocabulary with English translations, with Spanish definitions, and with pictures on both tests. All items from the tests were from the chapters taught in the course, and also had been included in the Anki decks. To prevent potential practice effects, some items were changed from the pre- to the post-test.

### **3.3. Procedure**

The researchers visited each of five classes of Beginning Spanish II during the third week of the semester to administer the baseline measures and Spanish vocabulary and grammar test (Time 1). After providing written consent, participants completed a hard-copy questionnaire packet. The packet contained the following: the language background questionnaire, the Spanish self-efficacy measure, two questions about

whether participants were considering majoring or minoring in Spanish, short questionnaires on the implicit theory of language learning, quick-learning beliefs, Spanish motivation, and study strategies, and finally the baseline Spanish test. They were given ample time to complete the measures and told to skip items they did not know on the test.

After all the participants had completed the measures, the researchers introduced Anki and how to use it. Participants were told that they should study with Anki for a minimum of 5 minutes a day for at least 5 days a week to get full credit. Furthermore, they were informed that this requirement would count as part of their homework grade, which comprised 10% of their final grade. Within 24 hours, each of the students received an email with instructions for downloading Anki and a link to a video created by the researchers explaining how to download a premade deck containing flashcards for all the vocabulary, grammar, expressions, and verb conjugations they would be using that semester. The vocabulary cards included audio recordings of the Spanish pronunciation made by a female native speaker that participants could listen to as they viewed the corresponding flashcard.

Students whose phones had an Android operating system downloaded the AnkiMobile application for free from the Google Play Store. Grants from the researchers' university covered the cost of the iPhone version, for which students with iPhones received a unique Anki installation link. The researchers returned the next class to make sure all students were able to install the application and download the flashcards, and to troubleshoot installation problems as necessary. The researchers had access to participants' accounts to monitor frequency of Anki usage, which was tracked weekly with the exception of the Thanksgiving vacation week (week 13).

At Time 2, participants completed the implicit theory of language learning, quick learning beliefs, Spanish self-efficacy, Spanish motivation, and study strategies questions. They were again asked if they were considering majoring or minoring in Spanish. This time, they were asked to describe their study habits for the class, first by circling which of the following six options best described how often they study: 'Every day,' '4-6×/week,' '2-3×/week,' '1×/week,' 'Before a test/quiz only,' or 'Never.' Next, they were asked to describe how they study for quizzes and tests (an open-ended question). Lastly, they were asked to indicate 'Yes' or 'No' if they used any of the following flashcard tools for this class: paper flashcards, Anki, Quizlet, other. If they selected 'Yes,' they were asked to put a check in one of four boxes to indicate how much they used that tool over the entire semester: '0-3 hours,' '4-7 hours,' '8-11 hours,' '12+ hours.' After this questionnaire, participants completed the Spanish vocabulary and grammar post-test.

## 4. Results

### 4.1. Change in beliefs

Participants endorsed a more incremental theory of language learning at the end of the semester relative to the beginning,  $t(60) = -2.48$ ,  $p = .016$  (see Table 1 for descriptive statistics). Endorsement of quick-learning beliefs did not change between the two time points,  $t(60) = -0.44$ ,  $p = .664$ . Both Spanish self-efficacy,  $t(60) = -3.98$ ,  $p < .001$ , and Spanish motivation,  $t(60) = -3.88$ ,  $p < .001$ , increased at the end of the semester.

Ratings of the effectiveness of re-reading,  $t(60) = -1.13$ ,  $p = .261$ , and quizzing,  $t(60) = -0.98$ ,  $p = .331$ , did not change significantly from Time 1 to Time 2 as study strategies did not change between Time 1 and Time 2. However, over time participants became significantly more confident that they could learn through re-reading,  $t(60) = -3.22$ ,  $p = .002$ , and marginally more confident that they could learn through quizzing,  $t(60) = -1.70$ ,  $p = .094$ .

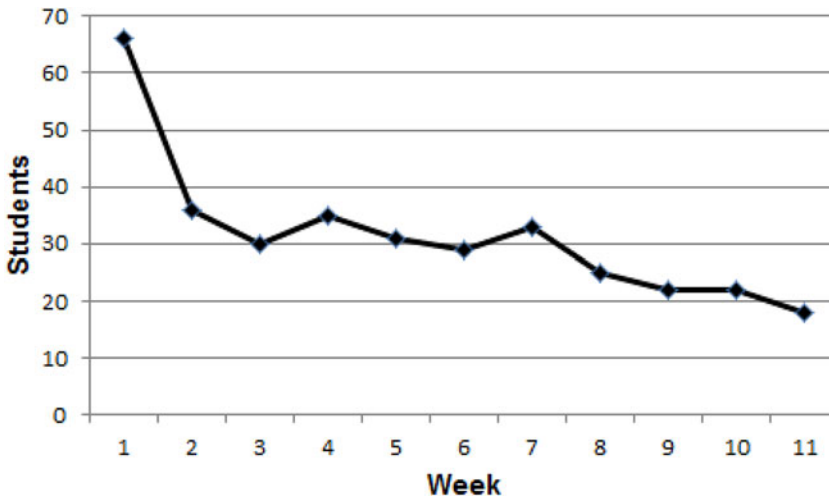
### 4.2. Anki usage

There was considerable variation in Anki usage (as tracked directly by the researchers), with a mean of 18.95 days over the course of the semester and a standard deviation of 21.18 days (see Figure 1 for a graph depicting usage over time). The mean usage per week was 1.72 days ( $SD = 1.93$ ). Given this variation, we identified students who used Anki for an average of at least 3 days a week ( $n = 14$ ) and those who did not ( $n = 52$ ) and performed independent samples  $t$ -tests on all Time 1 measures to assess if there were pre-existing differences between these two groups of students. (Although the sample sizes differed notably between the two groups, Levene's test for equality of variances revealed that the two groups had similar variances for Time 1 measure,  $ps > .06$ .)

The two groups did not differ significantly on baseline Spanish performance ( $p = .578$ ), Spanish self-efficacy ( $p = .130$ ), implicit theory of learning ( $p = .255$ ), quick-learning beliefs ( $p = .101$ ), Spanish motivation

**Table 1.** Mean scores on psychological measures at Time 1 and Time 2 (Standard deviations are reported in parentheses).

	Time 1	Time 2
Implicit theory of language learning	3.89 (.55)	4.06 (.51)
Quick learning beliefs	2.04 (.61)	2.08 (.63)
Spanish motivation	3.37 (.83)	3.62 (.83)
Spanish self-efficacy	3.07 (.92)	3.43 (.85)
Effectiveness of re-reading	3.44 (1.03)	3.57 (1.16)
Effectiveness of quizzing	4.33 (.79)	4.44 (.94)
Confidence in re-reading	3.16 (1.07)	3.54 (1.07)
Confidence in quizzing	4.26 (.79)	4.44 (.81)



**Figure 1.** Number of students accessing Anki each week after introducing Anki to students.

( $p = .116$ ), beliefs in the effectiveness of re-reading ( $p = .393$ ), confidence in learning through re-reading ( $p = .661$ ), or confidence in learning through quizzing ( $p = .265$ ). However, the group that used Anki regularly rated quizzing as marginally more effective than the group that did not use Anki,  $t(64) = -1.82$ ,  $p = .074$ .

### 4.3. Spanish performance

There was considerable overlap between the relevant variables (see Tables 2 and 3 for bivariate correlations), so a multiple regression analysis was used to control for shared variance when testing the relationship between studying with Anki and final Spanish performance. Time 2 Spanish performance was regressed onto all Time 1 and Time 2 psychological measures (motivation, self-efficacy, implicit theories, and quick learning), Time 1 Spanish performance, and total days of Anki usage. All predictors were mean-centered. The overall model explained 63% of the variance in Time 2 Spanish performance,  $F(10, 50) = 8.64$ ,  $p < .001$ . Time 2 Spanish performance was significantly predicted by Time 1 performance,  $\beta = .69$ ,  $t(50) = 5.95$ ,  $p < .001$ , Time 1 Spanish motivation,  $\beta = -.50$ ,  $t(50) = -2.57$ ,  $p = .013$ , Time 2 Spanish motivation,  $\beta = .62$ ,  $t(50) = 3.48$ ,  $p < .001$ , and number of days using Anki,  $\beta = .24$ ,  $t(50) = 2.37$ ,  $p = .022$ .

#### 4.3.1. High-usage students

The Time 1 and Time 2 Spanish performance of the five students with the highest Anki usage were inspected more carefully. The Time 1 and 2

**Table 2.** Bivariate correlations between proficiency, Anki usage, and all Time 1 measures.

	1	2	3	4	5	6	7	8	9	10	11
1. T1 proficiency	–										
2. T2 proficiency	.66**	–									
3. Anki (total days)	.39**	.36**	–								
4. T1 motivation	.24 <sup>†</sup>	.28*	.07	–							
5. T1 self-efficacy	.24 <sup>†</sup>	.31*	–.08	.56**	–						
6. T1 implicit theory	.07	.21	–.02	.52**	.51**	–					
7. T1 quick learning	.05	–.07	–.02	–.39**	–.30*	–.63**	–				
8. T1 rereading effectiveness	–.14	–.03	.00	.32*	.22	.46**	–.41**	–			
9. T1 quiz effectiveness	.09	.15	.05	.31*	.32*	.47**	–.35**	.16	–		
10. T1 rereading confidence	–.05	.07	–.10	.34**	.28*	.43**	–.42**	.72**	.10	–	
11. T1 quiz confidence	.06	.10	–.11	.30*	.40**	.54**	–.61**	.27*	.70**	.34**	–

\*Correlation significant at .01 level.

\*\*Correlation significant at .05 level.

<sup>†</sup>Correlation marginal at .06 level.**Table 3.** Bivariate correlations between proficiency, Anki usage, and all Time 2 measures.

	1	2	3	4	5	6	7	8	9	10	11
1. T1 proficiency	–										
2. T2 proficiency	.66**	–									
3. Anki (days)	.34**	.36**	–								
4. T2 motivation	.06	.31*	–.11	–							
5. T2 self-efficacy	.44**	.41**	–.01	.42**	–						
6. T2 implicit theory	–.09	.14	–.32*	.38**	.39**	–					
7. T2 quick learning	.21	.02	.04	–.01	–.12	–.31*	–				
8. T2 rereading effectiveness	.01	.22	–.16	.31*	.41**	.50**	.02	–			
9. T2 quiz effectiveness	–.16	.00	–.14	.20	.09	.46**	–.49**	.08	–		
10. T2 rereading confidence	.09	.19	–.22	.35**	.33**	.40**	–.04	.54**	.02	–	
11. T2 quiz confidence	–.06	.03	–.16	.14	.24	.39**	–.41**	.05	.55**	.16	–

\*Correlation significant at .01 level.

\*\*Correlation significant at .05 level.

**Table 4.** Days of use and proficiency change over time for top five Anki users.

	#Days of Anki use	Time 1 proficiency (percentile ranking)	Time 2 proficiency (percentile ranking)	Change
Participant 1	80	77	95	18
Participant 2	78	61	63	2
Participant 3	70	30	48	18
Participant 4	65	77	81	4
Participant 5	63	94	100	6
Mean		67.8	77.4	9.6

tests contained different questions with different scoring metrics, so we examined the percentile ranking of these students' test scores. As shown in Table 4, the top Anki users all showed gains in their relative level of Spanish (i.e. compared with other students). The average increase in percentile ranking for these five students was 9.6%.

## 5. Discussion

The current research tested the effectiveness of daily Spanish study with Anki, a spaced-repetition mobile flashcard application, by university



students in a Beginning Spanish II course. Students varied considerably in their compliance with the assignment, but the results showed a positive relationship between number of days studying with Anki and level attained of Spanish even while controlling for baseline abilities and for motivation, self-efficacy, and epistemological beliefs at both the beginning and end of the semester.

The gains in L2 connected to Anki usage observed in this study are consistent with past research showing that spaced-repetition studying is a powerful method for memory retention more generally (Kornell, 2009; Roediger & Butler, 2011). Smartphone applications like Anki can easily deliver flashcards according to complex spaced-repetition scheduling algorithms (Elmes, 2018; Wozniak, 1990), providing a convenient way to integrate this effective study strategy into daily life. Second language learning is a cumulative process requiring retention of early material, and the task of acquiring thousands of L2 words is a source of difficulty for many learners (Leki & Carson, 1994; Meara, 1980, 1984). The present study shows that spaced-repetition studying is a valuable technique that, when used in combination with other strategies (e.g. listening practice, shadowing), can potentially produce significant gains in L2 acquisition.

Based on low overall usage, we only tested the effect of natural variation in studying with Anki. Comparing an Anki intervention group with a control group would have provided more experimental rigor, but this would only be effective if most participants in the intervention group used Anki consistently. The pilot study revealed that student compliance would be an obstacle, so we opted to assign Anki to all classes to make sure we obtained a sufficient sample of students who were, in fact, studying with the app regularly. We then took steps to control for factors that could cause an artificial relationship between the decision to study with Anki and final Spanish performance. Specifically, we measured and controlled for multiple individual difference variables (e.g. motivation, beliefs) that are likely to influence both studying time and performance. Total days studying with Anki significantly and positively predicted final Spanish performance even while controlling for these variables, which lends support to its effectiveness for language learning.

Consistent with past research, in the regression analysis final (Time 2) Spanish motivation and baseline Spanish abilities positively predicted final Spanish performance. It may seem unusual that Time 1 motivation negatively predicted final Spanish performance, but this can be explained by the regression model partialling out shared variance with Time 2 motivation. To explain, Time 1 and 2 motivation were strongly correlated ( $r = .83$ ,  $p < .001$ ) and both Time 1 and Time 2 motivation were positively correlated with final performance (see [Tables 2](#) and [3](#)). When

these variables are all present in the regression model, the remaining variance in Time 1 motivation is *unshared* variance with Time 2 motivation and baseline abilities. Therefore, the negative relationship means that initial motivation that did not overlap with final motivation – which describes students who lost motivation – predicted worse Spanish performance. Critically, total days studying with Anki predicted a higher level of performance even while controlling for the powerful factor of motivation to learn Spanish.

It is noteworthy that the participant who reported living in Puerto Rico for the first five years of life showed slightly below average abilities at both Time 1 and Time 2, yet was among the highest users of Anki. When this participant was excluded from the analysis, the regression coefficient for the predictive value of Anki use on performance actually increased (from  $\beta = .24$ ,  $p = .022$  to  $\beta = .28$ ,  $p = .009$ ). As a heritage learner of Spanish, perhaps this participant's implicit knowledge of Spanish was not captured by our vocabulary and grammar tests. Additionally, it is possible that the explicit and contextually-poor nature of the Anki flashcard application was not as effective a strategy for this type of learner. Prior research has shown that heritage learners are different in significant ways from L2 learners. Bowles (2011) found that L2 learners had more explicit knowledge than heritage learners, while Camus and Adrada-Rafael (2015) found that heritage learners performed better than L2 learners during spontaneous writing tasks due to the more implicit nature of such tasks, which may explain the performance of the heritage learner participant here. We predict that this participant, as well as other learners with implicit knowledge, most likely would have benefited more from a study strategy targeting implicit learning. This would be an important consideration in future studies.

### **5.1. Issues and limitations in implementing Anki in classes**

These results suggest that studying with a mobile spaced-repetition flashcard application can benefit SLA, but students' willingness to use it affects its practical implementation. Despite being easily accessible and a required class assignment, many students did not study regularly with Anki. Similar findings of attrition were observed by Nielson (2011) and Read and Kukulska-Hulme (2015), but this contrasts with the results of a metastudy on mobile assisted language learning (MALL) by Shadiev, Hwang, and Huang (2017), in which students' perceptions were mostly positive. Also, Librenjak et al. (2016), McLaren and Bettinson (2016), and Chien (2015) found that students had positive attitudes about MALL. To better understand the low usage by our participants, we

solicited their feedback about Anki mid-semester. Their comments were: (1) They disliked studying words from chapters they had already been tested on; (2) they could not remember words even though they were quizzed on those words multiple times; (3) the application's interface was simple and not engaging.

The first issue is provocative because the goal of the application is to promote long-term retention of *all* words, whereas students wanted to study only the words that were necessary to do well on the next quiz. Indeed, they felt like reviewing 'old' words was a waste of time. This reveals that students' motivation to study Spanish was primarily extrinsic (i.e. grades). Learners who have intrinsic motivation to become proficient in an L2 may be more receptive to studying with Anki. The second issue is a genuine limitation, and one that is likely to vary based on the learners' overall memory and cognitive skills. Anki is effectively a form of rote memorization, and learners must generate their own memory aides while studying. Students with greater proficiency may be better at spontaneously developing connections, which would allow them to benefit more from unaided memorization. This would explain why frequency of studying with Anki was correlated with baseline Spanish abilities. Students with weaker memory skills and low proficiency may benefit more from tools like Memrise (2012) that supply mnemonics for them. Lastly, the final issue – interest and engagement – may be related to L2 motivation. Learners with low L2 motivation may need study tools that provide more stimulation or excitement to hold their attention.

Although students' feedback about the app hinted that they were primarily extrinsically motivated, it is worth noting that students also showed positive psychological changes over time. Compared with the beginning of the semester, at the end of the semester students reported having higher Spanish motivation and self-efficacy, and they reported believing that effort is more important than innate ability for successful language learning (i.e. an incremental implicit theory). It's encouraging to see that the language learning experience participants had during the semester, which for some included using Anki, was positive enough to improve their motivation to learn more Spanish, which is the primary goal of language education.

## 6. Conclusion and future directions

The results here suggest that spaced-repetition testing can be a valuable strategy for L2 acquisition. Despite these results and the decades of experimental evidence establishing its effectiveness for long-term memory (Kornell, 2009; Roediger & Butler, 2011; Underwood, 1970), an

important obstacle to implementation observed here is learners' willingness to use it. Our participants were college students taking a beginning Spanish class, the majority of whom were enrolled just to satisfy the university's language proficiency requirement. Daily studying with flashcards is effective yet time-consuming, so Anki may appeal more to learners who are intrinsically motivated to gain fluency in an L2. However, as Nielson (2011) found, even highly motivated participants may not engage in self-study if the proper support is not there.

A future direction for research on study strategy interventions in L2 learning could test spaced-repetition studying that simultaneously actively engages the learner such as through games or mnemonics. We chose Anki precisely because its simplicity provided experimental control for evaluating only spaced-repetition studying without confounding secondary activities. However, for L2 learners with low intrinsic motivation (e.g. students in required language courses), secondary activities may be an effective method to increase engagement and interest while simultaneously improving L2 vocabulary retention through spaced-repetition testing. Contrasting the effectiveness of applications with more bells and whistles against Anki would prove fruitful and informative for learners, educators, and software developers.

Returning to our original goal of evaluating spaced-repetition studying in L2 acquisition, future research could provide a more highly controlled test of its effectiveness through a laboratory study in which participants receive external incentives (e.g. monetary payment) to study with Anki. Although we measured and controlled for variables that might be confounded with Anki usage, the ideal test would circumvent this natural variation in learners' compliance with the assignment. Obtaining more consistent usage by all participants would provide a clearer picture of the relationships among strategy use and L2 learning outcomes. Future research could also provide learners with flashcards that embed verb conjugation and vocabulary in contextually rich sentences, which may increase learning even further and especially for heritage learners with more implicit linguistic knowledge. Additionally, a study comparing heritage learners with other L2 learners in their strategy use, motivation, and epistemological beliefs about language learning, and how these relate to language gains, would add depth to the present findings.

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## Disclosure statement

No potential conflict of interest was reported by the author.

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