The tablet for Second Language Vocabulary Learning: Keyboard, Stylus or Multiple Choice

La tablet para el aprendizaje de vocabulario en segundas lenguas: teclado, lápiz digital u opción múltiple

Stephanie Van-Hove
PhD Candidate in the iMinds Research Group for Media & ICT at the Department of Communication Studies at Ghent University (Belgium) (Stephanie.VanHove@UGent.be) (http://orcid.org/0000-0001-8652-9236)

Dr. Ellen Vanderhoven
Senior Researcher in the iMinds Research Group for Media & ICT at the Department of Communication Studies at the Ghent University (Belgium) (Ellen.Vanderhoven@UGent.be) (http://orcid.org/0000-0002-85)

Dr. Frederik Cornillie
Senior Researcher in applied linguistics in the Interdisciplinary Research Group ITEC at iMinds and KU Leuven (Belgium) (frederik.cornillie@kuleuven.be) (http://orcid.org/0000-0002-4820-7970)

Abstract
Mobile technologies are increasingly finding their way into classroom practice. While these technologies can create opportunities that may facilitate learning, including the learning of a second or foreign language (L2), the full potential of these new media often remains underexploited. A case in point concerns tablet applications for language practice: while tablets allow writing, as in pen-and-paper exercises, current applications typically offer multiple-choice exercises or fill-in-the-blank exercises that require typing and tapping. This change in medium and practice modality might have an impact on the actual second language-learning. Based on the embodied cognition perspective, this study hypothesizes that, for the learning of French L2 vocabulary, writing leads to better memorization, spelling, and use of diacritics in comparison with typing and completing multiple-choice exercises. This hypothesis is tested in a quasi-experimental classroom-based study in which learners (N=282) practiced French vocabulary on a tablet in one of three modalities: multiple choice, typing, and writing by means of a stylus. Whereas all three practice modalities aided learning, results show that pupils who had practiced vocabulary by writing or typing obtained higher scores on spelling and use of diacritics than the pupils who had practiced by means of multiple choice. Spending more time on learning vocabulary at a higher processing level leads thus to greater vocabulary gains.

Resumen
Las tecnologías móviles están aumentando su presencia en las aulas. Mientras estas tecnologías ofrecen oportunidades para facilitar el aprendizaje, entre ellas la adquisición de una segunda lengua (L2), su potencial sigue sin aprovecharse plenamente. Aunque las aplicaciones de las tablets permiten la ecritura y tareas similares a las que pueden hacerse en papel, siguen ofreciendo mayoritariamente ejercicios de selección mútiple o de relleno de huecos. Este cambio en medio y modalidad de práctica podría significar un impacto en el

aprendizaje de una segunda lengua. Basada en la perspectiva de la cognición incorporada, nuestra hipótesis predice que el hecho de escribir se traduce en un mejor proceso de memorización y una mejor ortografía frente a la escritura con teclado o al uso de ejercicios de opción múltiple. Esta hipótesis ha sido comprobada en un estudio cuasi-experimental basado en el aula: alumnos (N=282) que practicaron vocabulario de francés a través de tres modalidades de práctica: ejercicios de opción múltiple, escritura con un teclado y escritura a mano alzada. Aunque se haya encontrado que las tres modalidades de práctica apoyaron al proceso de aprendizaje, los resultados demostraron que los alumnos que practicaron el vocabulario escribiendo con lápiz o con tablet obtuvieron puntuaciones más altas en ortografía y dominio de signos diacríticos comparados con los alumnos que realizaron ejercicios de selección múltiple. Pasar más tiempo aprendiendo vocabulario a un nivel más alto de procesamiento conduce a una mayor adquisición de vocabulario.

1. Introduction

1.1. Mobile-assisted learning

From a pedagogical perspective, tablets hold the opportunity to support various aspects of the learning process, from activating prior knowledge and enhancing instruction, through enabling the processing of subject material in complex learning tasks as well as allowing part-task practice, to evaluating student knowledge and skills (Simon, Anderson, Hoyer, & Su, 2004). Therefore, several schools have decided to implement tablets in their classroom practice as a means for more active and personalized education to promote the individual strengths of pupils. In May 2014 the annual Tablets and Connectivity study from the British Educational Suppliers Association revealed that 76% of British secondary schools had adopted tablet computers in their classrooms (Paddick, 2015). In 2016, a Flemish study among 110 school principals and ICT coordinators showed that four out of ten secondary schools have at least ten tablets (Vanderhoven, Van-Hove & Anrijs, 2016). Some Flemish schools even decided to opt for one tablet device per pupil in the classrooms.

1.2. Practicing modality in L2 learning: tapping, typing and handwriting

Whereas the role of technology is studied most intensively in the field of computer-assisted language learning (CALL), most research in this field relies on second language acquisition theories, which ignore the crucial role that technology may play in the learning process (Stockwell, 2016). However, technology is increasingly being normalized in learning environments, which means that mobile technologies will be an integral part of the learning environment as much as pen and paper are (Bax, 2003). Therefore the presence of technology and its relation to the learning environment is at least as important as the learning outcome.

With regard to supporting part-task practice in language learning, tablets often rely on limited practice and test formats in contrast with pen-and-paper exercises, such as multiple-choice exercises in which correct answers need to be selected (Ducate & Lomicka, 2013). Although multiple-choice might lead to higher performance on tests, because recall is not required, it is often discouraged in part-task practice since it only facilitates recognition and may only be used as a learning tool if competitive alternative answers are provided to stimulate high-level processing (Little & Bjork, 2015; Nicol, 2007). In addition, with regard to one's ability to remember particular French words, Sturm (2006) argues that the duration of information processing in working memory plays a critical role, but

in contrast, multiple-choice formats stimulate learners to process subject material rapidly. In an empirical study, Heift (2003) investigated the effect of exercise type on learning outcomes in German learners and found that students who completed multiple-choice exercises performed worse than those using drag-and-drop or fill-in-the-blanks on a computer. Further, Webb (2005) compared receptive with productive vocabulary learning, and found that productive tasks (involving recall) resulted in significantly greater vocabulary gains. Because the productive task in his study required students to spend more time on learning than the multiple-choice exercises, he argued – in line with Sturm's (2006) claim – that task duration plays an important role in vocabulary learning.

In order to overcome these problems while still benefiting from the opportunities of mobile devices, multiple-choice exercises can be substituted by other closed-ended question types, such as fill-in-the-blank exercises, in which learners need to type down simple answers. However, although handwriting and typewriting involve the same brain regions (Higashiyama, Takeda, Someya, Kuroiwa, & Tanaka, 2015), there are still important differences. Handwriting entails a slower process using only one hand, strongly concentrating visual attention on the motor space where the words are written, furthermore each letter needs to be individually formed (Mangen & Velay, 2010). In contrast, typewriting requires (in theory) ten fingers to tap the keys, whereas each keystroke is not different from one another, but is significantly faster than handwriting (Mueller & Oppenheimer, 2014). The space where the letters are 'written' is different from the space where the letters appear (Mangen & Velay, 2010).

Several scholars hypothesize that handwriting movements are crucial in (language) learning and therefore suggest that the shift to keyboards is detrimental to learning (Longcamp & al., 2008; Longcamp, Boucard, Gilhodes, & Velay, 2006; Mangen & Velay, 2010; Sturm, 2006). The importance of handwriting in memorizing vocabulary has been proven by several empirical studies. Cunningham and Stanovich (1990b) found that words were better spelled if they were written out by hand than when they were typed or formed by dragging and dropping letter tiles. More recently, Longcamp and al. (2006) stated that the visual and sensorimotor imagery that people have of letters and words interact with one another. Seeing visual representations of letter shapes activates the corresponding sensorimotor component, such as handwriting movements, in memory. Kiefer and al. (2015) replicated the study of Cunningham and Stanovich (1990b) in preschoolers (3 months – 6 years) and found that word reading and writing performance increased in the handwriting training group compared to the group who practiced the letters by means of a keyboard. With regard to taking notes, longhand note-taking is found to result in deeper processing, due to the limited timeframe that forces learners to select and reframe the message in their own words (Mueller & Oppenheimer, 2014). Another study has shown that even preschoolers from four years on remembered and visually recognized significantly more letters if they copied the letters by hand instead of typing them (Longcamp, Zerbato-Poudou, & Velay, 2005).

Next to vocabulary and letter memorization, in several languages, such as Spanish and French, diacritical marks (including accents) are as important as the letters (Sturm, 2012). However, there has been little research that investigates what aids the recall of accent marks or diacritics. In French, six diacritics act as the keystone of orthography (accent aigu [´], accent grave [`], accent circonflexe [ˆ], tréma [¨], cédille [ç], apostrophe [']), which modifies the pronunciation of the vowels and the meaning of words (e.g. a / à (have / to), mur / mûr (wall / ripe), tache / tâche (dirty spot / task)...) ("Les accents et autres signes orthographiques," 2015; Sturm, 2012). Handwriting and typewriting involve making additional movements to add the appropriate accent to a word. Gascoigne-Lally (2000; 2006) found that the additional keystrokes that are needed to put an accent on a letter strengthen the application of diacritics. Similar to input enhancement, such as underlining words, using color codes or different fonts, the diacritical aspect of French words is rendered more salient through additional psychomotor steps (Gascoigne, 2006). Sturm (2006) replicated the aforementioned experiment, but did not find significant differences between handwriting and two typing groups using preprogrammed

function keys or ALT+ numeric codes. In contrast with the findings on memorization of second language vocabulary, these studies show that typing leads to a more correct use of diacritics than handwriting.

1.3. The embodied cognition

The embodied cognition perspective (Clark, 1998) might offer an explanation for the empirical findings described above. This theory sheds light on the embodied and action-oriented nature of learning activities, such as writing (Smith & Gasser, 2005; Thelen, Schöner, Scheier, & Smith, 2001). Similar to Piaget's constructivist theory (1952), which perceives children as active explorers of their environment, embodied cognition theory presumes that cognition results from sensorimotor interactions with the physical environment (Smith & Gasser, 2005; Thelen & al., 2001). If "cognition is the internalization of externalized action in the environment" (Wartella, Richert, & Robb, 2010: 123), then we might argue that handwriting fundamentally influences the way knowledge is acquired. Mangen and Velay (2010) put forth three theories from adjacent fields to indicate the reciprocity of the relation between body and thought. 'Motor theories of perception' (neuropsychology) state that external movements are mentally simulated, but 'the enactive approach' adds that sensorimotor patterns supply structure to cognition. While the first set of theories stresses the importance of cognitive processes and the second approach emphasizes the added value of perception, the 'theory of sensorimotor contingency' states that the relation between perception and cognition is mediated by knowledge of sensorimotor contingencies. Cognition induces the perceptual act of writing, in its turn providing structure to the learning process. However, knowledge of the sensory effects of writing will reinforce the learning-writing relationship. This implies that writing words down while perceiving them being formed on paper may facilitate the learning process.

It should be noted that previous studies most often focused on the comparison between handwriting on paper and typing on a technological device, thereby confounding the use of technology with the act of typing. However, the introduction of tablet devices in education offers new opportunities with regard to text input, such as the use of the stylus. The stylus can be used to write on a tablet device, making it possible to make a distinction between the impact of the use of a new technology and the impact of typing instead of writing. The current quasi-experimental study therefore explores the importance of handwriting by means of a stylus on a tablet, in contrast with typing and completing multiple-choice exercises in learning French L2 vocabulary in a tablet-assisted classroom setting. Based on the embodied cognition perspective and the results found in previous studies, the following hypotheses were put forth:

- Hypothesis 1: Multiple-choice as a testing modality leads to better grades than tests that require typing or handwriting.
- Hypothesis 2: On the basis of the embodied cognition perspective, learning French vocabulary by writing words down by means of a stylus leads to better memorization of the lemmas than typing the words on the on-screen keyboard or making multiple-choice exercises.
- Hypothesis 3: On the basis of the embodied cognition perspective, learning French vocabulary by writing words down by means of a stylus leads to better spelling than typing the words on the on-screen keyboard or making multiple-choice exercises.
- Hypothesis 4: Based on input enhancement literature, learning words using an on-screen keyboard in exercises denotes a more correct use of diacritics in French words when compared with handwriting using a stylus or making multiple-choice exercises.

To test these hypotheses, a quasi-experimental study was conducted in which the effects of three practicing modalities (stylus, keyboard and multiple-choice) on the memorization of the lemmas of the vocabulary and their spelling and diacritical marks are investigated.

2. Material and methods

2.1. Participants & design

In total, 282 pupils (129 boys and 153 girls) between 11 and 18 years old took part in the study. Classes were recruited from three Flemish schools that offer general secondary education, since French is part of the formal Flemish curriculum in general secondary education. Eventually 14 classes of nine teachers participated in the study and were randomly assigned, counterbalancing for age, to one of the three conditions. The stylus condition comprised 94 participants, the keyboard condition 93 and the remaining 95 pupils were assigned to the multiple-choice condition. 98.9% of the sample spoke Dutch as their primary language, while 5.8% also spoke French at home. Most pupils were in their fourth year (15-16 years old) and pupils were taught on average 5.72 years of French at school (SD=1.72).

Table 1: Cross table per condition and cycle (N=282)				
Pupils	**Stylus**	**Keyboard**	**Multiple-choice**	**Total**
First cycle (11-14 years)	24	48	21	93
Second cycle (14-16 years)	47	14	53	114
Third cycle (16-18 years)	23	31	21	75
Total pupils	94	93	95	282

2.2. Procedure

The intervention took place during three French courses (figure 1), of which the first and second lessons took place in the same week. 25 iPads were prepared for the study: interactive PDFs (course materials) were downloaded via the PDF Office app, the primary keyboard language was set to French and auto-correction and spell-check features were disabled. Once in the classroom the first author introduced the pupils to the study and explained to them how to use the interactive PDFs. The pupils and teachers were told that they would participate in a study that aimed to investigate how French vocabulary is learned. The underlying goals of the study (recognition of words and recall of words, spelling and diacritical marks) were not shared with the participants. During the remaining 40 minutes the pupils filled out an online survey and pretest.

In the second lesson the first author introduced the course theme with a presentation and a short movie, then the pupils got 10 minutes to memorize the vocabulary list of 36 words (hard copy). They were instructed to learn the words one-directionally: from Dutch to French. Moreover the researchers asked the pupils explicitly not to write any words down when they had to learn the 36-words vocabulary list. After having memorized the words the pupils filled out fill-in-the-blanks exercises individually and independently. Depending on the condition they were assigned to, they were instructed to complete these exercises using one of three modalities: multiple choice, typing, or writing by means of a stylus. At the end of the second lesson the pupils filled out a posttest, similar to the pretest, with the words in randomized order.

In the third and final lesson, the pupils took the posttest again, which served as a delayed posttest in our experimental design. A minimum of 10 days between the second and the third lesson was needed to be able to investigate retention effects in a proper way (Sturm, 2010) (figure 1).
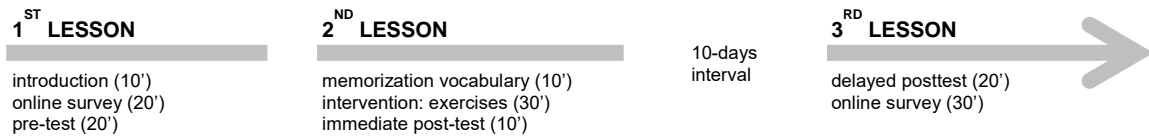
1ST LESSON

introduction (10')
online survey (20')
pre-test (20')

2ND LESSON

memorization vocabulary (10')
intervention: exercises (30')
immediate post-test (10')

10-days interval

3RD LESSON

delayed posttest (20')
online survey (30')

Figure 1: Study procedure

2.3. Instruments

Three tests were conducted: a pre-test was filled out before the intervention, a post-test right after the exercises at the end of the second lesson and a delayed post-test after a minimum of 10 days. In all tests, learning outcomes were measured. 175 pupils completed all three tests, 254 completed the pre-test, 238 pupils filled out the post-test and only 232 pupils completed the third delayed post-test. Due to technical issues, some tests were not properly saved and, accordingly, account for the missing tests. In addition, each of the teachers (except the class with internet difficulties) filled out an evaluation survey (N=9).

Test items. Sturm (2006) recommended in her study on the acquisition of accent marks in second language learners that infrequent and non-cognate words are imperative, because pupils achieved high results on the pre-test with common French words as garçon and déjeuner. To that end, each of the three tests consisted of 15 difficult non-commonly used French words with diacritics (target words) that were masked with 21 topic-related words (table 2). Thus, each pupil learned a total of 36 French words, with a minimum of 20 diacritical marks. The older the participants, the more diacritics they had to memorize. By creating a different course for each of the three cycles, the difficulty of the vocabulary was adapted to their skills and knowledge, except for the target words, which remained the same across three cycles.

Table 1: 15 French target words with diacritical marks			
French word	**Translation**	**French word**	**Translation**
présage	sign	ambiguïté	ambiguity
poêle	frying pan	boëtte	fish-bait
mûr(e) (adj.)	full-grown	mœurs	habits
mâtin(e)	guard dog	aigu(ë) (adj.)	acute,
capharnaüm	shambles	douçâtre (adj.)	sweetish
jeûne	fast (period of abstinence	râteau	rake
abîme	chasm	trèfle	clover
exiguïté	smallness		

- Learning outcomes. Knowledge about each of the 36 words was assessed using a fill-in-the-blanks format (e.g. La texte n'est pas difficile, elle ne comporte aucune [...]. [uncertainty]). The test comprised three sections that differed in terms of the testing format, which corresponded to the three conditions: 12 words are handwritten with a stylus and 12 words are typed using the on-screen keyboard. The other 12 words needed to be ticked off out of four possible answers (of which one was 'I don't know' to discourage guessing). To avoid order-confounding effects, the words and testing parts were randomized for each participating class. This implies that the words varied per testing format (e.g., the exercises of the testing part that had to be filled out by hand of the pretest were not the same as the exercises in the handwriting part of the post-test). Every word is scored on three different aspects: general memorization (0/1/2), spelling (0/1) and diacritical marks (0/1/2). Based on these word scores four aggregated scores were calculated for every 12 words per testing format (handwriting, typing and multiple-choice), resulting in a minimum score of 0 and a maximum score of 1:

- Total score: The total score is similar to a teacher's scoring method in a real school context and is calculated for the three testing methods, each consisting of 12 words. The word scores range from 0 to 3 with 0: no answer or completely incorrect answer, 1: the word is similar to the right answer, but it does nt sound the same (e.g. trefflé instead of trèfle), 2: the same lemma, but it is spelled incorrectly (including incorrect use of diacritic marks), 3: the word is correctly spelled (including correct use of diacritic marks). Multiple-choice exercises are only graded using 0 (incorrect answer) or 3 (correct answer) (e.g., "Les pommes sont [...], mais les prunes pas encore. [ripe]. Jeûne / aigu(ë) / mûres / je ne sais pas"). The sum of these 12 word scores is divided by 36, which is the maximum score if all 12 handwritten or typed words are spelled correctly.

- Memorization score: For each testing method, the sum of the 12 word scores on memorization (0: wrong, 1: similar to the answer, but does not sound the same, 2: sounds the same as the right answer) is calculated and divided by 24. The value of this denominator is the maximum score if all 12 words are correctly memorized. Multiple-choice exercises are only graded using 0 (wrong answer) or 2 (right answer).

Furthermore, the other two scores were computed independently of the number of correctly memorized words. The multiple-choice part of the tests was omitted, since writing accuracy (such as spelling and use of diacritics) cannot be tested using multiple-choice exercises. Only the correctly memorized (diacritical) words (memorization score=2) are taken into account to calculate the following scores per testing method (handwriting and typing):

- Spelling score / memorization: The 12 word scores on spelling (0: wrong, 1: right) are added up and divided by the number of correctly memorized words.

- Diacritical score / memorization: The word scores on accent marks (0: an accent mark is put if there wasn't one or reversed, 1: an accent mark is put on the wrong letter or the wrong accent mark is chosen, 2: right) are added up and divided by the number of correctly memorized words.

2.4. Analyses

In order to investigate the effects of practice modality (3 conditions: stylus, keyboard and multiple-choice) and time (3 tests: pre-test, post-test and delayed post-test), a series of repeated-measures ANOVAs were conducted. The within-subjects factor was time, while the between-subjects factor was practicing modality (condition). Different analyses were performed to investigate the effects on the total mean score of the tests and the total score, the memorization, the spelling and the diacritics score per testing method.

3. Results

3.1. Memorization outcomes

3.1.1. Total mean score

The total scores of the three testing methods were averaged, resulting in one total mean score (%) per test (pre-test, post-test and delayed post-test). Mauchly's test indicated that the assumption of sphericity had been violated by time ($\chi^2(2)$=55.429, p=.000, ε=.72), therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\hat{\varepsilon}$=.78). A two-way ANOVA with the total mean scores of the tests as repeated measures factor showed a significant effect of time ($F(1.56, 265.70)$=1024.94; p=.00). Although pupils gained lower scores on the delayed post-test compared to the post-test, Pairwise Comparisons showed that the scores on the post-test (M=67.35%, SD=20.01%) and delayed post-test (M=56.55%, SD=19.18%) are significantly higher than those of the pre-test (M=19.67%, SD=10.60%) (p=.00). On the contrary, there was no significant effect on how pupils practiced the vocabulary during the intervention ($F(2, 170)$=1.38; p=.25), nor was a significant interaction found between time and condition ($F(3.13, 265.70)$=1.81; p=.14).

Each test consisted of three testing methods (handwriting, typing and multiple-choice), which enabled us to compare the separate testing method scores. There was a main effect of the testing method on the partial scores of each testing method (F(2,340)=1057.81, p=.000), as well as a significant interaction between testing method and time (F(2.35, 399.27)=8.71, p=.000). The scores of the multiple-choice part of the tests (M=75.28, SD=14.00) were on average 41 percentage points higher than the scores of the testing methods that needed to be filled out by stylus (M=34.50, SD=18.91) or keyboard (M=33.79, SD=18.61) (see **¡Error! No se encuentra el origen de la referencia.**). Consistent with hypothesis 1 it was found that multiple-choice assessments yielded higher scores than fill-in-the blank assessments.

Regarding socio-demographics, a t-test of the total mean scores showed that girls (M=72.14%; SD=19.27%) achieved higher results than boys (M=63.65%; SD=21.28%) on the post-test (t(245)=-2.406; p=.017). This significant effect disappeared when taking the delayed post-test into account (t(220)=-4.797; p=.074). Furthermore, it was found that the school cycle had a significant effect (F(2,232)=60.493; p=.000). Pupils in the first cycle (M=47.15%; SD=16.84%) achieved a significant lower score on the post-test than the second (M=73.24%; SD=16.18%) and third cycle (M=77.44%; SD=17.62%).
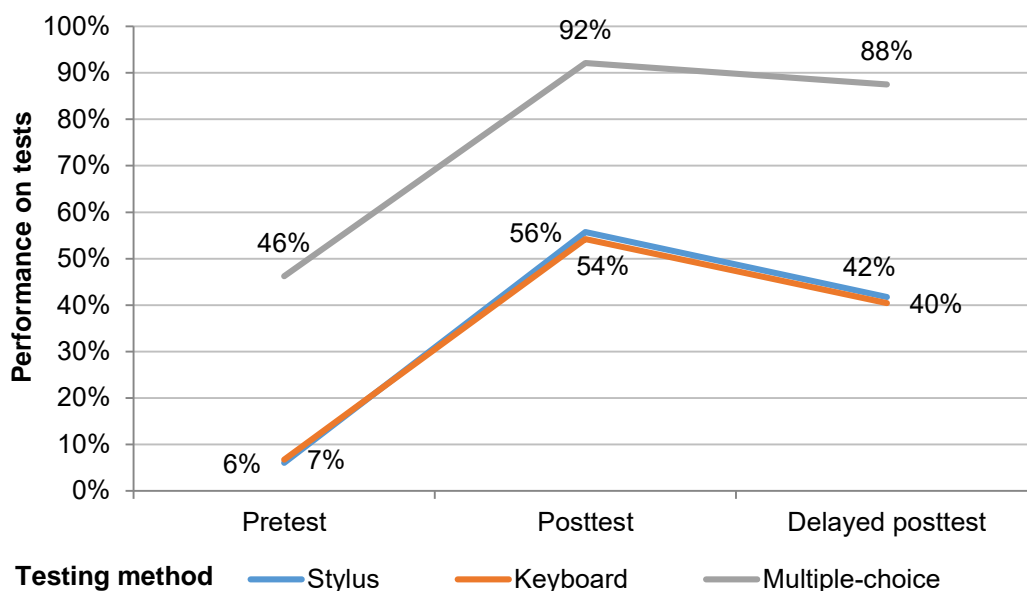

Figure 2: Total score per testing method (stylus, keyboard and multiple-choice) on each of the three tests (pretest, posttest an delayed posttest) (N=183).

3.1.2. Vocabulary memorization

The total memorization score for each of the three tests (pre-test, post-test and delayed post-test) was calculated by averaging the scores of the three testing methods, resulting in one memorization score (%) per test (pre-test, post-test and delayed post-test). Thus, in this analysis, the testing method was not taken into account. Similar to the analyses with total mean score, only a main effect of time F(1.58, 268.62)=1041.72, p=.00) was found. Pupils succeeded in gaining significant more knowledge of the provided vocabulary when the pre-test is compared to the two following posttests (p=.00). Scores on the pretest were the lowest (M=20.41%, SD=11.09%), whereas scores on the posttest were the highest (M=71.85%; SD=21.05%) and in between were the scores of the delayed posttest (M=60.29%, SD=20.65%). There was no significant main effect of practicing modality

(F(1,170)=.80, p=.45), nor an interaction of time × practicing modality (F(3.16, 268.62)=1.60, p=.188).

As stated above, it was expected that handwriting with a stylus is more efficient in terms of memorization than the other practicing modalities (H2). However, this hypothesis could not be confirmed in analyses with total mean score, nor with memorization score.

3.2. Writing accuracy: spelling & diacritics

In this section the multiple-choice testing parts are dropped from consideration, since writing accuracy, such as spelling and diacritics, cannot be tested using multiple-choice exercises. Hence only the handwriting and typewriting parts of the tests are taken into account. In addition, analyses were conducted using the spelling and diacritics scores for the correctly memorized words.

Spelling and diacritics were separately subjected to a two practicing modality (handwriting or typewriting) by three (time: pre-test, post-test, delayed post-test) ANOVA. Since a repeated measures ANOVA was used, the tests were adjusted for non-sphericity using the Greenhouse-Geisser estimates of sphericity with spelling ($\hat{\varepsilon}_{time}$=.77, $\hat{\varepsilon}_{time*testing}$=.75) and Huynh-Feldt estimates of sphericity with diacritics ($\tilde{\varepsilon}_{time}$=.91, $\tilde{\varepsilon}_{time*testing}$=.89). In line with earlier findings pupils wrote the learned vocabulary significantly more accurately and put the correct diacritics on the right letters in the post-test and delayed posttest when compared to the pretest (spelling: F(1.54, 277.24)=260.38, p=.00; diacritics: F(1.81, 326.47)=159.91, p=.00).

3.2.1. Spelling

Regarding spelling the practicing modality is a decisive factor. A main effect of practicing modality was found (F(2,180)=9.99, p=.000), as well as an interaction of time × practicing modality (F(3.08, 277.24)=4.57, p=.004). Although the test items were completed by means of a stylus or keyboard, learning new French vocabulary by handwriting or typewriting led to higher spelling scores based on post-hoc pairwise comparisons on the post-test (p≤.005) and on the delayed posttest (p≤.015) in comparison with completing multiple-choice exercises during the intervention. While the scores of the pupils in the handwriting and typewriting conditions are respectively 76.51% (SD=14.69%) and 81.04% (SD=17.46%) in the post-test and 73.66% (SD=16.91%) and 75.74% (SD=20.82%) in the delayed post-test, the multiple-choice condition got no higher scores than on average 67.43% (SD=21.00%) in the post-test and 64.10% (SD=27.14%) in the delayed post-test (figure 3).

The third hypothesis can be partially confirmed. Learning vocabulary by writing the words down leads to higher spelling scores in comparison with completing multiple-choice exercises. Specifically, the handwriting practitioners along with the typewriting condition were more able to write the words correctly than those who completed multiple-choice exercises.
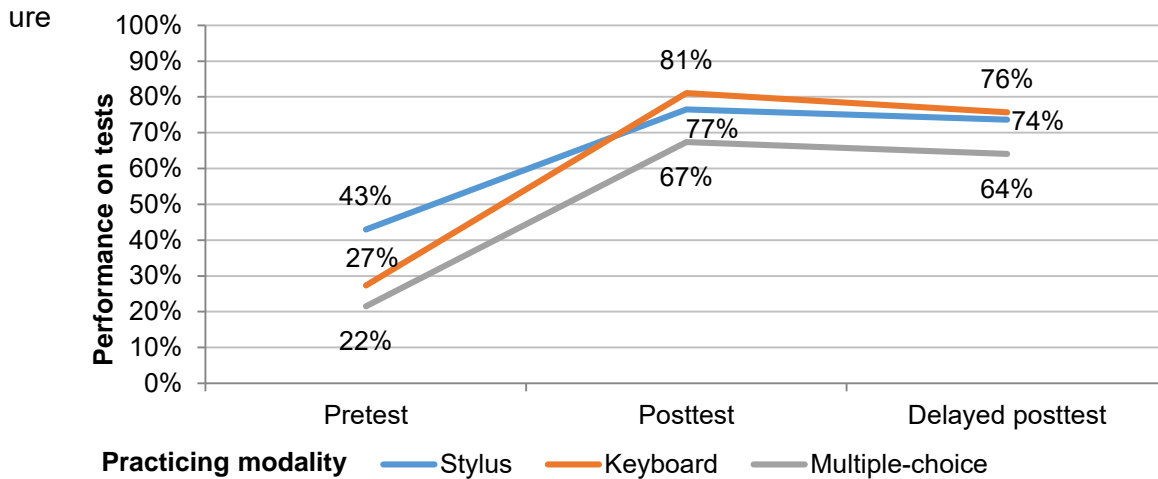
Figure 3:

Spelling score per practicing method (stylus, keyboard and multiple-choice) on each of the three tests (pre-test, post-test and delayed post-test) (N=183).

3.2.2. Diacritics

The practicing modality seemed of crucial importance with regard to the increasing score on diacritics (significant interaction time × practicing modality, $F(3.63, 326.47)=4.83$, $p=.00$). With regard to making correct use of diacritics, learning French L2 words and their typical diacritics by typewriting pays off in comparison with making multiple-choice exercises. Pairwise comparisons showed significant differences between the typewriting and multiple-choice conditions in both the post-test ($p=.00$) and delayed post-test ($p=.035$), whereas the handwriting condition did not differ significantly from the other conditions. While the typewriting condition scored on average 66.68% (SD=25.09%) on the post-test and delayed post-test, the multiple-choice condition hardly got half of the points (M=50.24%; SD=31.82%) (figure 4).
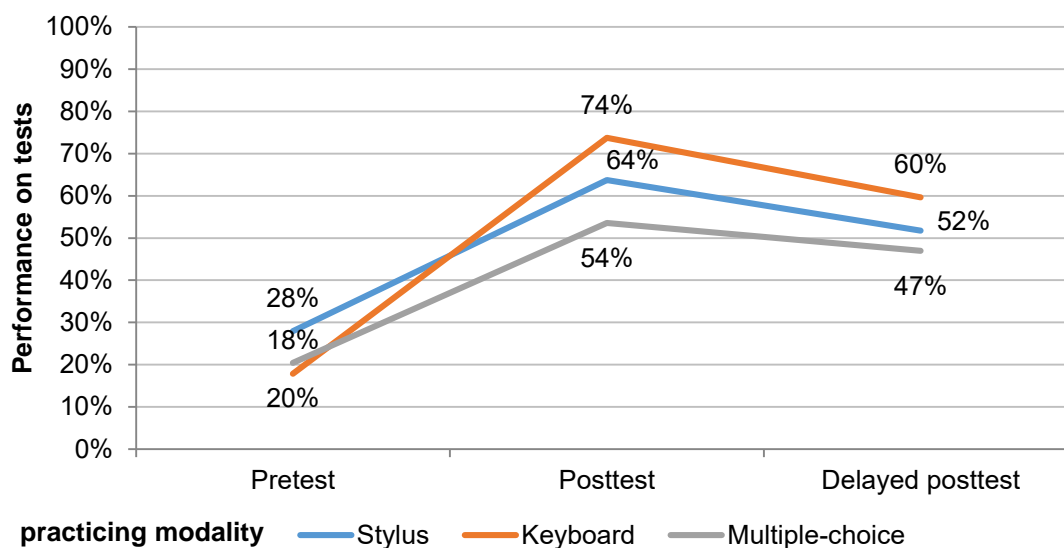
Figure 4: Diacritics score per practicing method (stylus, keyboard and multiple-choice) on each of the three tests (pre-test, post-test and delayed post-test) (N=183).

These findings partially support hypothesis 4. Typewriting was found to be a better alternative for practicing French vocabulary with regard to the memorization of diacritics in comparison with multiple-choice exercises.

4. Discussion and conclusion

The study shows that each of the three practicing groups made vocabulary gains. Whether the pupils practiced the vocabulary by writing down the words with a stylus, typed the words using the on-screen keyboard of the iPads or ticked the appropriate word out of three possible answers, the learning effect is shown and lasted minimum 10 days. As an alternative to writing with pen on paper, some pupils were making writing movements on their desk when memorizing the words. Similar to Mangen and Velay (2010) who stated that writing movements involve letter memorization, this could imply that memorization and the psychomotor act of writing are part of the same representation process.

In contrast, with regard to the productive spelling and diacritics measures it was found that pupils who spent more time learning the vocabulary by writing or typing, obtained higher scores over time than the multiple-choice group. None of the groups knew in advance how their vocabulary knowledge would be assessed, therefore we assume that the writing and typing groups practiced the vocabulary on a higher processing level than the multiple-choice group did. This is in line with previous L2 acquisition studies, which found that clicking is less efficient than typing (Heift, 2003). Furthermore the vague contribution of writing movements in memorization that was confirmed in literacy studies and in particular in writing studies (Cunningham & Stanovich, 1990a; Mangen & Velay, 2010), was not found in this study. Practicing vocabulary through handwriting and typing thus did not differ significantly from one another.

Regarding the testing method, pupils got higher scores on the multiple-choice part of the tests, which reflects the less demanding nature of this method when compared to handwriting or typewriting. Despite the effort of the researchers to discourage guessing, it is possible that pupils still were guessing to increase their chance to get after all the right answers, because there were no negative consequences attached if the answer was wrong.

Although we found that the practicing modality matters, some limitations of this research should be considered. The sample did not consist of novice learners of French as a foreign language. In the Flemish school system pupils get their first French courses at the age of 10, the youngest participants

in the sample learned already about 2.5 years French at school. Nevertheless, the difficulty of the vocabulary and the fill-in-the-blanks exercises and assessments were adapted to their level. In contrast to the samples of Sturm's (2006, 2010, 2012) and Gascoigne Lallly's (2000) studies the French and Dutch languages do not differ as much as French and English do. Dutch is enriched with a lot of French loan words, for this reason Flemish people and, by extension, the whole Dutch speaking population is already used to the usage of the following accent marks: ´ (café), ` (scène), ¨ (reünie) and ^ (gêne).

References

Bax, S. (2003). Call. Past, Present and Future. System, 31(1), 13-28. https://doi.org/10.1016/S0346-251X(02)00071-4

Clark, A. (1998). Being There: Putting Brain, Body, and World Together Again. The Philosophical Review, 107, 4, 647-650. https://doi.org/10.2307/2998391

Cunningham, A.E., & Stanovich, K E. (1990a). Assessing Print Exposure and Orthographic Processing Skill in Children: A Quick Measure of Reading Experience. Journal of Educational Psychology, 82(4), 733-740. https://doi.org/10.1037/0022-0663.82.4.733

Cunningham, A.E., & Stanovich, K.E. (1990b). Early Spelling Acquisition: Writing Beats the Computer. Journal of Educational Psychology, 82(1), 159-162. https://doi.org/10.1037/0022-0663.82.1.159

Ducate, L., & Lomicka, L. (2013). Going Mobile: Language Learning with an Ipod Touch in Intermediate French and German Classes. Foreign Language Annals, 46(3), 445-468. https://doi.org/10.1111/flan.12043

Gascoigne-Lally, C. (2000). The Effect of Keyboarding on the Acquisition of Diacritical Marks in the Foreign Language Classroom Lally. The French Review, 73(5), 899-907.

Gascoigne, C. (2006). Explicit Input Enhancement: Effects on Target and Non-target Aspects of Second Language Acquisition. Foreign Language Annals, 39(4), 551-564. https://doi.org/10.1111/j.1944-9720.2006.tb02275.x

Heift, T. (2003). Drag or Type, But Don't Click: A Study on the Effectiveness of Different CALL Exercise Types. Canadian Journal of Applied Linguistics, 6(3), 69-85.

Higashiyama, Y., Takeda, K., Someya, Y., Kuroiwa, Y., & Tanaka, F. (2015). The Neural Basis of Typewriting: A Functional MRI Study. Plos One, 10(7). https://doi.org/10.1371/journal.pone.0134131

Kiefer, M., Schuler, S., Mayer, C., Trumpp, N.M., Hille, K., & Sachse, S. (2015). Handwriting or Typewriting? The Influence of Pen-or Keyboard-based Writing Training on Reading and Writing Performance in Preschool Children. Advances in Cognitive Psychology, 11(4), 136-146. https://doi.org/10.5709/acp-0178-7

Little, J.L., & Bjork, E.L. (2015). Optimizing Multiple-choice Tests as Tools for Learning. Memory & Cognition, 43(1), 14-26. https://doi.org/10.3758/s13421-014-0452-8

Longcamp, M., Boucard, C., Gilhodes, J.C., & Velay, J.L. (2006). Remembering the 0rientation of Newly Learned Characters Depends on the Associated Writing Knowledge: A Comparison between Handwriting and Typing. Human Movement Science, 25, 646-656. https://doi.org/10.1016/j.humov.2006.07.007

Longcamp, M., Boucard, C., Gilhodes, J.C., Anton, J.L., Roth, M., Nazarian, B., & Velay, J.L. (2008). Learning through Hand- or Typewriting Influences Visual Recognition of New Graphic Shapes: Behavioral and Functional Imaging Evidence. Journal of Cognitive Neuroscience, 20(5), 802-815. https://doi.org/10.1162/jocn.2008.20504

Longcamp, M., Zerbato-Poudou, M.T., & Velay, J.L. (2005). The Influence of Writing Practice on Letter Recognition in Preschool Children: A Comparison between Handwriting and Typing. Acta Psychologica, 119(1), 67-79. https://doi.org/10.1016/j.actpsy.2004.10.019

Mangen, A., & Velay, J.L. (2010). Digitizing Literacy: Reflections on the Haptics of Writing. In M. H. Zadeh

(Ed.), Advances in Haptics (pp. 385-403). InTech. https://doi.org/10.5772/8710

Mueller, P.A., & Oppenheimer, D.M. (2014). The Pen Is Mightier Than the Keyboard: Advantages of Long-hand Over Laptop Note Taking. Psychological Science, 25(April), 1159-1168. https://doi.org/10.1177/0956797614524581

Nicol, D. (2007). E-assessment by Design: Using Multiple-choice Tests to Good Effect. Journal of Further and Higher Education, 31(1), 53-64. https://doi.org/10.1080/03098770601167922

Paddick, R. (2015). Tablet Adoption Continues to Rise. (http://goo.gl/cR6vt0) (2015-09-15).

Piaget, J. (1952). The Origins of Intelligence in Children (Vol. 8). New York, NY: International Universities Press. https://doi.org/10.1037/h0051916

Simon, B., Anderson, R., Hoyer, C., & Su, J. (2004). Preliminary Experiences with a Tablet PC based System to Support Active Learning in Computer Science Courses. In ITiCSE '04 (pp. 213-217). https://doi.org/10.1145/1007996.1008053

Smith, L., & Gasser, M. (2005). The Development of Embodied Cognition: Six Lessons from Babies. Artificial Life, 11(1-2), 13-29. https://doi.org/10.1162/1064546053278973

Stockwell, G. (2016). Mobile Language Learning. In F. Farr, & L. Murray (Eds.), The Routledge Handbook of Language Learning and Technology (pp. 296-307). Abingdon: Taylor and Francis Inc. https://doi.org/10.4324/9781315657899

Sturm, J.L. (2006). The Effect of Keyboarding and Presentation Format on the Recall of Accent Marks in L2 Learners of French. Working Papers in Tesol & Applied Linguistics, 6(2), 1-15. https://doi.org/10.7916/D8RX9BMS

Sturm, J.L. (2010). The acquisition of accent marks in L2 French: The effects of keyboarding and text format. Proceedings of the Second Congrès Mondial de Linguistique Française, 1591-1606. https://doi.org/10.1051/cmlf/2010032

Sturm, J.L. (2012). Meaning and Orthography in L2 French. Writing Systems Research, 4(1), 47-60. https://doi.org/10.1080/17586801.2011.635950

Thelen, E., Schöner, G., Scheier, C., & Smith, L.B. (2001). The Dynamics of Embodiment: A Field Theory of Infant Perseverative Reaching. Behavioral and Brain Sciences, 24, 1-86. https://doi.org/10.1017/S0140525X01003910

Vanderhoven, E., Van-Hove, S., & Anrijs, S. (2016). Er zijn steeds meer tablets op school, maar vele leraren wijzen op gebrekkige software en een falend wifinetwerk. [Schools are increasingly adopting tablets, but many teachers point to the poor software and insufficient Wi-Fi networks] (http://goo.gl/7CskKF) (24/08/2016).

Varios (2015). Les accents et autres signes orthographiques. [Accents and other orthographical signs] (2015). Espace Français. (http://goo.gl/VajbvY) (2015-09-20).

Wartella, E., Richert, R., & Robb, M.B. (2010). Babies, Television and Videos: How did we get here? Developmental Review, 30(2), 116-127. https://doi.org/10.1016/j.dr.2010.03.008

Webb, S. (2005). Receptive and Productive Vocabulary Learning: The Effects of Reading and Writing on Word Knowledge. Studies in Second Language Acquisition, 27(01), 33-52. https://doi.org/10.1017/S0272263105050023