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Predicting EFL vocabulary, reading, and spelling in English as a foreign language using paired-associate learning

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ABSTRACT

L1 studies show that the paired-associate learning (PAL) of novel pronunciations, verbal learning, contributes to the prediction of individual differences in vocabulary, reading, and spelling development. The present study examined whether verbal learning predicts vocabulary and literacy development in English as a Foreign Language (EFL). Dutch Grade 7 students ($N = 455$) completed a PAL task in which they learned to associate known Dutch words with their unknown English (spoken and written) translation. Both verbal and orthographic learning were assessed. Additionally, vocabulary, and reading and spelling skills were measured at the beginning of Grade 7 and five months later. The results showed that verbal learning contributed to development in vocabulary and reading accuracy. The contribution of orthographic learning was limited to development in spelling and pseudoword reading fluency. Overall, these findings are in line with findings in L1, indicating that especially verbal learning adds to the prediction of EFL development.

As English is the lingua franca, across the world there are many students that have to learn English as a foreign language (EFL). In many countries, formal EFL instruction at school usually starts at 10–12 years of age. By then, there are already large individual differences in EFL proficiency. These large differences are in part due to differences in out-of-school English exposure (Thijs et al., 2011) and not to EFL aptitude, that is the ease and speed of EFL learning (Li, 2016). Variations in out-of-school exposure hamper the prediction of the further acquisition of EFL and make it more difficult to determine which children need extra help from the start of instruction because of problems in learning EFL. In the current study we examine the contribution of a language aptitude test to the prediction of individual differences in EFL development.

Word learning can be regarded as a central component of language aptitude (Li, 2016). In (E)FL, vocabulary learning generally occurs through learning a translation (Hulstijn, 2001), which can be considered a specific form of paired-associate learning (PAL) (Steinel et al., 2007). Generally, PAL entails learning an arbitrary association between two different stimuli, by consecutively presenting one item of the pair and asking the learner to provide the other one. The presentation format of the stimuli determine the PAL form. For instance, visual-verbal PAL entails presentation of a symbol and associating it with a spoken word. Learning a translation can be considered a type of verbal-verbal PAL, as translation learning entails learning an arbitrary association between a word in a first language (L1) and the word in the foreign language. The association is arbitrary, except when cognates are involved.

Words in a foreign language can be learned using backward translation (translating the foreign word to L1) or forward translation (translating the L1 word to the foreign word). These translation directions are not equivalent: Forward translation requires a verbal response for which learning the phonological form is necessary. It thus consists of learning, retrieving and producing the novel word (Krepel et al., 2021; Steinel et al., 2007). Learning a word through forward translation is a type of PAL primarily reflecting verbal learning (Litt & Nation, 2014). In backward translation, the phonological form only needs to be recognized; representations can be less precise and still be recognized.

L1 PAL studies have shown that PAL tasks requiring learning the spoken form of a novel word, that is verbal learning, are related to different aspects of language development such as vocabulary (Gellert & Elbro, 2013), reading (e.g. Litt & Nation, 2014), and spelling (Wang et al., 2017). Furthermore, experimental studies show that the specific aspect of verbal learning contributing to language development is

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establishing a precise phonological representation, rather than associative learning (Litt & Nation, 2014). In what follows, we will describe the evidence on the relation of verbal learning with the acquisition of vocabulary, reading and spelling. Most of this evidence comes from studies in L1.

1. PAL and vocabulary

Gellert and Elbro (2013) studied the predictive value of PAL on L1 vocabulary growth. In the visual-verbal PAL task, third grade Danish students had to learn both the pronunciation and meaning of novel words. They were presented with a picture and had to provide the spoken word. Afterwards, students were presented with the pronunciation and were asked to provide semantic attributes of the word. Results showed that PAL predicted vocabulary growth over a period of 9 months. Especially the recall of the pronunciations of the words, the *verbal* learning component of the task, was predictive of vocabulary development, whereas the recall of the semantic attributes of words was not.

Few studies have examined the role of PAL in foreign language acquisition, even though verbal learning might be especially important in this instance. When learning a foreign word through translation, students often already know the meaning of the word in L1, and mainly need to associate it with the new phonological form. The assumption is thus that a PAL task that includes a measure of verbal learning ability would be related to foreign language vocabulary growth. Studies testing this hypothesis have apparently not been conducted yet. However, research has addressed the relationship between performance on the paired associates subtest from the Modern Language Aptitude Test (MLAT; Carroll & Sapon, 2002) on foreign language vocabulary development. In this MLAT-task, students are given 2 min to learn a list of (presumably unknown) Kurdish translations of 24 English words through self-study. Subsequently, a written multiple choice test is administered: students are presented with a Kurdish word and have to select the correct written English translation. In a meta-analysis on the validity of the MLAT, this PAL subtest hardly predicted vocabulary development (Li, 2016). This is likely due to the fact that the MLAT PAL task does not test for verbal learning, as it does not require students to retrieve and provide the correct spoken form of the word either during learning or at test. Following L1 findings, we expect that in foreign language learning, PAL that includes a measure of verbal learning ability is related to vocabulary growth. To our knowledge this hypothesis has not yet been tested.

2. PAL and word reading

Verbal learning also seems involved in reading development. The ability to acquire detailed phonological representations of words is often believed to underlie the development of phonological skills, particularly phoneme awareness, which in turn fuels the development of reading. Elbro and de Jong (2017) argued that orthographic learning also required verbal learning, as verbal learning is involved in learning the letter-sound relationships. More importantly, verbal learning is also involved in learning the association between the written and the spoken form of words as the spoken form generated by the written form, its spelling pronunciation, will often deviate from the standard pronunciation of the word in memory (see also Elbro et al., 2012). Thus, verbal learning is also required in learning the association between a spelling and a standard pronunciation. Indeed, many L1 studies have found that verbal learning measured through PAL tasks is related to L1 word reading ability concurrently in students ranging from 6 to 12 years old (Clayton et al., 2018; Litt & Nation, 2014; Windfuhr & Snowling, 2001, and 18-year-olds in Mourgues et al., 2016).

Besides the concurrent findings of verbal learning and reading, to our knowledge, only two longitudinal studies have assessed the contribution of verbal learning on the development of reading. Lervåg et al. (2009) examined the role of verbal learning in reading development in Norwegian 6-year olds. Verbal learning was measured with three different PAL tasks, in which children had to associate nonwords to pictures of children, fantasy animals, and unfamiliar symbols. In each learning trial, children were shown the picture and asked to provide the pronunciation of the corresponding nonword. Surprisingly, Lervåg et al. (2009) found that verbal learning did not contribute to the development of reading skills over 2 years. Possibly this is due to the regularity of the Norwegian orthography. Linking associations between orthography and phonology might be more straightforward than in a less transparent orthography with more arbitrary associations between orthography and phonology. Verbal learning (which in a PAL task involves learning arbitrary associations) might contribute less to reading development in a transparent language (Lervåg et al., 2009). Indeed, in Chinese, an orthography in which the phonology-to-orthography mapping is much less straightforward than in Norwegian, verbal learning did predict reading development from K2 to K3 in Chinese kindergarteners (Georgiou et al., 2017). In this study, verbal learning was measured in a PAL task in which children associated Chinese syllables with pictures of imaginary animals. The children were shown a picture and were asked to provide the name. For English, which has a more opaque orthography than Norwegian but is less opaque than Chinese, PAL seems more likely to be related to the development of reading.

3. PAL and spelling

Spelling is a skill closely related to reading (Conrad, 2008). As both reading and spelling rely on the same representations (Purcell et al., 2017), verbal learning might also be important for spelling development. Despite the relatively limited amount of research on verbal learning and spelling, the conducted studies do report that verbal learning facilitates the acquisition of spelling in L1 English. Wang et al. (2017) administered three different PAL tasks and an orthographic learning task to Grade 3 and 4 students. The PAL tasks differed in the extent to which they measured verbal learning. In the first PAL task students learned the association between different shapes, requiring no verbal output. The second and third PAL task required verbal learning, as students learned the pronunciation of a nonword and had to link it to either a shape or to a different nonword. In the orthographic learning task, students were shown a word embedded in a sentence four times. After this exposure phase the students were asked to provide the spelling of the embedded words. Only the PAL tasks that required verbal learning were found to be associated with learning a word's spelling in the orthographic learning task.

If verbal learning is related to spelling acquisition, it can also be expected to predict spelling development over time. However, outcomes regarding the contribution of verbal learning to spelling development are mixed. A longitudinal study in the relatively transparent Norwegian orthography (Lervåg & Hulme, 2010), using the same PAL task as Lervåg et al. (2009), did not find that verbal learning predicted spelling development. In contrast, a longitudinal study in the more opaque Danish orthography did find a contribution of verbal learning to spelling development in beginning readers (Nielsen & Juul, 2016). In the Danish study, Grade 2 children completed two PAL tasks in which they were shown a picture of a cartoon animal and had to associate it with either a common name or a previously unknown nonword. Only the PAL task in which the children had to provide the nonword (which relies more on verbal learning, as a new pronunciation had to be learned) was related to spelling in Grade 5. Similar to verbal learning and reading, verbal learning seems more predictive of spelling in more opaque languages, in which word-specific knowledge is important to accurately spell a word. As the English orthography is even less transparent than Danish, we expected a relation of PAL with EFL spelling development.

4. Present study

Generally, previous research supports the view that verbal learning, as measured in a visual-verbal of verbal-verbal PAL task, predicts acquisition of L1 vocabulary, reading, and spelling. In the current study, we investigated the contributions of PAL in EFL development of Dutch EFL students over the period from the start of EFL instruction, beginning of Grade 7, to the end of Grade 7. Since verbal learning appears to be a critical component for language development, students in the current study had to learn the spoken English form of a Dutch word. The EFL PAL task differed from the usual L1 PAL task in two ways. First, since word learning in EFL consists of translation learning, we designed an EFL PAL task in which students learned the spoken English translations of Dutch words. Instead of providing students with a picture and asking them to provide the pronunciation of the word, we provided students with the written Dutch word and asked them to provide the English pronunciation. This verbal PAL task contrasts with the more visual PAL task that has often been used in foreign language aptitude research (Carroll & Sapon, 2002; Li, 2016). Following the results of L1 studies, we expect that performance on this PAL task will contribute in the prediction of the development of vocabulary, reading and spelling.

For exploratory reasons, we also investigated the role of (incidental) orthographic learning. In EFL word learning spoken and written forms of words are often encountered in close proximity or even presented at the same time (Bassetti, 2008; Krepel et al., 2021). Therefore, we also included the written form during learning and measured (incidental) orthographic learning. Moreover, acquisition of the orthography is a notable component of word learning (Perfetti & Hart, 2002), making it of interest to investigate the contribution of orthographic learning. According to the lexical quality hypothesis, spelling and reading require precise phonological representation as well as orthographic representations (Martin-Chang et al., 2014; Perfetti, 2007). Learning both phonological as well as orthographic representations might therefore be important for reading and spelling development. Thus, we provided both the spoken and the written forms of the English words during the PAL task. Orthographic learning was measured by administering a spelling test of the novel words halfway and at the end of the PAL task (e.g., Byrne et al., 2008; Deacon et al., 2019). In L1, orthographic learning has been related to the development of reading and orthographic knowledge (Deacon et al., 2019). Accordingly, we expected that orthographic learning in EFL students will also be related to progress in reading and spelling.

5. Methods

5.1. Participants

A total of 503 Grade 7 students from 18 classes in 7 public schools in the Netherlands completed English proficiency measures in November–December and April–June of Grade 7. Secondary education in the Netherlands has a tracked system with different levels. The sample in the present study consisted of five classes in pre-vocational secondary education (vmbo), five in a combination of higher vocational secondary education and pre-university education (havo-vwo), and six classes in pre-university education (vwo). We excluded 18 students (3.5%) who did not complete all measures at both time points and 30 students who reported to speak English with their parents or caretakers. This resulted in a final sample of 455 students (246 boys, 209 girls), 12 years and 7 months old on average (11–13 years, $SD = 5$ months). Of this sample, 26.5% (118 students) were not native Dutch speakers, of which 35 students did not speak Dutch at home with their parents or caretaker. Of all students, 19 students spoke Turkish with their parents, 36 spoke Moroccan, and 61 students spoke a different language (Spanish, French, Afghan, Arabic, Chinese, German, Egyptian, Armenian, Bosnian, Italian, Kurdish, Tamil). All students were sufficiently proficient in Dutch. As the outcomes of the analyses were unaffected by in- or exclusion of the group of students who were not native Dutch speakers, we report the outcomes of the sample containing this group.

The students were in Grade 7, the onset of formal English education in the Netherlands. Almost all students reported to have some English classes in primary school, mostly starting in Grade 5 (54.6%). Only 7 students reported that they did not have English classes before Grade 7. Participation was voluntary and parents of all students were informed of the study and could refuse participation of their child. The research was conducted in accordance with the ethical principles of the American Psychological Association (2017) as well as The Netherlands Code of Conduct for Scientific Practice issued in 2004 (revised in 2014 by the Association of Universities in the Netherlands). Since this study concerned standard research in an educational setting and the European Union's General Data Protection Regulation (2016) was not yet implemented, adherence to the Code of Scientific Practice sufficed and no approval was required by the Institutional Review Board of the institution.

5.2. Measures

All students completed a test battery consisting of the PAL task, as well as EFL proficiency measures for vocabulary, spelling and reading. The same EFL proficiency measures were administered at Time 1 and Time 2.

5.2.1. Paired-associate learning task

In the PAL task, students were asked to associate 8 word pairs. In contrast to PAL tasks in which students learn the association between a picture and a novel word, each pair consisted of a known Dutch word and its English translation. On each learning trial, students were provided with the Dutch word and had to give the English pronunciation (verbal learning). After each trial, the written form of the English word was given as feedback. We also measured whether students acquired the spellings of the English target words in a dictation task (orthographic learning).

Students were first familiarized with the spoken and written form of each Dutch word and its English translation in two blocks of exposure trials. The exposure trials were followed by up to eight blocks of learning trials, in which students were presented with the Dutch word and had to verbally provide the English word. After the third block of learning trials, the task was interrupted to measure orthographic learning in a dictation task. The learning trials were then resumed. The task ended after a student had translated all eight words correctly in two subsequent blocks of learning trials, or after all eight blocks of learning trials had been completed. After the PAL task, students completed a post-test for verbal learning and orthographic learning to test whether the words associations were retained in memory.

5.2.1.1. PAL target words selection. Target words were selected based on Age of Acquisition (AoA; Brysbaert et al., 2014; Kuperman et al., 2012). To ensure that the students were unfamiliar with the English words, we selected words with an English AoA around the age of the participants (12–13 years). For the English words, we selected a Dutch translation with a Dutch AoA younger than the age of the participants (5–10 years). This way, students were likely unfamiliar with the English words, but did know the Dutch translations. From the words that met these requirements, we selected low-frequency nouns and adjectives that were not cognates (for example, the non-cognate *froth* with its Dutch translation *schuim*). Cognates were excluded (e.g., English *apple* and Dutch *appel*), as the relationship between the L1 word and the foreign word is not arbitrary in these cognates. Half of the words had a consistent spelling in which all graphemes follow the standard grapheme-phoneme rules (based on van Berkel, 2006) (for example, <froth>) and half of the words had an inconsistent spelling (for example, the word <aerie>, in which <ae> is inconsistent as it can be pronounced in different ways;

see Appendix for the full list of words).

5.2.1.2. PAL procedure. The PAL task was administered individually by an experimenter in PowerPoint using a laptop. The task started with two blocks of exposure trials. Each block consisted of eight trials, one trial for each word. Within each block, trials were presented in a random order. In an exposure trial, students were presented with the written form of the Dutch word and its English translation next to each other on-screen for five seconds and the experimenter said the Dutch and English word aloud (for example, "*Schuim means froth*"). The student had to repeat the English word to ensure that students could accurately pronounce the words. If a student's pronunciation was incorrect, the experimenter corrected the student until the student could pronounce the word correctly, but this was rarely the case.

Following the exposure trials, students were presented with up to eight blocks of learning trials. In the learning trials, students were presented with the written Dutch word on-screen for two seconds and then had 15 s to give the English translation. After a correct answer, the experimenter gave students feedback that their answer was correct ("*Indeed / Yes*") and the correct written English word was shown on the screen for two seconds. After an incorrect answer, the experimenter gave feedback about the correct pronunciation ("*No, this is not frop, the correct word is froth*"), and the correct written English word was shown on the screen for two seconds.

After the third block of learning trials, the orthographic learning task was administered (described below). After this intermission, the experimenter continued with the remaining learning trials. Following the PAL task, students performed an unrelated 15-min computer task (Mulder, van de Ven, Segers, Krepel, et al., 2021). Immediately following this distractor task, the experimenters administered a post-test for verbal learning and orthographic learning and the final scores were noted.

5.2.1.3. PAL outcomes

5.2.1.3.1. Verbal learning. The score for verbal learning was calculated using the number of correct learning trials; trials that were not administered after the learning criterion had been reached were assumed to be correct (maximum score = 64). The verbal learning post-test resembled the learning trials: the experimenter said the Dutch word out loud and the student had to provide the English translation. Students did not receive feedback. The number of correctly translated words at post-test was noted as the post-test verbal learning score (maximum score = 8). Due to students' Dutch accent, pronunciations were deemed correct if they were fairly successful attempts at the English pronunciation (for example, <frof> instead of <froth>). In contrast, pronunciations were deemed incorrect if students added or omitted a phoneme of the word (for example, <frop> or < frolth>).

5.2.1.3.2. Orthographic learning. Orthographic learning was measured using a dictation task, which was administered after the third block of learning trials and at post-test. In the dictation task, the experimenter read the English target words out loud, and the student was instructed to provide the correct spellings of these target words. Students did not receive feedback. The number of correctly spelled words was noted as the scores for orthographic learning (maximum score = 8) and orthographic learning at post-test (maximum score = 8).

5.2.2. Vocabulary

A shortened version of the Peabody Picture Vocabulary Test (PPVT), Fourth Edition (Dunn & Dunn, 2007) was used to measure English vocabulary. For the shortened version, we selected 60 items that were used in a classroom setting. The PPVT is normally administered individually and consists of 19 sets of 12 item. We selected every third items from set 1 to set 15 (four items per set). The ensuing selection covers a wide range of vocabulary knowledge, since we expected that participants in our sample would show a large variation in vocabulary knowledge. Previous studies have shown that this selection leads to reliable results (Pasquarella et al., 2011; Sparks & Deacon, 2015; Wang et al., 2013). Students completed items in a booklet with four picture options printed for each item. Students heard the target word (for example "*shoe")* and had to mark the corresponding picture. All answers were scored as correct or incorrect with a maximum score of 60. Cronbach's Alpha of the task was 0.77.

5.2.3. Spelling

English spelling was measured using an English dictation task (developed by van Viersen and de Bree, pc). The dictation task consisted of 20 target words that were embedded in sentences read aloud by the experimenter. The experimenter repeated the target word after each sentence (for example, "*I always receive a postcard on my birthday - receive*"). Students then had to write down the target word. Word length and difficulty of the items increased along the task (ranging from *two* to *mathematician*). The items mostly had irregular spellings, as regular words would likely be too simple for the students. The first 15 words consisted of nouns (*scarf*), adjectives (*quiet)* and conjunctions (*except*) and the last five words consisted of conjugated verbs (*achieved)*. Items were scored as correct or incorrect with a maximum of 20. Cronbach's Alpha of the task was 0.80.

5.2.4. Reading

5.2.4.1. Reading accuracy. Regular and irregular word reading accuracy in English was measured using the Castles & Coltheart 2 Task (Castles et al., 2009). Students read a word list that consisted of 40 regular (e.g., *check*) and 40 irregular (e.g. *cough*) words in the same order as the original test. The regular and irregular words were matched on word length, frequency and grammatical class. The word list was presented in two columns on a sheet of paper. Students had to read the entire list as accurately as they could, and it was emphasized that they did not have to read as quickly as they could. Cronbach's Alpha of the task was 0.78 and 0.75 for regular words and 0.78 and 0.76 for irregular words respectively at Time 1 and Time 2.

Since the students in this study had a Dutch accent in English, their accent was taken into account while scoring the reading tasks. As we are interested in reading accuracy and decoding ability, we aimed to separate decoding errors from systematic articulation errors. To this end, we composed a list of acceptable and unacceptable pronunciations. For example, since the <th> is difficult for Dutch speakers, pronunciation of the word <thunder> (with voiceless *th*) similar to <funder> (with voiceless fricative *f*) was considered acceptable but pronouncing it differently such as <zunder> (with voiced fricative *z*) was considered unacceptable. As per the original guidelines, a decoding error, like pronouncing the word <thunder> as <thunter>, was scored as incorrect.

5.2.4.2. Reading fluency. Subtests of the Test of Word Reading Efficiency second edition (TOWRE, Torgesen, 2012), were used to measure reading fluency in English. Word reading fluency was measured using the Sight Word Efficiency subtest, containing 109 (regular and irregular) words that increase in difficulty (for example, *go*, *horizon*). Pseudoword reading fluency (decoding) was measured using the Phonemic Decoding Efficiency subtest. This subtest consists of 66 pseudowords, which all have a regular pronunciation (for example *pog*, *throbe*). In both subtests, students are instructed to read as many words accurately as possible in a 45 s time-limit. Experimenters scored the pronunciations using the same scoring rules as for the reading accuracy task. For the pseudoword reading task, the first 10 words were all scored as correct. Because these English pseudowords were short words with no obvious English existing word as a counterpart, they were difficult to score. Examples are *pu* or *ku*, which end in *u*, even though there are very few English words that end with this letter. Since we are mainly interested in individual

differences between students, this decision does not impact the findings. The TOWRE subtests have been shown to be reliable, with an internal consistency ranging from 0.86 to 0.97 (Hayward et al., 2008).

5.3. Procedure

Tests were administered in the beginning (November 2016–January 2017) and at the end (April–June 2017) of the schoolyear. The vocabulary and dictation task were administered in a classroom setting with the teacher present. In an individual session in a quiet room, an experimenter administered the PAL task and the reading tasks. Other measures were also administered, as the study was part of a larger project. The classroom session lasted approximately 50 min and the individual session approximately 25 min. All experimenters were trained by the researchers and practiced scoring the reading tasks by scoring at least 2 examples of each reading test and comparing the outcomes with the researcher. Any scoring differences between experimenters were discussed until all experimenters agreed on how the pronunciation should be scored.

5.4. Analysis

Separate regressions were performed to examine the contributions of verbal learning and orthographic learning at Time 1 to development in the vocabulary, reading, and spelling outcomes. In these analyses, we used verbal learning and orthographic learning at the Time 1 to predict variance in the Time 2 outcomes, while controlling for the autoregressive effects in the first step. Verbal learning and orthographic learning were always added in the next steps. These analyses were performed twice. First, we added verbal learning in the third step and orthographic learning in the fourth step; we reversed the order in the second analysis. In this way, we determined whether verbal and orthographic learning had a unique contribution on top of the control variables and the shared contribution of verbal and orthographic learning.

To exclude the possibility that the contributions of PAL are driven by prior vocabulary knowledge, we added vocabulary as an additional control variable in the analyses predicting reading and spelling development. In these analyses, we controlled for the autoregressive effects at Time 1 in the first step and controlled for Vocabulary at T1 in Step 2. Verbal learning and orthographic learning were added as predictors in Step 3 and 4.

6. Results

6.1. Descriptive statistics

Descriptive statistics for all measures at both time points are reported in Table 1. The scores were approximately normally distributed, with all standardized skewness and kurtosis scores under 1.96 (Field, 2009). We found no meaningful differences in EFL proficiency and their interrelationships between the different school levels, so these were analyzed together. A repeated measures MANOVA exploring the mean differences between Time 1 and Time 2 showed that students improved in vocabulary, reading and spelling between these time points, $F(6,444) = 123.420$, $p < .001$, $\eta_p^2 = 0.625$. Verbal learning as measured by the total number of correct learning trials indicated that students made around 13 errors during the task. The mean score on orthographic learning showed that students had learned the spellings of 85% of the words after only five exposures, as the average score was 6.76 out of 8 (see Table 1). The post-test scores were even closer to ceiling. Therefore, only the measures for verbal learning and orthographic learning *during* the PAL task were used for further analysis. Thus, for verbal learning we used the total number of correct learning trials, and for orthographic learning we used the performance on the spelling task that was administered after the third learning trial.

Correlations between the EFL proficiency measures and PAL are reported in Table 2. The intercorrelations among the different EFL proficiency measures were moderate to large (range 0.39 to 0.75) with only a weak correlation between vocabulary and pseudoword reading fluency (0.22 at Time 1 and 0.27 at Time 2). The large correlations between time points of the same measures (0.69 to 0.82) indicate that these EFL proficiency measures were stable over time. Within the PAL task, verbal learning was moderately related to orthographic learning ($r = 0.59$).

The verbal learning outcome from the PAL task correlated moderately with the measures of EFL proficiency at Time 1 (0.38–0.52) and Time 2 (0.35–0.48). Similar correlations with verbal learning were found for orthographic learning and EFL proficiency at Time 1 (0.24 to 0.52) and Time 2 (0.29 to 0.51). There were some small differences. For example, pseudoword reading fluency was more strongly related to orthographic learning (0.46 at T1 and 0.47 at T2) than verbal learning (0.40 at T1 and 0.35 at T2). On the other hand, vocabulary was correlated more strongly with verbal learning (0.38 at T1 and 0.41 at T2) than orthographic learning (0.24 at T1 and 0.29 at T2) and irregular word reading was also correlated more strongly with verbal learning (0.47 at T1 and 0.48 at T2) than orthographic learning (0.37 at T1 and 0.37 at T2). These reported differences were all significant using Fisher's r to z transformations, $p < .05$.

6.2. Contributions of verbal and orthographic learning to the development of EFL

To examine whether PAL at Time 1 contributed to development in EFL proficiency between Time 1 and Time 2, we conducted regression analyses. The results of these analyses are reported in Table 3. In the first analyses we predicted EFL vocabulary at Time 2, after controlling for the autoregressive effects at Time 1 in the first step. In Step 2 and 3 verbal learning and orthographic learning were added in two orders to assess

Table 1
Descriptives of English proficiency and PAL measures at Time 1 and Time 2.

	Variable	Time 1			Time 2		
		M	SD	Range	M	SD	Range
EFL Proficiency	Vocabulary	38.78	5.70	21–57	41.84	5.52	25–56
	Spelling (max 20)	6.32	3.35	0–18	8.08	3.81	1–20
	IRA (max 40)	17.67	4.29	5–32	18.71	4.17	8–32
	RA (max 40)	33.29	4.17	18–40	34.24	3.82	19–40
	WRF (max 108)	60.21	10.09	22–92	64.06	9.04	32–89
	PRF (max 66)	38.59	10.10	12–62	41.89	9.89	15–66
PAL	VL (max 64)	51.95	10.37	15–64	–	–	–
	OL (max 8)	6.76	1.26	2–8	–	–	–
	VLP (max 8)	7.13	1.16	2–8	–	–	–
	OLP (max 8)	6.95	1.11	3–8	–	–	–

IRA = Irregular word Reading Accuracy, RA = Regular word Reading Accuracy, WRF = Word Reading Fluency, PRF = Pseudoword Reading Fluency, VL = Verbal Learning during Task, OL = Orthographic Learning during Task, VLP = Verbal Learning Post-test, OLP = Orthographic Learning Post-test.

Table 2
Correlations for the English proficiency measures at Time 1 and Time 2.

	T1								T2					
	VL	OL	Vocab	Spelling	IRA	RA	WRF	PRF	Vocab	Spelling	IRA	RA	WRF	PRF
T1 VL	–													
T1 OL	0.59	–												
T1 Vocab	0.38	0.24	–											
T1 Spelling	0.48	0.47	0.49	–										
T1 IRA	0.47	0.37	0.50	0.59	–									
T1 RA	0.52	0.52	0.39	0.56	0.62	–								
T1 WRF	0.49	0.46	0.42	0.55	0.57	0.64	–							
T1 PRF	0.40	0.46	0.22	0.43	0.43	0.64	0.71	–						
T2 Vocab	0.41	0.29	0.69	0.56	0.60	0.44	0.46	0.28	–					
T2 Spelling	0.47	0.51	0.53	0.81	0.60	0.59	0.59	0.47	0.58	–				
T2 IRA	0.48	0.37	0.57	0.62	0.69	0.55	0.52	0.33	0.59	0.66	–			
T2 RA	0.48	0.45	0.42	0.53	0.52	0.72	0.58	0.52	0.45	0.60	0.62	–		
T2 WRF	0.43	0.43	0.43	0.57	0.49	0.55	0.82	0.66	0.46	0.61	0.57	0.61	–	
T2 PRF	0.35	0.47	0.23	0.41	0.40	0.59	0.68	0.77	0.27	0.48	0.44	0.60	0.75	–

VL = Verbal Learning during Task, OL = Orthographic Learning during Task, Vocab = Vocabulary, IRA = Irregular word Reading Accuracy, RA = Regular word Reading Accuracy, WRF = Word Reading Fluency, PRF = Pseudoword Reading Fluency. All correlations are significant at $p < .001$.

Table 3
Longitudinal regressions predicting English proficiency at T2 from the PAL task at T1.

Step	Variable Added	Vocabulary		Irregular Reading Accuracy		Regular Reading Accuracy		Word Fluency		Pseudoword Fluency		Spelling	
		% ΔR^2	β	% ΔR^2	B	% ΔR^2	B	% ΔR^2	β	% ΔR^2	β	% ΔR^2	β
1	Autoregressor	47.6**	0.62**	47.9**	0.48**	51.2**	0.58**	67.9**	0.76**	59.4**	0.70**	65.8**	0.66**
2	Vocabulary	–	–	6.6**	0.27	0.2**	0.14**	0.9**	0.10*	0.4*	0.06*	2.1**	0.16**
3	Verbal Learning	2.8**	0.16**	1.7**	0.11**	0.9**	0.09*	0.0	−0.03	0.1	−0.05	0.4*	0.01
4	Orthographic Learning	0.1	0.04	0.3	0.06	0.0	0.06	0.3*	0.07*	1.5**	0.16**	1.4**	0.15**
3	Orthographic Learning	1.5**	0.04	1.2**		0.7*	0.06	0.2	0.07*	1.4**	0.16**	1.8**	0.15**
4	Verbal Learning	1.4**	0.16**	0.7*		0.4*	0.09*	00	−0.03	0.1	−0.05	0.0	0.01
	Total R^2	50.4		56.4		54.6		69.0		61.4		69.6	

Final β corresponds to the predictor in the complete model.
* $p < .05$.
** $p < .01$.

their unique contributions. In the regression analyses of reading and spelling development, we added the autoregressive effects and vocabulary at Time 1 in Step 1 and 2. The predictors verbal learning and orthographic learning were added in Step 3 and 4.

6.2.1. Vocabulary

Verbal learning in the PAL task significantly predicted vocabulary development. After controlling for the autoregressive effect of vocabulary at Time 1 in the first step (47.6%), verbal learning contributed 2.8% to vocabulary at Time 2. Orthographic learning did not contribute significantly to vocabulary development when it was added after verbal learning. However, when orthographic learning was added in the second step, it significantly predicted 1.5% of variance of vocabulary at Time 2. Beyond the contribution of orthographic learning in the second step, verbal learning uniquely contributed 1.4% in the third step.

6.2.2. Reading

Reading development was examined in separate regression analyses for each reading measure. When predicting irregular word reading accuracy at Time 2, the analysis showed that beyond the autoregressive effect (which explained 47.9%) and the effect of vocabulary (which explained 6.6%), verbal learning contributed 1.7% to irregular word reading accuracy at Time 2. Orthographic learning did not contribute any further unique variance in the fourth step. When orthographic learning was added before verbal learning in the third step, it contributed 1.2% and verbal learning subsequently contributed 0.7% in the third step. Since orthographic learning was not significant if it was added in the fourth step after verbal learning, this means that the explained variance of orthographic learning was entirely accounted for by verbal learning.

When predicting regular word reading accuracy at Time 2, the autoregressive effect explained 51.2% and vocabulary explained 0.2% of variance. Additionally, verbal learning contributed 0.9% to regular word reading development whereas orthographic learning did not have a significant contribution beyond verbal learning. When orthographic learning was added in Step 3, it explained 0.7% of variance with verbal learning contributing 0.4% on top of that in Step 4.

Verbal and orthographic learning hardly predicted variance in Time 2 word reading fluency. After controlling for the large autoregressive effect (which explained 67.5% of variance) and the effect of vocabulary (which explained 0.9%), only orthographic learning made a tiny but significant contribution to fluency development (0.3%). Verbal learning did not contribute to Time 2 word reading fluency at all beyond the autoregressive effect.

In comparison to word reading fluency, verbal and orthographic learning during the PAL task contributed substantially more to pseudoword reading fluency at Time 2. After the autoregressive effect, explaining 59.4%, and vocabulary, explaining 0.4%, verbal learning did not contribute to pseudoword reading fluency. However, orthographic learning contributed 1.5% to pseudoword reading fluency beyond the non-significant contribution of verbal learning. When orthographic learning was added in the second step before orthographic learning, it contributed 1.4% to pseudoword reading fluency, after controlling for the autoregressive effect.

Taking all reading measures together, mainly verbal learning contributed to development in reading accuracy, since orthographic learning did not contribute to reading accuracy independently from verbal learning. In contrast, orthographic learning did contribute to development in pseudoword reading fluency, whereas verbal learning did not. Verbal and orthographic learning did not predict the

development of word reading fluency.

6.2.3. Spelling

As expected, PAL verbal and orthographic learning made significant, albeit small, contributions in the prediction of spelling development. After controlling for the autoregressive effect (65.8%) and vocabulary (2.1%), verbal learning contributed 0.4% to spelling at Time 2. Orthographic learning subsequently contributed 1.4% beyond the contribution of verbal learning. When orthographic learning was added in the second step before verbal learning, it explained 1.8% variance of spelling development and the contribution of verbal learning in Step 4 was not significant. The finding that verbal learning did not contribute to spelling development after controlling for orthographic learning indicates that the additionally explained variance of PAL in spelling development is mainly due to orthographic learning.

7. Discussion

The present study aimed to establish whether verbal and orthographic learning during a PAL task contribute to the prediction of EFL development in vocabulary, reading and spelling. In the PAL task, we assessed verbal learning by measuring how quickly students learned the English translations of Dutch words. Because of the relevance of orthographic learning in EFL, we also measured orthographic learning during the PAL task. Our main findings are that verbal learning uniquely contributed to the prediction of vocabulary and reading accuracy development, whereas orthographic learning added to the prediction of spelling and pseudoword reading fluency development. Below, we will consider the relation of verbal and orthographic learning to vocabulary, reading, and spelling in more detail.

7.1. PAL as a predictor of vocabulary

Regarding EFL vocabulary, verbal learning was related to vocabulary concurrently and contributed to the prediction of vocabulary growth, in line with results in L1 studies (e.g., Gellert & Elbro, 2013). The verbal learning component appeared crucial in the relationship between PAL and vocabulary, since orthographic learning did not contribute to the prediction of vocabulary growth. In previous foreign language studies, PAL was not found to be related to vocabulary growth (Li, 2016). This is likely due to the fact that, in those studies, the PAL task lacked a verbal response. Our findings show that, if verbal learning is included, PAL does predict vocabulary growth in foreign language vocabulary. These outcomes are comparable to L1 (Gellert & Elbro, 2013).

The PAL task used in the (L1) study by Gellert and Elbro (2013) was somewhat different from our PAL task, as in our study students learned the English translation for a known-word, instead of learning the pronunciation of a nonword in relation to a picture. Although there is a possibility that students were already familiar with the words, this seems unlikely given the low frequency and difficulty of the words. The PAL task in the current study thus requires verbal learning, which has been shown to be the crucial component in visual-verbal and verbal-verbal paired associate learning (Litt, Wang, Sailah, Badcock, & Castles, 2019; Litt & Nation, 2014).

7.2. PAL as a predictor of reading

We found that verbal learning was related to reading concurrently, as well as reading development over time, in line with several other studies (Clayton et al., 2018; Litt et al., 2013; Litt & Nation, 2014). However, orthographic learning did not contribute uniquely to reading development, which was somewhat unexpected since orthographic knowledge is deemed to be important for reading. With the exception of pseudoword reading, we found that only verbal learning uniquely predicted reading. These results match the conclusion of experimental studies that verbal learning is critical in the L1 PAL-reading relationship (Litt, Wang, Sailah, Badcock, & Castles, 2019; Litt & Nation, 2014).

This is one of the few studies in which PAL and reading are investigated in a longitudinal design. Previous results have been mixed: verbal learning was not found to be predictive of reading development in relatively transparent Norwegian (Lervåg et al., 2009), but it was in relatively opaque Chinese (Georgiou et al., 2017). In agreement with the hypothesis that verbal learning is mainly predictive of reading development in more opaque orthographies (Lervåg et al., 2009), we found that verbal learning contributed to the prediction of reading development in the opaque English orthography. We found a similar pattern *within* English word reading, as verbal learning contributed more to reading opaque (irregular) words than reading regular words.

Previous studies have shown that verbal learning mainly contributes to reading accuracy rather than speed (Poulsen & Elbro, 2018). This is also reflected in our findings, since verbal learning did not contribute to prediction in word reading fluency. Improvement in word reading fluency between Times 1 and 2 mainly concerned faster reading speed (average words read increased from 67.09 to 70.84), as word reading accuracy remained stable (average percentage of errors decreased from 10.27% to 9.57%). The change in word reading fluency therefore reflects increases in retrieval speed, given that the pronunciations are known. Since verbal learning concerns learning novel pronunciations, verbal learning would primarily relate to whether a reader can correctly pronounce a word or not. In line with this view, verbal learning contributed to word reading accuracy but not to word reading fluency.

Verbal learning did not contribute to pseudoword reading fluency. Similar to word reading fluency, progress in pseudoword reading fluency mainly concerned reading speed instead of reading accuracy. Additionally, students do not possess phonological representations of pseudowords in their memory, meaning that recall of verbal information does not benefit reading these pseudowords. Unexpectedly, orthographic learning did contribute to pseudoword reading fluency. This speaks to results of Byrne et al. (2008), who found that pseudoword reading and orthographic learning loaded on the same factor, together with spelling achievement. They hypothesized that this common factor reflects orthographic learning rate, and that pseudoword reading and spelling achievement are the product of orthographic learning. Byrne et al. (2008) take orthographic learning to relate to pseudoword reading because orthographic learning reflects the responsiveness to learning opportunities. For example, orthographic learning taps into the ability to learn orthographic patterns, a skill that is also involved in pseudoword reading.

7.3. PAL as a predictor of spelling

Orthographic learning contributed to the prediction of development in orthographic knowledge, as measured in the spelling task. Students that were proficient in orthographic learning likely acquired more orthographic knowledge throughout the year, which was reflected in increased spelling gains. This finding is consistent with previous results on orthographic learning (Byrne et al., 2008; Deacon et al., 2019). Verbal learning also contributed to spelling growth, similar to previous L1 findings (Nielsen & Juul, 2016), but this was merely due to the overlap between verbal learning and orthographic learning, as orthographic learning accounted entirely for the contribution of verbal learning. Verbal learning reflects learning novel pronunciations. This is not required in a spelling task, as the pronunciation in a spelling task is provided by the experimenter. Therefore, verbal learning did not uniquely contribute to prediction in spelling development. Overall, we find that learning tasks can predict development better if the type of learning matches the output of the task.

7.4. Modest contributions of PAL to EFL development

The contributions of the PAL task to the prediction of EFL development were relatively small, although of a comparable size relative to the

time duration as in previous studies. For example, in the study of Gellert and Elbro (2013) the number of correct learning trials in the PAL task contributed 6% to vocabulary growth over 9 months, while in our study, PAL contributed 3% to vocabulary growth over 5 months. The modest contributions are related to two assumptions underlying the advantages of language learning aptitude tests. First, it is assumed that the PAL task is a 'pure' measure of learning aptitude that is independent from previous exposure to English (Li, 2016). This is not necessarily the case, as previous studies have shown that prior orthographic knowledge and vocabulary knowledge are associated with both verbal learning (Masoura & Gathercole, 2005) and orthographic learning of new words (Cunningham et al., 2002; Wang et al., 2013). Verbal and orthographic learning might therefore not just be an indication of learning aptitude, but also of previous English exposure, lowering the potential value of the PAL task in predicting development over and beyond prior knowledge. However, in the current study, we controlled for prior vocabulary knowledge in the analyses and found that the PAL task was only moderately correlated with EFL proficiency, indicating that the measure was relatively independent from previous exposure.

A second, and likely more important assumption related to contributions of learning aptitude is that individual differences due to exposure are assumed to be larger at the beginning of the school year than at the end of the school year. We expected that at the start of Grade 7, individual differences would be substantial due to differences in prior exposure. These individual differences would decrease once all students follow the same English curriculum. The decrease of individual differences could lead to an increase of the contribution of language learning aptitude to language development. Subsequently, the association between aptitude tests and proficiency would become stronger. However, our findings show that the proficiency measures were very stable over time, meaning that the individual differences due to exposure in EFL proficiency might have persisted. Overall, considering the small predictive value of PAL, using a PAL task to determine a student's (short-term) learning trajectory is not of much practical value. Nevertheless, it is notable that significant contributions were found at all, as they do shed light on the role of verbal learning and orthographic learning in vocabulary acquisition and development in reading and spelling skills in EFL.

It is important (but difficult) to identify which aspects of PAL are the driving force for EFL development. Verbal learning measured in this PAL task can be considered a multifaceted skill as it concerns acquiring, storing and retrieving associations between verbal (phonological) stimuli. PAL has also been found to be related to other skills, such as verbal short-term memory and phonological awareness (Gathercole, 2006; Litt et al., 2013). In turn, both phonological awareness and verbal short-term memory are important predictors for reading development, with effects of verbal memory being subsumed in phonological awareness and being less important for reading than phonological awareness (de Jong & van der Leij, 1999). Especially in opaque languages such as English, phonological awareness is related to reading development (Landerl et al., 2019; Ziegler et al., 2010). It is therefore conceivable that the additional contribution of PAL to reading development might be accounted for by the role of phonological awareness and/or the role of verbal short-term memory.

We did not include measures of phonological awareness and verbal short-term memory. However, it seems unlikely that phonological awareness and verbal short-term memory fully account for the contributions of PAL to language development. First, studies that have simultaneously included measures for PAL, phonological awareness and verbal short-term memory have shown that PAL contributes to reading independently from both phonological awareness (Litt et al., 2013; Warmington & Hulme, 2012), as well as verbal short-term memory (Mourgues et al., 2016; Windfuhr & Snowling, 2001). Furthermore, for more advanced EFL learners verbal short-term memory has been found to be unrelated to PAL (Masoura & Gathercole, 2005). Finally, studies have shown that phonological awareness and verbal short-term memory do not contribute to reading and spelling development, especially in more advanced readers, once autoregressive effects are taken into account (de Jong & van der Leij, 1999; Lervåg et al., 2009). We controlled for autoregressive effects and still found a limited contribution of PAL to literacy. Overall, our findings seem to indicate that the contributing factor to reading is a process in PAL that is distinct from phonological awareness and verbal short-term memory. This cognitive process likely entails storing and retrieving new verbal information in long-term memory, rather than manipulating sound units in spoken words or keeping verbal information in short-term memory.

7.5. Limitations

A limitation of the current study concerns the fact it was carried out in a specific sample with a specific L1 and a specific foreign language. Predictors of reading acquisition in a foreign language vary depending on the features of the foreign language: In a study investigating L1 Dutch students learning different foreign languages, Zeguers et al. (2018) showed that predictors for foreign language reading development differed depending on whether the foreign language is alphabetic or non-alphabetic and whether the orthography is transparent or opaque. Furthermore, not just features of the foreign language, but also features of the first language affect reading in a foreign language, as students apply their knowledge of L1 orthography and phonology rules while learning to read in a foreign language. Depending on the combination of the languages this can be either beneficial or detrimental (Bassetti, 2008; Figueredo, 2006). Therefore, overlap between these languages can affect the outcomes. For example, despite differences in orthographic opacity between Dutch and English, there are also similarities. A word in the PAL task such as "*starling*" can be decoded to the correct English pronunciation using both English or Dutch grapheme-phoneme rules. This orthographic overlap between Dutch and English might partly explain why the findings from this study are similar to L1 studies. Whether similar patterns would be found for Dutch students learning a non-alphabetic language like Chinese is unclear, as Chinese orthography is processed differently than an alphabetic orthography (Wang et al., 2003). Such differences in orthographic processing might relates differently to reading and spelling outcomes. Extending the current findings in future research using different type of languages is therefore warranted.

7.6. Conclusion

Overall, the current study demonstrated that PAL contributes to the prediction of development in vocabulary, reading and spelling in Dutch students learning EFL. Similar to previous L1 studies, we found that especially verbal learning was a unique predictor for vocabulary and reading. The unique contribution of orthographic learning was limited to growth in spelling and pseudoword reading, with the latter taken to be part of the same factor as orthographic learning. Together, our findings show that verbal learning is of importance for vocabulary and reading in opaque English orthography, whereas orthographic learning is important for specifically spelling development. Individual differences in word learning aptitude have a small contribution in predicting EFL development.

Declaration of competing interest

None.

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Appendix A. Word characteristics for the paired associate learning task

Word	Dutch translation	Inconsistent graphemes*	Frequency per Million	English AoA	Dutch AoA
Pretest					
aerie	nest	<ae>	0.04	13.00	5.94
budgie	parkiet	<dg> <ie>	0.04	12.90	6.93
haughty	arrogant	<aught>	0.18	12.93	10.59
boon	zegen	<oo>	1.24	12.84	8.66
humdrum	alledaags	–	0.02	12.89	9.17
tempest	storm	–	0.04	12.88	6.46
pith	kern	–	1.22	12.83	9.93
starling	spreeuw	–	0.67	13.00	8.82

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