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Testing the predictive power of executive functions, motivation, and input on second language vocabulary acquisition: a prospective study

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Abstract
This longitudinal study assessed the relative importance of second language exposure, motivational and attitudinal factors, and executive functions in predicting receptive vocabulary acquisition in children and adolescents after controlling for background characteristics (socio-economic status, non-verbal intelligence) and prior knowledge. The sample comprised 721 participants from French-speaking Belgium: 369 fifth-graders from 13 elementary schools and 352 eleventh-graders from 9 secondary schools. The background, input, and socio-affective data were obtained through questionnaires, the cognitive and language data through a round of computerized data collection, twice with an 18-month interval. While some input and motivational variables were predictive of vocabulary acquisition when analyzed separately, most of them lost significance once combined. Measures of executive functions were not related to vocabulary acquisition. Classroom input was predictive among children and adolescents, but other age-related differences emerged. The findings call for caution regarding the separate treatment of factors believed to be involved in second-language acquisition.

Keywords Foreign-language acquisition · Executive functions · Motivation · Input

Introduction

Attaining proficiency in a second language can greatly benefit speakers' social, academic, and/or professional lives. Trying to understand how proficiency in foreign languages develops, researchers have developed and tested a wide range of models, often including factors related to various types of target language input and exposure, to the learners' motivation,

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or, to a lesser extent, to cognitive skills such as executive functions (e.g., Ellis, 2008; Mitchell et al., 2013; Ortega, 2009). As such, these studies on second language acquisition (SLA) mirror studies in other fields of education which have shed light on how contextual, motivational, and cognitive variables interact and collectively inform academic achievement (Bransford et al., 2000; Lu et al., 2011; Veas et al., 2018). However, many SLA studies, often for practical reasons, focus on only one of these aspects, and few adopt a longitudinal approach. The present study therefore investigated gains in (Dutch or English) target language receptive vocabulary acquisition in a sample of children and adolescents in French-speaking Belgium, identifying the contribution of three types of variables (input and exposure, motivational and attitudinal variables, and executive functions) and controlling for selection effects such as prior achievement or socio-economic background. Additionally, the presence of two age cohorts (5/6th grade and 11/12th grade) allowed us to probe into age-related educational and acquisitional differences. If our focus on receptive vocabulary may seem rather specific, it should be mentioned that vocabulary size is not only regarded as an important predictor of academic achievement and literacy acquisition in general (see Bialystok et al., 2010, for references), but, with respect to second or foreign language learning, there is also clear evidence that vocabulary knowledge, and vocabulary size in particular, is linked to proficiency in various language skills and a "major contributor to success in language performance" (Milton, 2013, p. 72; Miralpeix & Muñoz, 2018).

Input and exposure

The role of exposure to and interaction with the target language, both in formal and informal contexts, is forwarded as an important factor promoting language learning in second language acquisition theories such as the input hypothesis (Krashen, 1985) and the interaction hypothesis (Long, 1996; Mackey, 1999). The amount and quality of target language input learners experience in and outside the classroom have therefore been a point of interest among SLA scholars for a while now, and the intensity of exposure to the target language has been found to be an important correlate of proficiency outcomes (e.g., Lambelet & Berthele, 2015; Moyer, 2009; Muñoz, 2008, 2011; Sundqvist & Wikström, 2015; Torras & Celaya, 2001).

Studies show that contact with target language speakers positively informs L2 learning achievement, and they suggest this is particularly the case in informal rather than formal contexts (e.g., Kinsella, 2009; Moyer, 2009). Outside school exposure to the target language on the internet or television can also prove to be advantageous (De Wilde et al., 2020, 2021; Peters et al., 2019). For instance, in a study comprising 865 10/11-year-olds from seven European countries, Lindgren and Muñoz (2013) found outside school L2 exposure to be associated with performance on English listening and reading tests. Sundqvist (2009) also found that the English oral proficiency and particularly vocabulary knowledge of adolescents (age 15/16) in Sweden were positively associated with exposure outside the classroom. Overall, the respective contribution of formal and informal exposure is not clear, as much depends on the learning context, although we do know that adolescent learners appear to profit more from informal exposure than younger learners (Peters et al., 2019). Surprisingly, very few longitudinal studies have investigated the contribution of target language input or exposure beyond the effect of initial L2 mastery. Certainly, some level of input is needed to learn a second language, but the associations observed in cross-sectional studies could also reflect

the fact that a higher level of L2 proficiency leads to easier and more frequent exposure to L2 or that both exposure and proficiency are associated with a third causal variable, for instance, motivation or attitude.

Motivational and attitudinal factors

The role of motivation in student learning and achievement has been studied extensively (e.g., Barron & Hulleman, 2015; Olivier, Archambault, De Clercq & Galand, 2019; Wigfield & Cambria, 2010), and motivation is also considered an influential individual variable in second language learning (Dörnyei & Ryan, 2015). Expectancy-value theory, a prominent motivational model in educational psychology, posits that individuals' beliefs about how well they will perform a task (expectancy for success) and the extent to which they value the task at hand (perceived task value, including interest, importance, and utility) are good predictors of achievement and persistence (Jiang et al., 2018; Wigfield & Eccles, 2000). The model also includes an additional but less studied component, namely perceived cost, referring to the amount of effort needed to succeed, the loss of time and energy for other valued activities, and the psychological cost of failure (Barron & Hulleman, 2015; Jiang et al., 2018).

If learning a L2 in an educational setting shares many features with learning any other school subject, it also differs in terms of its socio-cultural dimension. The L2 motivational research tradition thus differs somewhat from motivational research more generally, in that the attitude toward (or identification with) the target language and the target language community are also considered determinant, whether as part of an integrative motive (in the socio-educational model, Gardner, 1985) or as co-formative of the ideal L2 self (in the L2 Motivational Self-System, Dörnyei, 2005, 2009). Indeed, several studies found that L2 proficiency is associated with various motivational constructs (e.g., Clément et al., 1994; Joe et al., 2017; Masgoret & Gardner, 2003; Pae, 2008). However, most studies on motivational and attitudinal factors in SLA are cross-sectional, and consequently do not provide evidence of the direction of the effects or of the contribution of those factors on L2 proficiency improvement. Moreover, they do not routinely consider the potentially confounding effects of differences in input/exposure or executive functions nor do they usually control for prior achievement (Joe et al., 2017).

Executive functions

Executive functions refer to cognitive processes "needed to control thoughts, behavior, and emotions" (Vandenbroucke et al., 2017, p. 103) and are generally considered to belong to three categories (Miyake et al., 2000): inhibition, cognitive flexibility, and (verbal and non-verbal) working memory. These functions emerge and develop early in life and form the foundation for complex cognitive functions such as planning and organizing (Diamond, 2013; Garon et al., 2008; Zelazo & Carlson, 2012). Several longitudinal investigations have shown the importance of cognitive abilities, including executive skills, in general school achievement (e.g., Alloway & Alloway, 2010; Monette et al., 2011; Welsh et al., 2010), but less research has been conducted to investigate predictive relations between these skills and L2 development (Nicolay & Poncelet, 2013a). Indeed, most research on the relationship between executive functions and bilingualism has looked at the potential cognitive benefits of being bilingual, and not

the other way around. For instance, it is suggested that bilinguals could have enhanced inhibition skills because, since both languages are simultaneously activated, bilinguals have to constantly inhibit the language that they are not using (cf. Green's (1998) model of inhibitory control). If this cognitive advantage has been found in a range of contexts and among different populations (Bialystok et al., 2012), more recently studies found no marked advantages for bilinguals and/or L2 learners (Paap & Greenberg, 2013; Paap et al., 2015; for a review, see Lehtonen et al., 2018). Possibly, variables such as age, stage of acquisition, or type of setting (with an impact on the opportunity for interaction, the amount of input, the frequency of switching) may explain the differential results (Goriot et al., 2018a).

Findings from the scarce literature available on the predictive relations between executive functions and L2 vocabulary development provide mixed evidence for the existence of such relationship in young children. In a longitudinal study with a group of 5-year-olds ($n = 61$), Nicolay and Poncelet (2013a) found that flexibility, but not inhibition, appeared to play a significant role in L2 vocabulary development, whereas in Woumans et al.'s (2018) longitudinal study, measures of inhibitory control were predictive of L2 vocabulary acquisition among a group of 47 pre-schoolers. However, whether these effects can be found in larger samples and among older student populations remains a question (Simonis et al., 2019). It is also possible that L2 learners require different types of cognitive functions in later stages of L2 acquisition compared to the earlier stages. Nicolay and Poncelet (2013a, b), for instance, suggest that interference inhibition, which refers to the ability to suppress interference of irrelevant information, rather than response inhibition, which refers to the ability to inhibit prepotent responses, is more likely to become important as L2 proficiency grows (see also Friedman & Miyake, 2004). Moreover, studies on executive functions usually do not consider the role of socio-affective variables like motivation and attitude.

Research questions

It should be clear from the review of the studies discussed above that the different categories of factors (input and exposure, motivational and attitudinal factors, and executive functions) can potentially influence second-language acquisition to some extent. However, we can also discern a number of limitations among these studies: most studies involve a relatively small group of participants, few of them adopt a longitudinal approach, and, to our knowledge, no study has looked into the predictive value of the different categories when combined.

This overreliance on small samples, cross-sectional designs, and isolated approach is problematic both for our understanding of L2 vocabulary acquisition and for educational interventions. Studies with small samples tend to find larger effect sizes than studies with larger, more representative, samples (Cheung & Slavin, 2016). To assess the specific contribution of a category of variables (e.g., L2 motivation) to an outcome (e.g., L2 proficiency), it is also important to control for other known predictors of the outcome. For instance, past performance or achievement is often the best predictor of further performance or achievement (Tricot & Sweller, 2014), so associations observed in studies that failed to take previous knowledge into account risk to be spurious. Moreover, potential predictors like input and exposure, motivation and attitude, and executive functions can be intertwined (Pessoa, 2009). Studying them separately does not help us to disentangle their interrelations and their respective contribution to L2 learning: the effects of some factors could be additive, the effect of other could

be mediated, and the effects of still other ones could be spurious. These knowledge gaps can also have practical implications, leading to the investment of scarce resources into interventions that target some variables identified as potential predictors. Unfortunately, even when these interventions manage to impact the targeted variable, it is not sure at all that they really improve learning (Guay et al., 2016; Melby-Lervåg et al., 2016).

Therefore, we conducted a prospective study with two measurement points and a large sample from two age cohorts (5th/6th grade and 11th/12th grade). Our aim was to assess the relative importance of L2 exposure, motivation and attitude toward L2, and executive functions in predicting L2 receptive vocabulary acquisition, and the research questions were as follows:

- What is the contribution of each category of factors (input and exposure, motivational and attitudinal factors, and executive functions) on L2 receptive vocabulary acquisition when considered separately?
- What is their direct contribution when all categories of factors are considered together?
- Can we discern any age-related differences in the predictors? In other words, are the results different for contrasted age cohorts (5th/6th grade and 11th/12th grade)?

In order to properly test the contribution of the factors under scrutiny, we also controlled for a number of background variables that are often mentioned in the literature as being possibly related to one of the (dependent or independent) variables that we used, namely gender, non-verbal intelligence, socio-economic status, grade retention, bilingualism at home, and L1 vocabulary knowledge (Buckingham et al., 2013; Goriot et al., 2018b; Hoff, 2006; Jaekel et al., 2017; Lehtonen et al., 2018).

Method

Sample and procedure

The sample comprised 721 participants from 22 schools in French-speaking Belgium: 369 fifth-graders from 13 elementary schools (51.7% girls; M_{age} = 10.5, SD_{age} = .49) and 352 eleventh-graders from 9 academic-track secondary schools (53.4% girls; M_{age} = 16.5, SD_{age} = .61). Most of the children were born in Belgium (92.3%). In French-speaking Belgian schools, mandatory second language courses start in grade 5 and extend to grade 12 in academic track (Mettewie & Van Mensel, 2020).

The data were collected in October 2015 (Time 1) and April 2017 (Time 2). The Time 1 data collection was conducted in two phases: (a) the background, input, and socio-affective data were obtained through a student questionnaire administered in schools by research assistants during regular school hours and, for some background variables, through a parent questionnaire which was distributed via schools; (b) the language data and the cognitive data were obtained through a round of computerized data collection which took place in the university computer rooms and was supervised by the researchers. The Time 2 language data collection was also computerized and took place in university computer rooms. Student participation in the project was voluntary; written consent was obtained from parents and students, after approval by the ethics committee of our department.

Instruments

Receptive target language vocabulary

The elementary and secondary students' target language receptive vocabulary was measured through a computerized version of the Peabody Picture Vocabulary Test for English (PPVT-IV; Dunn, Dunn, & Pearson Assessments, 2007) and the Dutch version of the same test (PPVT-NL-III; Dunn & Dunn, 2005). The PPVT is a standardized task consisting of a series of four-picture sets from which the participants need to select the drawing corresponding to a word they hear; the score consists of the number of correct answers identified. The task is frequently used to assess receptive vocabulary gains (see Goriot et al., 2018b, for references, as well as for an evaluation of the suitability of using the PPVT for these purposes). In our study, the raw scores—and not the age-based norm scores as they only apply to L1 speakers—were transformed into standardized scores for each target language (English or Dutch) separately. Those standardized scores were then used in subsequent analyses combining both target languages.

Executive functions

The students' executive functions were measured with three variables: mental flexibility, and two indicators of inhibitory control, response inhibition and interference inhibition, the latter in order to test Nicolay and Poncelet's (2013a, b) suggestion that interference inhibition may become more important than response inhibition as proficiency grows. The tasks we used are well-established and widely used in the literature (Simonis et al., 2019). Flexibility was assessed with the Dimensional Change Card Sort task (DCCS), which measures task shifting. The students completed a computerized version of this task adapted from Zelazo (2006) and Bialystok and Martin (2004), and the score that we retained for our analyses is the switching cost score, which reflects the difficulty to switch between different sorting rules, hence mental flexibility. Response inhibition, the ability to inhibit prepotent responses, was measured with a computerized version of the Simon task, adapted from Simon and Rudell (1967), and interference inhibition, the ability to suppress interference of irrelevant information, was measured with an Attention Network Task (ANT), adapted from Fan et al. (2002). For a detailed description of tasks and testing procedures, see Simonis et al. (2019). With respect to the reliability of the tasks, we should note that the expected markers of executive control were observed (switching and mixing cost for the DCCS; congruency and Gratton effects for the Simon task; congruency, alerting, and orienting effects for the ANT; cf. Simonis et al., 2019).

Motivational and attitudinal variables

The student questionnaire measuring the motivational and attitudinal aspects was written in French (De Smet et al., 2019). The students' target language learning motivation was measured based on the expectancy-value model (Wigfield & Eccles, 2000). The scales we used, based on existing validated adaptations in French (Galand & Hospel, 2015), were expectancy for success (five items, $\alpha = .76$, e.g., "I know I am able to learn Dutch/English if I really want it"), perceived task value (eight items, $\alpha = .85$, e.g., "I would like to learn more Dutch/English"), and cost (three items, $\alpha = .71$, e.g., "Learning Dutch/English hampers me

from doing too many other things that I like"). Responses were given on a 7-point Likert scale, ranging from strongly disagree (1) to strongly agree (7). The attitudes toward the target languages as such were measured through two constructs: perceived easiness of the target language (six items, $\alpha = .83$, e.g., "Dutch/English is a language which is difficult/easy to understand") and perceived attractiveness of the target language (three items, $\alpha = .88$, e.g., "Dutch/English is an ugly/beautiful language"). These items, based on Mettewie (2004), were formulated as semantic differentials, ranging from 1 (the negative end) to 7 (the positive end).

Input variables

In order to address possible differences related to the students' target language input, two different variables were applied in our analyses. The first variable is a construct measuring the frequency of informal contact with the target language outside school (four items, $\alpha = .78$, e.g., "How often do you hear Dutch/English outside school"), with responses on a scale from 1 (never) to 5 (very often). The second variable measures the frequency of target language use by the language teacher in the foreign language class, as reported by pupils (3 items, $\alpha = .83$, e.g., "The teacher provides instructions in Dutch/English," responses on a scale ranging from 1 (never) to 6 (always)). Exploratory factorial analysis supported the repartition of the items into these two scales.

Control variables/background characteristics

We included the following background variables in our analyses: gender; the highest level of education of the mother as a proxy for socio-economic status (SES, cf. Duru-Bellat, 2015), subdivided in three categories (low (primary and secondary school), medium (higher education outside university), and high (university degree)); grade retention, measured by whether a student has never had to repeat a school year or not; home language, referring to whether the student has (an)other language(s) than French as a home language; the pupils' non-verbal intelligence, measured through a computerized version of the Raven's Standard Progressive Matrices (Raven et al., 1998); and the L1 (French) vocabulary knowledge, measured through a computerized version of EVIP, the French version of the Peabody vocabulary test (Dunn et al., 1993).

Analyses

Students speaking only Dutch/English at home ($N = 61$) were discarded from the analyses. The analyses reported on in this article were conducted in SPSS 25. All analyses were conducted separately for the elementary and secondary student cohort.

In order to identify the factors that contribute to gains in L2 vocabulary knowledge, we conducted our analyses in different steps. In a first step, we calculated correlations between all selected variables and outcome variables in each cohort. The second step consisted of a set of multiple regression analyses for each set of variables separately (models 1 to 4), with Time 2 target language receptive vocabulary as the dependent variable, controlling for Time 1 achievement. Only those variables which contributed significantly to target language development in this intermediary step, either in the primary or secondary cohort, were then retained for a final model (model 5). Preliminary analyses including target language (Dutch vs. English) as a control variable (besides prior

achievement) showed that it had no significant effect in our models and that its inclusion did not change any results. Consequently, we dropped if from subsequent analyses for the sake of parsimony.

Results

Correlations

Table 1 shows the correlations between the various predictor variables and the outcome variables (the correlations between the predictor variables are provided in Table 4 in the Appendix). The following predictors are significantly correlated with L2 vocabulary knowledge at Time 2 (end of 6th/12th grade): prior achievement (beginning of 5th/11th grade), the control variables except gender and home language, both input variables, and most motivational/attitudinal variables. None of the variables measuring executive functions are significantly associated with the Time 2 outcomes. Overall, few differences can be observed between the two age groups, although most associations with motivational variables are clearly lower in the primary school sample.

Regression analyses

Tables 2 and 3 display the regression coefficients for each of the outcome variables, first per independent variable group separately (models 1 to 4, cf. RQ1) including prior achievement (model 0). Significant predictors from these models were then retained for a "combined" model 5 (cf. RQ2).

As expected, the strongest predictor of vocabulary knowledge at T2 remained prior achievement throughout all models for both age cohorts.

When looking at each subgroup of variables separately (models 1 to 4), the following observations can be made. Regarding the control variables (model 1), SES appeared to be the only consistent—yet not very strong—predictor for both outcome variables. For the adolescent cohort, L1 receptive vocabulary knowledge also predicted future L2 vocabulary acquisition, with a slightly higher coefficient than SES. The pupils' non-verbal intelligence was significantly related to the outcome in the elementary school cohort, yet we found no such relation for the adolescent cohort. Next, both input variables (model 2) were predictive of receptive vocabulary learning in the secondary school cohort, but acquisition in the younger age group was only predicted by the input provided in the classroom. The motivational and attitudinal variables (model 3) show the most differentiated picture: for the elementary age cohort, cost and perceived easiness of the target language were significant predictors; for the secondary age cohort, none of these variables were predictive of receptive vocabulary acquisition, although they all correlated significantly with T2 L2 vocabulary knowledge (see above, Table 1). There was no predictive relationship between the executive functions and the outcome variables (model 4), as could be expected given the lack of correlation between these variables (see Table 1).

Although some commonalities can be noted, for instance, the persistence of prior achievement as the strongest predictor of future learning, and the continued presence of SES as a predictor, it is worthwhile to look at the combined models (model 5) separately

Table 1 Means and standard deviations for predictor variables (Time 1) and correlations with receptive vocabulary (Time 2)

Variables	Elementary			Secondary		
	M	SD	Receptive vocabulary T2 (r)	M	SD	Receptive vocabulary T2 (r)
Outcome						
Receptive vocabulary Time 2	−.7079	.7594		.7215	.6454	
Prior achievement						
Receptive vocabulary Time 1	−.8003	.6700	.592**	.6381	.7220	.720**
Background variables						
Gender	.49	.501	−.024	.47	.500	.077
SES	2.08	.811	.289**	2.16	.768	.329**
Home language	1.43	.603	−.078	1.28	.537	.029
Grade retention	.11	.317	−.179**	.19	.391	−.121*
Non-verbal intelligence	29.08	7.77	.209**	43.9	7.369	.342**
L1 vocabulary	100.901	20.4363	.197**	140.429	13.0027	.363**
Input variables						
TL input outside school	2.0228	.94276	.243**	2.6631	1.027	.271**
TL input in classroom	4.3354	1.36859	.398**	5.1419	.8956	.362**
Motivational and attitudinal variables						
Expectancy for success	5.4135	.99250	.109*	5.138	1.058	.247**
Perceived task value	5.0933	1.15213	.063	4.748	1.212	.225**
Cost	2.5772	1.38523	−.177**	2.575	1.317	−.267**
Perceived easiness TL	4.2934	1.34856	.272**	4.531	1.165	.239**
Perceived attractiveness TL	5.6350	1.12693	.006	4.782	1.725	.124*
Executive functions						
Flexibility	91.9911	238.56899	−.036	37.0461	157.60484	−.070
Inhibition (information)	173.809331	95.1004929	−.040	113.8619	45.2418	−.071
Inhibition (response)	47.1277017	42.2772968	−.062	25.3360	29.6450	−.040

$N_{elementary}$ = between 280 and 369; $N_{secondary}$ = between 292 and 352

* $p < .05$ ** $p < .01$

Table 2 Regression for receptive vocabulary as the outcome variable among elementary students

Receptive vocabulary	Elementary											
	Model 0		Model 1		Model 2		Model 3		Model 4		Model 5	
	B	SE	*B*	SE	*B*	SE	*B*	SE	*B*	SE	*B*	SE
Prior achievement												
Receptive vocabulary Time 1	.593***	.055	.532***	.059	.514***	.060	.562***	.056	.596***	.055	.463***	.064
Background variables												
Gender			−.042	.075								
SES			.138*	.049							.138**	.048
Home language			−.055	.065								
Grade retention			−.041	.137								
Non-verbal intelligence			.118*	.005							.132*	.005
L1 vocabulary			.068	.002								
Input variables												
TL input outside school					.094^{+}	.040					.031	.043
TL input in classroom					.176**	.029					.111*	.030
Motivational and attitudinal variables												
Expectancy for success							.017	.049				
Perceived task value							−.037	.049				
Cost							−.113*	.030			−.052	.030
Perceived easiness TL							.129*	.033			.105^{+}	.031
Perceived attractiveness TL							−.069	.044				
Executive functions												
Flexibility									−.037	.000		
Inhibition (information)									−.028	.000		
Inhibition (response)									−.051	.001		
R^2	.352		.412		.398		.382		.361		.413	

$+ p < .10$ * $p < .05$ ** $p < .01$ *** $p < .001$; *N* ranges from 240 to 280

Table 3 Regression for receptive vocabulary as the outcome variable among secondary students

Receptive vocabulary	Secondary											
	Model 0		Model 1		Model 2		Model 3		Model 4		Model 5	
	B	SE	*B*	SE	*B*	SE	*B*	SE	*B*	SE	*B*	SE
Prior achievement												
Receptive vocabulary Time 1	.720***	.035	.625***	.041	.638***	.038	.685***	.038	.720***	.035	.574***	.043
Background variables												
Gender			.044	.053								
SES			.107*	.036							.090*	.036
Home language			.073^{+}	.055							.033	.057
Grade retention			.006	.073								
Non-verbal intelligence			.088^{+}	.004							.077^{+}	.004
L1 vocabulary			.114*	.003							.115*	.003
Input variables												
TL input outside school					.139**	.028					.129**	.031
TL input in classroom					.143***	.028					.125**	.029
Motivational and attitudinal variables												
Expectancy for success							.014	.032				
Perceived task value							.074	.033				
Cost							.009	.026				
Perceived easiness TL							.055	.030				
Perceived attractiveness TL							−.020	.030				
Executive functions												
Flexibility									−.053	.000		
Inhibition (information)									−.008	.001		
Inhibition (response)									.030	.001		
R^2	.518		.573		.556		.525		.522		.605	

$+ p < .10$ * $p < .05$ ** $p < .01$ *** $p < .001$; *N* ranges from 277 to 324

for both cohorts. The children's receptive vocabulary acquisition (Table 2) was most strongly predicted by prior achievement. The predictive weight of SES and non-verbal intelligence was maintained in the integrated model; the input provided in the classroom also remained predictive of the outcomes, but its impact decreased somewhat. None of the other variables maintained any direct relationship in this model. Together, the included variables explained 41.3% of the variance, an increase of about 6% compared to the baseline model (model 0).

Regarding receptive vocabulary proficiency in the adolescent cohort (model 5, Table 3), prior achievement was the strongest predictor, complemented this time by the students' SES and L1 vocabulary knowledge as well as both target language input variables. No other variables played a significant role in predicting these learner outcomes. The variables in this model explained 60.5% of the variance, which is an increase of 7.5% compared to model 0.

Discussion

The aim of this prospective study was to assess the relative importance of input and exposure, motivational and attitudinal factors, and executive functions in predicting L2 vocabulary acquisition in children (5th/6th grade) and adolescents (11th/12th grade), after controlling for a number of background characteristics as well as prior level of receptive vocabulary.

Our first research question centered upon the contribution of each category of factors when analyzed separately. First, both input variables (taken at T1) correlated significantly with the T2 outcomes and were predictive of these outcomes 18 months later (model 2), although in one case only marginally (see the discussion below). This finding echoes the results from many studies in second language acquisition and aligns with theories underlining the importance of a sufficient level of relevant input (Krashen, 1985; Long, 1996; Mackey, 1999). In contrast, even if most of the motivational and attitudinal variables displayed significant correlations with the outcomes, only a few of them directly predicted L2 acquisition once initial vocabulary knowledge was taken into account (model 3), suggesting significant overlap between these variables and prior knowledge. A negative effect of perceived cost of target language learning and a positive effect of perceived easiness of the target language were observed at elementary school level, suggesting that perceived difficulty could be more relevant at this age than interest or attractiveness. Nevertheless, this finding was not replicated at secondary school level. The measures of the executive functions were not related to vocabulary acquisition (model 4). The null effect of these variables suggests that these do not play an important role in L2 vocabulary learning, at least not in the age cohorts under study. In previous longitudinal studies that looked into the predictive relations between executive functions and L2 vocabulary development (Nicolay & Poncelet, 2013a; Woumans et al., 2018), executive functions were measured at a (much) younger age, which may partly explain why our results are at odds with these studies (see also Simonis et al., 2019). The suggestion by Nicolay and Poncelet (2013a) that information interference inhibition—rather than response interference inhibition—might play a role when L2 proficiency grows was not supported by our data. It could be that other components of executive functions, such as working memory, are more related to L2 vocabulary

acquisition, at least at the elementary school level (Segalowitz & Hulstijn, 2005). However, working memory training failed to generalize to other skills (Melby-Lervåg et al., 2016; Melby-Lervåg & Hulme, 2013), which casts doubt on the predictive power of working memory for L2 vocabulary acquisition.

With respect to the second research question, we observed, perhaps somewhat unexpectedly, that only three or four of the 17 potential predictors investigated were directly related to the receptive vocabulary score at T2 controlling for the score at T1 in model 5. The only two variables that consistently (yet still only moderately) affected L2 receptive vocabulary acquisition in both age cohorts of this study were SES and the perceived frequency of target language use by the language teacher in the foreign language class. This last finding resonates with those of many prior L2 vocabulary acquisition studies and highlights the importance of formal besides informal exposure in a general population of students. Results of the integrated model (model 5) indicated that student-reported teacher input is the only variable that provides incremental predictive power above the effects of previous level of vocabulary and background variables for both cohorts. The effect of perceived cost of learning the target language and perceived easiness of the target language did not remain significant once introduced in the integrated model at elementary school. In other words, there was no additive effect of motivational or attitudinal variables when input, background variables, and previous performance were included in the same analyses (except maybe an effect of perceived cost at the elementary level). These results, coupled with the paucity of longitudinal studies on motivation in SLA, raise questions regarding the incremental contribution of motivational and attitudinal individual differences to vocabulary acquisition (Joe et al., 2017; Olivier et al., 2019).

Looking at the differences between the age cohorts, in order to answer our third research question, we found that non-verbal intelligence has an effect in the younger group, while L1 vocabulary proficiency has an effect in the older group. Typically, research on cognitive aspects would include a measure of L1 proficiency as a proxy for verbal intelligence (Simonis et al., 2019), and, in a similar vein, some studies in second language acquisition point at the role of language aptitude (Ortega, 2009). We could possibly consider the L1 vocabulary variable as a proxy of language aptitude or verbal intelligence, but then why younger learners' L2 vocabulary acquisition would be less affected remains an open question, also because other studies have shown that L1 vocabulary knowledge plays a positive role in L2 word learning among young children (e.g., Koenig & Woodward, 2012).

A second difference between the two age cohorts relates to the impact of target language input outside school. The marginal effect of this variable disappears in the final model for the primary age cohort, but it remains unaffected for the older cohort (compare models 2 and 5, Tables 2 and 3). A possible explanation lies in a shift in the students' dependence on their parents, which is likely to decrease once the children move into adolescence. The growing independence may impact the students' agency in terms of the ability to create affordances to gain access to the target language in outside school situations, with a higher mean level of input outside school in the older cohort (see Table 1). Our findings thus confirm previous studies (Sundqvist, 2009; Lindgren & Muñoz, 2013; Unsworth et al., 2015) suggesting the importance of outside classroom exposure for second language acquisition, at least with respect to receptive vocabulary, among adolescents but not children.

Conclusions, limitations, and perspectives

All in all, our findings call for caution regarding the impact of input, motivational, and cognitive variables on L2 (vocabulary) development separately, which is how these factors have often been studied. The precise relationship between these variables however, the nature of the interrelations, cannot be established on the basis of the present analyses and should be addressed in future studies that cover a larger period of time starting at a younger age. Our results suggest that the factors related to L2 vocabulary acquisition are not exactly the same at the end of primary or secondary school, but more direct tests of differences between age cohorts on some specific variables could be performed in future studies, for instance, through multigroup analyses (building on the present study and others to choose the variables to target). Additionally, one could think of testing other cognitive predictor variables that might be more related to later phases of vocabulary acquisition and L2 learning more generally. Furthermore, studies designed to assess L2 formal input at the classroom level, and not at the individual level like in the present study, would help us to better understand the role of teacher input in L2 acquisition. Such studies, which could be based on data collected via classroom observations or from the teachers, for instance, would not only enhance the validity of the input variable but would also provide a more complete picture of the dynamics and complexities of classroom interaction. Finally, for practical and logistical reasons, we limited our outcomes here to a restricted domain of L2 acquisition, namely receptive vocabulary knowledge. It should be verified whether similar results can be obtained for other skills. Even if we know that vocabulary knowledge in a foreign language is linked to proficiency in the four language skills of reading, writing, listening, and speaking (Milton, 2013), it may be that the variables under study contribute in varying degrees of importance to the development of these other language skills.

Despite these limitations, the present study contains various strengths: the study addressed a range of variables which are otherwise treated separately, we used a rather large sample from two different age groups, and we controlled for various background characteristics. In terms of the implications of our findings for future research, perhaps the most important finding is the role of prior achievement as a predictor (sometimes referred to as the Matthew effect, see Majuddin et al., 2021 for references). The incremental value of the integrated model is weak compared to the separate analyses, especially at elementary school level, showing few additive effects of the different categories of variables. The motivational and attitudinal variables investigated in the present study appear to have no predictive value above baseline vocabulary and background characteristics (Joe et al., 2017). Indicators of executive functions were found to be unrelated to target language vocabulary. Only a few background and input variables were found to directly predict receptive vocabulary acquisition. The best predictor was not a general background, cognitive, or motivational characteristic but previous specific knowledge (Tricot & Sweller, 2014). This last finding, together with the observation that target language input in the classroom is the only variable directly predicting vocabulary acquisition in both age groups, also has important implications for practitioners. Our study clearly highlights the relevance of the input learners receive from their teachers and this independently of several background and individual variables and—in the case of the secondary age group in our study—outside school exposure. Even if it is clear that the various actors involved (schools, teachers, parents) should work to encourage learners and provide opportunities to engage with the target language extra muros as much as possible (Peters et al., 2019), the input teachers provide in the classroom setting still represents a major source of language learning.

Table 4 Correlations between predictor variables.

	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Background variables																
1	Gender		.033	.025	.031	−.044	.009	.041	−.008	−.073	−.121*	.101*	−.099*	−.151**	.035	.027	.055
2	SES	.122*		−.034	−.302**	.216**	.167**	.082	.162**	.010	−.075	−.041	.017	−.177**	.021	.025	−.004
3	Home language	.007	−.076		.134**	−.004	−.136*	.307**	−.061	.094	.118*	.105*	.084	.066	.010	.071	−.084
4	Grade retention	.091	−.025	.060		−.167**	−.131*	.012	−.144**	−.028	.059	.131**	−.062	.013	−.019	.014	−.056
5	Non-verbal intelligence	.090	.245**	−.108*	−.160**		.353**	.063	.112*	.019	−.059	−.064	−.003	−.074	−.018	−.184**	−.105
6	L1 vocabulary	.104*	.254**	−.200**	−.112*	.369**		−.031	−.029	−.045	.001	−.137*	−.038	−.129*	−.008	−.139*	.010
	Input variables																
7	TL input outside school	−.040	−.017	.260**	.016	−.016	−.015		.156**	.201**	.280**	−.082	.221**	.157**	.018	.062	−.071
8	TL input in classroom	.005	.184**	−.010	−.093	.181**	.182**	.077		.064	.112*	−.157**	.192**	.080	−.049	.093	.014
	Motivational variables																
9	Expectancy for success	−.049	.015	.096*	.028	−.064	.005	.384**	.061		.532**	−.234**	.415**	.339**	−.050	.029	−.036
10	Perceived task value	−.119*	−.114*	.184**	.002	−.055	−.049	.601**	.055	.592**		−.326**	.328**	.557**	−.054	.116*	−.003
11	Cost	.138**	.029	−.110*	.008	−.021	−.029	−.370**	−.171**	−.577**	−.595**		−.194**	−.281**	−.020	−.068	−.072
12	Perceived easiness TL	−.037	−.044	.179**	.011	.022	−.060	.476**	.086	.549**	.581**	−.519**		.307**	−.030	.053	.087
13	Perceived attractiveness TL	−.134**	−.180**	.136**	.035	−.058	−.063	.563**	−.021	.424**	.702**	−.508**	.619**		.002	.094	.060
	Executive functions																
14	Flexibility	−.024	.030	.091	.028	−.126*	−.032	.075	−.041	−.028	.044	.031	−.041	.003		.103	.025
15	Inhibition (information)	−.005	−.088	.080	−.026	−.232**	−.093	−.083	−.050	−.020	−.013	.048	−.084	−.031	−.014		.091
16	Inhibition (response)	.000	−.106*	.043	.085	−.170**	−.223**	.076	−.076	−.014	.019	.024	.006	.052	.125*	.119*	

Primary school correlations are displayed above the diagonal, and secondary school correlations are displayed below the diagonal. $N_{elementary}$ = between 280 and 369; $N_{secondary}$ = between 292 and 352; * $p < .05$ ** $p < .01$

Appendix

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Declarations

Conflict of interest The authors declare no competing interests.

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Most relevant publications in the field of Psychology of Education:

De Smet, A., Mettewie, L., Galand, B., Hiligsmann, Ph., & Van Mensel, L. (2018). Classroom anxiety and enjoyment in CLIL and non-CLIL: Does the target language matter? *Studies in Second Language Learning and Teaching, 8*(1), 47-72.

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Most relevant publications in the field of Psychology of Education:

De Clercq, M., Galand, B., & Frenay, M. (2013). Learning processes in higher education: Providing new insights into the effects of motivation and cognition on specific and global measures of achievement. In D. Gijbels, V. Donche, J. Richardson & J. Vermunt (Eds.), *Learning Patterns in Higher Education: Dimensions and research perspectives* (pp. 141-162). Oxon: Routledge.

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