

ORIGINAL ARTICLE

The role of training and exposure to print for the mastery of connectives in French

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Abstract

A good knowledge of connectives like *moreover* and *therefore* is crucial for reading comprehension and academic success, yet not all connectives, especially infrequent connectives mostly used in writing, are well mastered even by adults. The main goal of this paper is to assess the possibility to improve the ability to use connectives in discourse during the transitional teenage years. To do so, we examined whether 228 native French-speaking teenagers and 60 adults improved their performance with eight infrequent (prototypical and non-prototypical) connectives in a sentence-completion task after active or passive training. The results revealed that training had only a limited effect on the ability to use both types of connectives, while the degree of exposure to print was an important predictor of individual variations. These findings suggest that connectives' mastery depends more on exposure to extensive written input that allows to internalize their procedural meaning over time rather than on one-time explicit activation of the mapping between their form and function.

Keywords: Connectives; experimental study; French; L1 development; teenagers

Teenage years are an important period of linguistic development between the emergence of a basic linguistic competence and a more advanced mastery of language (e.g., Berman, 2004). Language development in teenagers continues evolving on lexical, semantic, syntactic, and pragmatic levels (e.g., Berman, 2004; Nippold, 2004, 2008), and the mastery of connectives lies at the interface between these domains. Knowledge of a wide variety of connectives is part of a more complex academic lexicon (Barr et al., 2019) that appears in argumentative and expository texts, introducing complex reasoning and ideas, to which speakers start to be exposed mostly from middle school when they become more autonomous readers (Nippold, 2004). The increasing production of longer sentences with subordinate clauses, as well as texts with greater cohesion, also relies a lot on the mastery of

connectives (Nippold, 2008). Moreover, the growing number of social interactions promotes the development of pragmatic skills that rely on connectives, such as remaining on topic during conversation (Nippold, 2006), making smooth transitions between topics, and presenting opposite sides of an argument (Nippold, 2008).

Not only do connectives play a central role in the linguistic system and in the ability to express complex reasoning, but their knowledge is also crucial for academic success. Discourse connectives improve overall writing quality in argumentative essays (e.g., Andreev & Uccelli, 2023; Duggleby *et al.*, 2016; Uccelli *et al.*, 2013) and are considered to be an integral part of fundamental academic language (e.g., RAND Reading Study Group & Snow, 2002). Academic language is mostly used in written formal educational contexts and has a certain number of characteristic linguistic features. For instance, it employs a more diverse and precise vocabulary, has a highly organized structure, and has a complex syntax involving the use of discourse connectives (Tolchinsky & Berman, 2023; Snow & Uccelli, 2009; Ucelli, 2019). As its name suggests, this type of language is used not only in language and literature classes but also in all other subjects, as a means to transfer academic knowledge. Therefore, the success in these subjects depends on the ability to use this language with all its typical features as well as to read and understand texts written in it. Indeed, ample evidence suggests that performance in various academic domains is linked to reading comprehension skills (see, e.g., Fuentes, 1998; Korpershoek *et al.*, 2015).

Even the most common connectives, such as *before* and *because*, however, are not completely mastered by the age of 12 years (e.g., Cain & Nash, 2011; D'Arcais Flores, 1978; Irwin & Pulver, 1984), and some infrequent connectives are challenging even for adults (Zufferey & Gygax, 2020a). Therefore, it is crucial to establish why certain connectives are not fully mastered even by adults and how their mastery can be improved through specific training during the transitional period of teenage years. In the next section, we review factors that predict the difficulty of some connectives for teenagers and present theories of explicit and implicit learning.

Using connectives in discourse

Studies assessing how connectives are used by teenage native speakers suggest that the low frequency in corpora (Crosson & Lesaux, 2013a; Nippold *et al.*, 1992) is the most prominent predictor of their difficulty. For instance, the French infrequent connectives *aussi* “therefore” (e.g., Tskhovrebova, Zufferey & Gygax, 2022; Zufferey & Gygax, 2020b) and *en outre* “moreover” (e.g., Tskhovrebova, Zufferey & Gygax, 2022; Tskhovrebova, Zufferey & Tribushinina, 2022; Zufferey & Gygax, 2020b) were found to be particularly challenging to use for both native French-speaking teenagers and adults. However, it is necessary to conduct further research to validate whether frequency in the input serves as a reliable predictor for all connectives. Therefore, there is a need for more comprehensive investigations into connectives with similar or even lower frequencies that have not yet been explored.

One could further assume that the difference in cognitive complexity between different coherence relations, as conceptualized by Sanders et al. (1992) and further developed by Sanders et al. (2018), can explain why some connectives are more difficult to use than others for young speakers. According to the cognitive coherence relation model (Sanders et al., 2018), coherence relations can be analyzed across five primitives, namely, basic operation (additive vs. causal), polarity (positive vs. negative), order of the segments (basic vs. nonbasic), source of coherence (objective vs. subjective), and temporality (nontemporal vs. temporal). Within each primitive, one constituent is considered to be cognitively more complex than the other, and relations that represent a combination of more complex dimensions are acquired during childhood after those that include easier dimensions, on both production (e.g., Evers-Vermeul & Sanders, 2009) and comprehension (e.g., Spooren & Sanders, 2008) levels.

Yet, previous research has demonstrated that the type of coherence relation conveyed by a connective is not a strong predictor of the ability to use connectives in offline tasks such as sentence-completion ones by speakers of different languages aged 12 years and older (e.g., for English: Nippold et al., 1992; for French: Tskhovrebova, Zufferey & Tribushinina, 2022; Zufferey & Gygax, 2020b; for Russian: Tskhovrebova, Zufferey & Tribushinina, 2023). This is likely due to the fact that by that age, all the common coherence relations, such as addition, cause, concession, consequence, and contrast, have already been acquired, and cognitive complexity is not well captured by offline tasks (i.e., tasks that measure the result of language processing *after* the process has been completed).

So far, research has mostly assessed the competence with connectives that signal coherence relations such as addition, cause, consequence, temporality, contrast, and concession. These types of relations typically exist in many different languages and are listed and described by various frameworks of coherence relations, even though their label may differ (e.g., Asher & Lascarides, 2003; Carlson et al., 2003; Prasad et al., 2019). Yet, there are also other types of relations which are not straightforward to describe and may not even have a designated label, in other words, relations that are less *prototypical*.

For instance, the main inventory of the French connectives Lexconn (Roze et al., 2012) does not provide a label for the connectives *au fur et à mesure que* “approx. as” and *suivant que* “approx. depending on.” Indeed, these connectives signal relations that do not appear to correspond to any common category. *Au fur et à mesure que* signals a cause that intensifies with time, as in example (1); and *suivant que* is used to introduce a series of at least two conditions, as in example (2).

- (1) L'économie du pays se détériore au fur et à mesure que les mois avancent.
“The country’s economy is deteriorating CONNECTIVE the months go by.”
- (2) La taxation change suivant que la personne a une voiture à essence ou électrique.
“The taxation changes CONNECTIVE the person has a petrol or an electric car.”

In contrast, the connective *or* “approx. however” has a categorization in Lexconn, but it does not represent quite precisely one of the functions of this polyfunctional

connective. One function of *or* is to mark concession, a quite prototypical relation, but another function is to signal a continuation of narration as in (3), which is more specific than the more “conventional” additive relation. This relation is not conveyed by a specific connective in closely related languages like English, German, and Spanish (Zufferey, 2016).

- (3) Le médecin a peur des virus. Or il y a beaucoup de patients grippés en ce moment.
 “The doctor is afraid of viruses. CONNECTIVE there are a lot of flu patients at the moment.”

Moreover, the three connectives mentioned so far not only signal less prototypical coherence relations but also are quite unique, as they cannot be substituted by equivalent and more frequent connectives. This is not the case of more common coherence relations that often can be expressed by several connectives varying in frequency. For instance, the causal relation in English can be signaled by various connectives, such as a more frequent *because* (778.18¹) and by a less frequent *given that* (14.82). As a result, it is possible that infrequent connectives marking less prototypical coherence relations may require additional cognitive effort and may, therefore, be more difficult to learn, use, and understand, especially for less experienced speakers who may not have had ample exposure to them.

Besides the fact that certain connectives are challenging even for adult speakers, the competence with connectives is also associated with important individual variations between speakers of all age groups (e.g., for children: Karlsson *et al.*, 2019; Volodina & Weinert, 2020; for teenagers: Tskhovrebova, Zufferey & Tribushinina, 2022, 2023; van Silfhout *et al.*, 2015; for adults: Zufferey & Gygas, 2020a). Interestingly and in contrast to children, for the teenage population, individual differences in academic background (Tskhovrebova, Zufferey & Gygas, 2022; Zufferey & Gygas, 2020b), vocabulary size, and exposure to print (Tskhovrebova, Zufferey & Tribushinina, 2022, 2023) have been shown to predict accuracy on sentence-completion tasks, even better than readers’ age. Therefore, an important angle of investigation is whether and how it is possible to improve the ability to use connectives and to attenuate individual differences, especially in writing. Crosson and Lesaux (2013b) proposed a set of strategies for explicit instruction of connectives at school. However, the impact of such instruction on mastering connectives has not been empirically evaluated to date.

Examining how to enhance the competence with connectives in writing is particularly important, as written language is distinct from oral speech in numerous respects (see Halliday, 1987, for a complex perspective on the distinction between oral and written genres). For example, written language is often planned, noninteractive, and formal, whereas oral speech is often spontaneous, interactive, and informal. Other important differences include the use of connectives, as a larger variety of connectives with more precise functions is used in written discourse than in oral speech (see, e.g., Castellà, 2004; Crible, 2020; Crible & Cuenca, 2017). Hence, learning how to use connectives in written texts may be similar in some way to learning a second language that possesses its own features, and for which exposure is often limited and mostly linked to a context of formal instruction in the classroom.

Connectives in written texts have their own characteristics, which are different from those in oral use, and the amount of input that learners receive may be limited, as in classroom learning of a second language.

Explicit and implicit knowledge

Research on second language learning often refers to the concepts of implicit and explicit knowledge that are involved in the process of language learning (see, e.g., Ellis, 1994; Ellis et al., 2009; Rebuschat, 2015; VanPatten & Smith, 2022; Wong & Simard, 2015). Implicit knowledge is understood as an underlying knowledge of language that is usually unconscious and cannot be easily explained by speakers, despite the fact that they are able to access it (e.g., Ellis et al., 2009; VanPatten & Smith, 2022). The implicit knowledge of language is formed based on comprehensible linguistic input. In consequence, it is widely assumed that to enhance the process of acquisition of implicit knowledge about language, it is important to receive a sufficient amount of input combined with instruction, helping to extract and process data from input (e.g., Wong & Simard, 2015).

Explicit knowledge is a conscious awareness of how certain elements of the language work, and hence this type of knowledge involves metalinguistic reasoning (e.g., Ellis et al., 2009; Rebuschat, 2015). As suggested by Ellis (1994), it is possible that explicit knowledge about the functioning of language, received through instruction in the form of rules, may transform into an implicit knowledge. For this transformation to happen, readers should practice how to apply these rules so that using them becomes automatic. For example, in the case of connectives, providing readers with an instruction about the use of connectives in general may help them to better identify the connectives they find in the input, to create the relationship between their form and function, and with practice to internalize their functioning in their mental lexicon.

The present study

Our study has two main objectives. First of all, we assess how teenagers use infrequent French connectives, indicating both prototypical and non-prototypical coherence relations, in order to verify whether the low scores observed for the connectives *aussi* “therefore” and *en outre* “moreover” in previous studies can be associated with their low frequency. If connectives having similar or lower frequencies receive comparable accuracy scores on the sentence-completion task, for both prototypical and non-prototypical relations, it would mean that low frequency in corpora can be used as an important predictor of the connective use in general. Alternatively, if only the connectives *aussi* and *en outre* get the lowest scores, even compared to other infrequent connectives, this would indicate that the difficulty is not necessarily associated with the frequency but with other characteristics of these specific connectives. Finally, if only connectives that mark non-prototypical coherence relations, such as *au fur et à mesure que*, *suivant que*, and *or*, receive the lowest accuracy scores, it would suggest that this type of relations represents a particular challenge for teenagers.

The second goal is to study whether the use of connectives by young speakers can be improved with explicit instruction activities, and/or whether it is long-term exposure to written language, as measured by the teenage version of the French Author Recognition Test (*ART-F-CL*) (Tskhovrebova, Zufferey & Tribushinina, 2022), that allows to develop a better mastery of connectives. As such, our study will allow us to shed light on the learning mechanisms involved in developing competence with connectives as elements encoding both concepts and procedures (Wilson, 2011). After participants undergo training in the form of explicit instruction about the functioning of connectives, they may not yet completely internalize the received explicit knowledge, but they should probably better apply the rule they have been exposed to and, as a result, should have higher scores on the sentence-completion tasks fulfilled after training.

The performance with connectives in the sentence-completion task can become even better if the proposed training involves a more active engagement with the rule. Indeed, the explanation of how connectives function in discourse may not be sufficient for the retention of new information about connective functioning. According to the Involvement Load Hypothesis (ILH) introduced by Hulstijn and Laufer (2001), learning new lexicon depends on the degree of involvement in its processing. The concept of involvement includes three main components, such as need, that is, the source of motivation to fulfill a task, search of the meaning of an unknown word, and evaluation of how the word fits its context. The greater the involvement load, the better the retention of an unfamiliar word (see Liu & Reynolds, 2022, for a review of studies supporting this hypothesis). Based on the logic of the ILH, we expect that a more active engagement with the rule, involving the search for the meaning of a connective and providing feedback on whether it was used correctly or not, should result in a better performance on the sentence-completion task than a less engaging learning through the reading of the rule.

The amount of input, however, is still the primary source that enables readers to build an implicit knowledge about language, especially in L1 (e.g., VanPatten & Smith, 2022). Therefore, we expect that readers with a greater degree of exposure to written language input, as measured by the Author Recognition Test (ART) (Stanovich & West, 1989), should on average have a more advanced general competence with connectives, independently of the training activity, as their knowledge of connectives functioning should be better internalized and automatized.

Method

All materials, data, and code are available on the OSF repository (<https://osf.io/9fx6u/>).

Participants

A group of 228 native French speakers aged 12 to 20 years ($M_{age} = 15.81$, $SD = 2.14$) participated in this study. The age range of this cohort was chosen to ensure appropriate variability in exposure to print.

The experiment was conducted in classes of four schools in the French-speaking part of Switzerland (secondary schools and high schools). In order to determine the baseline of competence with connectives, we also recruited 60 adult native French speakers aged 19–46 years ($M_{\text{age}} = 28.22$, $SD = 6.53$) via the crowdsourcing platform Prolific© (Prolific, Oxford, UK, www.prolific.co). The informed consent for participation in the study was provided by adult participants as well as by all the teachers responsible for teenagers.²

Materials

Sentence-completion task

Choice of connectives. Two types of infrequent connectives³ were selected for this study. Non-prototypical connectives consisted of connectives that do not have more frequently used synonyms and that signal uncommon and less prototypical coherence relations, such as continuation of narration (*or*), cause that intensifies with time (*au fur et à mesure que*), and series of conditions (*suiwant que*). Prototypical connectives included connectives that are infrequent in corpus data but that have more frequent synonyms and signal more common and prototypical relations (e.g., Prasad et al., 2019), such as consequence (*aussi*), exception (*hormis que*), causality (*étant donné que*), addition (*en outre*), and condition (*dans la mesure où*). Table 1 summarizes different types of connectives used in this study.

The connective frequencies were calculated based on a large web-crawled corpus of French, counting more than 15.1 billion words (Jakubíček et al., 2013). Three connectives, namely *dans la mesure où*, *aussi*, and *or*, had two functions, and it is their less frequent functions that were assessed in the current study. Although polyfunctionality per se was not found to be a factor of difficulty for using and understanding connectives (Tskhovrebova, Zufferey & Tribushinina, 2023; Zufferey & Gygax, 2020a, 2020b), we controlled that non-targeted functions of polyfunctional connectives were not competing with the targeted functions (see section “Structure of the test” for more details). The conditional function of *dans la mesure où* represents about 20% of the occurrences in corpora in contrast to the causal one, which represents all the other uses of this connective. The consequence function of *aussi* has approximately 10% of the occurrences in corpora in comparison to its dominant function of addition (the distribution is taken from Zufferey & Gygax, 2020a). For the connective *or*, the function of continuation of narration constitutes about 30% of occurrences compared to the concessive one. The frequencies of *dans la mesure où* and *or* were calculated by randomly selecting 100 occurrences and manually annotating each function (following Zufferey and Gygax, 2020a). The proportion of each function was extrapolated to the whole corpus. Since the connective *aussi* in a sentence-initial position only expresses consequence, we used this syntactical constraint to search for the frequency of this function directly in the main corpus without making the additional annotation.

Structure of the test. The participants were asked to fill in gaps between two sentences with an appropriate connective (see the materials at the OSF repository for examples <https://osf.io/9fx6u/>). Instead of commonly used punctuation marks such as commas or full stops, the gap between sentences was demarcated by double slashes “//_____//” so that punctuation between the two sentences did not affect

Table 1. Summary of the assessed connectives

Connective	Relation	Approximate translation in English	Frequency per million words	A more frequent synonym
Prototypical connectives				
<i>dans la mesure où</i>	condition	in so far as	4.15	<i>si</i> “if” (1,457.7)
<i>aussi</i>	consequence	therefore	27	<i>donc</i> “so” (348.02)
<i>hormis que</i>	exception	except	0.11	<i>sauf que</i> “except” (15.35)
<i>étant donné que</i>	cause	given that	6.4	<i>parce que</i> “because” (294.07)
<i>en outre</i>	addition	moreover	49.6	<i>en plus</i> “also” (118.49)
Non-prototypical connectives				
<i>or</i>	continuation of narration	and	27.88	–
<i>au fur et à mesure que</i>	a cause that intensifies with time	as	4.45	–
<i>suivant que</i>	series of at least two conditions	depending on	0.76	–

the choice of a connective. The test included 5 sentences per connective, amounting to a total of 40 sentences presented to participants in a randomized order.

To ensure that only one option was possible, not all connectives were always proposed as answer options. For instance, *aussi* “therefore” was never proposed among the answer options for the sentences targeting the additive connective *en outre*, because *aussi* can signal both consequence and additive relations. Similarly, *dans la mesure où* “in so far as,” which can mark both condition and cause, was not proposed among answers for the sentences targeting the causal connective *étant donné que* “given that.”

The sentences that targeted prototypical connectives encoding common coherence relations had four answer options, randomly selected from the five connectives marking these relations included in the experiment (*aussi*, *hormis que*, *étant donné que*, *en outre*, and *dans la mesure où*). The sentences targeting the non-prototypical connectives signaling uncommon coherence relations always included the three connectives *or*, *au fur et à mesure que*, and *suivant que* so that connectives belonging to the same category of uncommon coherence relations were the only possible choices for these connectives. We decided not to match the number of options between prototypical and non-prototypical connectives, so as not to artificially constrain the possible answers for prototypical ones and artificially inflate

possible answers to non-prototypical ones. As this methodological particularity influences the probability of choosing the right answer, answers to prototypical and non-prototypical connectives were analyzed separately.

Participants completed three completion tests over three sessions so that it was possible to assess whether their performance on these tests was affected by a training activity carried out in-between sessions 1 and 2. The difference between sessions 2 and 3 was meant to assess whether the improvement would be lasting in time or whether it would come later (i.e., sleeper effect). The second session was held one week after the first one. It included a training activity on the use of the tested connectives, followed by the completion test, evaluating the immediate effect of the training on the performance with connectives. The third session included only the completion task and took place four weeks after the second one in order to assess the long-term effect of the training on the use of connectives. For each participant, the sentences included in the completion task differed between the three sessions (i.e., were randomly selected) so that they were always actively engaged in the task and could not simply reproduce previously given answers.

Training activities

One of two types of training—both frequent in language learning classes—was randomly allocated to participants and was administered through written instructions. We relied on the written mode, as we wanted to ensure that all the participants received exactly the same type of training. The first type of training was receptive (Nation, 1990; Schmitt, 2014; Webb, 2005) and presented a limited involvement load (Laufer & Hulstijn, 2001), as participants simply had to read the information about each connective one after the other, without actively engaging with it. The instruction included a rule describing the function of a connective, followed by three example sentences with the same connective, as illustrated in example (4). When a connective had a more frequent synonym, it was mentioned in the rule and the examples, following the recommendations of Crosson and Lesaux (2013b) to create an association between known connectives from oral contexts and unknown ones.

- (4) Example of a receptive training for the connective *dans la mesure où*

The rule:

Le connecteur *dans la mesure où* peut introduire une **condition** et est utilisé entre deux phrases de la même manière que le connecteur **si**.

“The connective *dans la mesure où* can introduce a condition and is used between two sentences in the same way as the connective *si*”

Examples:

- Tu peux manger ce dessert **dans la mesure où** (= **si**) tu en laisses un morceau à ton frère.
“You can eat this dessert in so far as (= if) you leave a piece for your brother.”
- Le port du masque restera obligatoire dans des espaces publics **dans la mesure où** (= **si**) la situation sanitaire ne se normalise pas.

“The wearing of masks will remain mandatory in public spaces in so far as (= if) the health situation does not normalise.”

- Tout le monde peut publier son contenu sur ce site **dans la mesure où** (= **si**) ce contenu n’incite pas à la violence.
“Anyone can publish their content on this website in so far as (= if) this content does not promote violence.”

The second type of training was productive (Nation, 1990; Schmitt, 2014; Webb, 2005) and presented a greater involvement load (Laufer & Hulstijn, 2001). First, participants had to deduce the function of a connective and, where possible, elicit synonyms, by answering step-by-step questions, as in (5a). Second, they had to complete the rule about the functioning of a connective, similar to example (5b). Third, after deducing the rule, they had to put this rule into practice and choose an appropriate continuation for a sentence followed by a connective, as in example (5c). There were two sentences to complete, each of which was followed by the correct answer, as demonstrated in example (5d). Thus, on the one hand, this instruction activity aligned with the guidelines of Crosson and Lesaux (2013b), as it involved probing questions about the meaning of connectives used in context, thinking of more frequent synonyms, and completing the examples of their use. On the other hand, it also had a high degree of involvement, as participants had to actively engage with the instruction material, by searching for the function of a connective, reconstructing the rule of its functioning, and putting this rule into practice. Moreover, at each stage of the instruction, participants received feedback on how accurately they performed and what the correct answer was.

- (5) Example of a productive training for the connective *dans la mesure où*
- a) Read the following sentence:

Tu peux manger ce dessert **dans la mesure où** tu en laisses un morceau à ton frère.

“You can eat this dessert insofar as you leave a piece for your brother.”

Of the options below, which word is most similar to the connector *insofar as* in the previous phase?

- c’est pourquoi “that’s why”
- si “if”
- même si “even if”
- pour que “so that”

- b) Please complete the following rule:

Le connecteur *dans la mesure où* introduit une relation de (conséquence/condition/concession/même si/pour que).

“The connective *dans la mesure où* introduces a relationship of (consequence/condition/concession/purpose) and can be used between two sentences in the same way as the word (*that’s why/if/ even if/so that*).”

- c) You will see a sentence followed by a connective and three continuation options. Please choose the option that best fits the content.

Le port du masque restera obligatoire dans des espaces publics dans la mesure où . . .

“The wearing of masks will remain mandatory in public spaces in so far as . . .”

- la situation sanitaire ne se normalise pas.
“the health situation does not normalise.”
- personne n’est plus contaminé par le virus.
“no one is infected with the virus anymore.”
- il faut qu’on en achète encore trois boîtes.
“we need to buy three more boxes.”

- d) The correct answer:

Le port du masque restera obligatoire dans des espaces publics dans la mesure où la situation sanitaire ne se normalise pas.⁴

“The wearing of masks will remain mandatory in public spaces in so far as the health situation does not normalise.”

Author Recognition Tests

To measure the degree of exposure to written language input, we use two French versions of the ART (see Stanovich & West, 1989, for the original English ART). Teenagers’ degree of exposure to print was assessed with an adapted version of the Author Recognition Test (*ART-F-CL*), developed by Tskhovrebova, Zufferey and Tribushinina (2022). An adult version of the ART (*ART-F*), developed by Zufferey and Gygax (2020a), was used to measure the adults’ level of exposure to print. The reliability of the two ART tests was quite high (like in previous studies), as indicated by their Cronbach’s alphas (*ART-F-CL*: .88, 95% CI [.86–.90]; *ART-F*: .90, 95% CI [.84–.93]).

Procedure

All the tasks were administered online via a web link that teenagers received directly on their classroom computers. The tasks were part of French classes and were administrated under the supervision of teachers responsible for those classes. During the first session, the participants started with the sentence-completion task and proceeded to the ART. During the second session, the participants fulfilled one of the two training activities and afterward did the second completion task. Finally, during the third session, they just completed the third sentence-completion task (see Table 2 for the distribution of different tasks between the three sessions). Once the participants gave an answer and proceeded to the next question, they could not go back and correct their initial response. Each session had no time limit, but they had to be completed without interruptions. Teenagers spent, on average, 20–25 minutes completing tasks during sessions 1 and 3, and 30–35 minutes during session 2.

Table 2. Distribution of tasks between the three experimental sessions

Order	Session 1 (week 1)	Session 2 (week 2)	Session 3 (week 6)
1	Sentence-completion task	Training activity	Sentence-completion task
2	ART	Sentence-completion task	–

Analysis strategy

For both prototypical and non-prototypical connectives, the accuracy of responses ($1 = \text{right}$, $0 = \text{wrong}$) in the sentence-completion task was analyzed with a generalized mixed-effects logistic regression model in the R software (R Core Team, 2020). In both set of analyses, we first compared the general effect of training and inter-individual variation in exposure to print on the teenagers' performance on the sentence-completion tasks. Second, we examined whether the effect of training was different for different connectives between the three sessions.

After assessing the performance on the sentence-completion tasks over three sessions, we conducted additional analysis to examine whether one type of training (productive or receptive) better predicted the performance of teenagers on the sentence-completion tasks during Sessions 2 (short term) and 3 (long term). Finally, the same analyses were performed also for adults. Even though adults generally outscored teenagers, the results showed similar trends within the two groups and were reported for convenience in Supplementary Materials on the OSF repository.

The models were built with the *glmer* function of the *lme4* package (Bates et al., 2015), and the model comparison was done with the *anova()* function, using a forward-selection approach. When comparing models, we assessed the contribution of random slopes to the models' fit by using log-likelihood tests, when the random slopes were justified by the design (as suggested by Barr et al., 2013). The p-values of the final model were obtained with the *summary()* function from the *lmerTest* package (Kuznetsova et al., 2014).

Results

General effect of print exposure and training

Prototypical connectives

For prototypical connectives, the model fit kept improving after adding ART-F-CL ($\Delta\chi^2 = 32.80$, $\Delta df = 1$, $p < .001$) and Session (Session 1, 2, and 3) ($\Delta\chi^2 = 11.63$, $\Delta df = 2$, $p = .003$) as fixed factors. As a result, the final model included ART-F-CL and Session as fixed factors and Item, Participant, and Age as random intercepts. The fact that ART-F-CL improved the model fit more than Session shows that print exposure, on average, better explains the variation in the scores on the connective task than formal instruction. Indeed, the outcome of the final model revealed that teenagers with a higher degree of print exposure had higher scores on the sentence-completion task (with an estimated increase of 0.63). In contrast, instruction had no significant positive effect either during Session 2 or Session 3 (see Table 3 for the estimates).

Table 3. Estimates for the best-fitting models for teenagers. The Estimate indicates an estimated difference between the value of a reference variable (Intercept) and the values of other variables. The standard error of a regression (SE) expresses the degree of uncertainty in the accuracy of the dependent variable's projected values. The p-value and z-statistics show the significance of the estimated coefficient for the tested variable

	Estimate	SE	z	p
Prototypical connectives				
(Intercept)	-0.81	0.31	-2.57	.010
ART-F-CL	0.63	0.10	6.34	<.001
SESSION				
Session 2	-0.07	0.05	-1.44	.151
Session 3	-0.17	0.05	-3.41	.001
Non-prototypical connectives				
(Intercept)	-0.61	0.33	-1.85	.065
ART-F-CL	0.94	0.13	7.05	<.001

Non-prototypical connectives

For non-prototypical connectives, the model fit improved after adding ART-F-CL ($\Delta\chi^2 = 43.47$, $\Delta df = 1$, $p < .001$), but not after adding Session (Session 1, 2, and 3) ($\Delta\chi^2 = 0.85$, $\Delta df = 2$, $p = .6528$) as a fixed factor. Therefore, the final model included ART-F-CL as a fixed factor and Item, Participant, and Age as random intercepts (see Table 3 for the estimates of both models). The results demonstrate that in the case of non-prototypical connectives, exposure to print, overall, was the main predictor of a more accurate performance on the connective task (with an estimated increase in score of 0.94).

Effects of print exposure and training across the different connectives

Prototypical connectives

The model fit kept improving after adding Connective ($\Delta\chi^2 = 64.10$, $\Delta df = 4$, $p < .001$), a two-way interaction between Connective and Session ($\Delta\chi^2 = 108.68$, $\Delta df = 10$, $p < .001$), and ART-F-CL ($\Delta\chi^2 = 33.46$, $\Delta df = 1$, $p < .001$) as fixed factors. Finally, including Connective as a random slope by Participant prevented the model from converging. As a result, the final model included Connective, Session, and ART-F-CL as fixed factors and Item, Participant, and Age as random intercepts. Treatment contrasts were applied for the unordered factor of Connective. The causal connective *étant donné que* was set as reference level for comparing the scores associated with the different connectives.

The results revealed that two connectives received particularly low mean scores across the three experimental sessions, namely the connectives *aussi* “therefore” ($M = .38$, 95% CI [.26, .50]) and *en outre* “moreover” ($M = .38$, 95% CI [.26, .50]) (see Table 4 for the estimates and Figure 1 for the visualization of the results). For all the other connectives, teenagers scored between .71 and .85.

Table 4. Estimates for the best-fitting models for teenagers

	Estimate	SE	z	p
Prototypical connectives				
(Intercept)	0.98	0.28	3.45	.001
CONNECTIVE				
<i>aussi</i> “therefore”	-3.16	0.21	-14.86	<.001
<i>dans la mesure où</i> “in so far as”	-1.26	0.21	-5.89	<.001
<i>en outre</i> “moreover”	-3.00	0.21	-14.17	<.001
<i>hormis que</i> “except”	-1.36	0.21	-6.38	<.001
SESSION				
Session 2	-0.85	0.14	-6.10	<.001
Session 3	-0.65	0.14	-4.53	<.001
ART-F-CL	0.64	0.10	6.43	<.001
CONNECTIVE*SESSION				
<i>aussi</i> * Session 2	1.05	0.17	6.12	<.001
<i>dans la mesure où</i> * Session 2	0.62	0.18	3.53	<.001
<i>en outre</i> * Session 2	1.17	0.17	6.85	<.001
<i>hormis que</i> * Session 2	0.65	0.17	3.75	<.001
<i>aussi</i> * Session 3	0.82	0.18	4.65	<.001
<i>dans la mesure où</i> * Session 3	0.46	0.18	2.52	0.012
<i>en outre</i> * Session 3	0.22	0.18	1.24	0.214
<i>hormis que</i> * Session 3	0.68	0.18	3.74	<.001
Non-prototypical connectives				
(Intercept)	-0.07	0.36	-0.19	0.846
CONNECTIVE				
<i>or</i>	-1.12	0.22	-5.12	<.001
<i>suisant que</i> “depending on”	-0.57	0.22	-2.57	0.010
SESSION				
Session 2	-0.44	0.13	-3.43	0.001
Session 3	-0.26	0.13	-1.90	0.057
ART-F-CL	0.94	0.13	7.05	<.001
CONNECTIVE*SESSION				
<i>or</i> * Session 2	1.05	0.17	6.04	<.001
<i>suisant que</i> * Session 2	0.36	0.17	2.05	0.041
<i>or</i> * Session 3	0.77	0.18	4.35	<.001
<i>suisant que</i> * Session 3	0.04	0.18	0.20	0.843

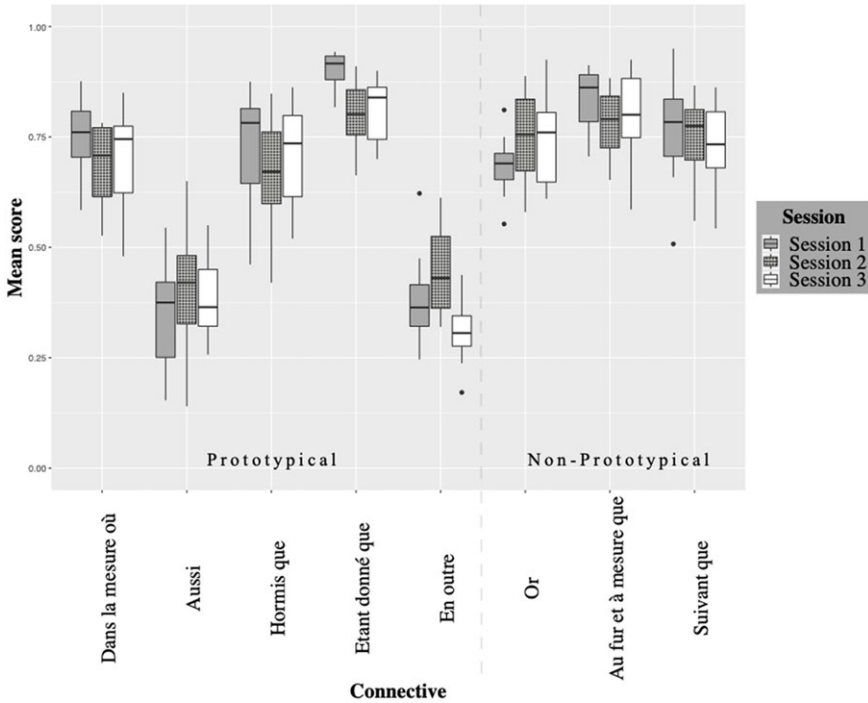


Figure 1. Distribution of mean scores per connective in sentence-completion task across the three sessions among teenagers.

As for the difference between the three experimental sessions, the post hoc pairwise comparison (see Table 5 for the statistics) demonstrated that the participants overall scored significantly higher between Sessions 1 and 2 only for the connectives *aussi* “therefore” and *en outre* “moreover” (see Table S4 in the Supplementary Materials for the mean scores per connective). In contrast, the scores of all the other connectives significantly decreased. However, the comparison of the scores between Sessions 1 and 3 did not reveal the long-term effect of training for any of the connectives, as their scores remained unchanged (*aussi* “therefore,” *dans la mesure où* “in so far as,” *hormis que* “except”) or decreased (*étant donné que* “given that,” *en outre* “moreover”).

Non-prototypical connectives

Adding Connective ($\Delta\chi^2 = 6.47$, $\Delta df = 2$, $p = .039$), a two-way interaction between Connective and Session ($\Delta\chi^2 = 46.93$, $\Delta df = 6$, $p < .001$), and ART-F-CL ($\Delta\chi^2 = 43.61$, $\Delta df = 1$, $p < .001$) as fixed factors kept improving the model fit. The final model included Connective, Session, and ART-F-CL as fixed factors and Item, Participant, and Age as random intercepts. The connective *au fur et à mesure que* was set as reference level for comparing the scores between the different connectives.

Table 5. Pairwise comparison between connectives and experimental sessions

	Estimate	SE	z	p
Prototypical connectives				
<i>Etant donné que</i>				
Session 1–Session 2	0.85	0.14	6.10	<.001
Session 1–Session 3	0.65	0.14	4.53	<.001
Session 2–Session 3	–0.19	0.13	–1.54	0.123
<i>Aussi</i>				
Session 1–Session 2	–0.20	0.10	–2.00	0.046
Session 1–Session 3	–0.17	0.10	–1.64	0.102
Session 2–Session 3	0.03	0.10	0.32	0.748
<i>Dans la mesure où</i>				
Session 1–Session 2	0.23	0.11	2.12	0.034
Session 1–Session 3	0.20	0.11	1.77	0.076
Session 2–Session 3	–0.03	0.11	–0.30	0.765
<i>En outre</i>				
Session 1–Session 2	–0.32	0.10	–3.25	0.001
Session 1–Session 3	0.43	0.10	4.13	<.001
Session 2–Session 3	0.75	0.10	7.24	<.001
<i>Hormis que</i>				
Session 1–Session 2	0.19	0.11	1.82	0.069
Session 1–Session 3	–0.02	0.11	–0.22	0.827
Session 2–Session 3	–0.22	0.11	–1.99	0.046
Non-prototypical connectives				
<i>Au fur et à mesure que</i>				
Session 1–Session 2	0.44	0.13	3.43	0.001
Session 1–Session 3	0.26	0.13	1.90	0.057
Session 2–Session 3	–0.19	0.13	–1.45	0.147
<i>Or</i>				
Session 1–Session 2	–0.61	0.12	–5.23	<.001
Session 1–Session 3	–0.52	0.12	–4.40	1.06E-05
Session 2–Session 3	0.09	0.12	0.70	0.482
<i>Suivant que</i>				
Session 1–Session 2	0.08	0.12	0.71	0.480
Session 1–Session 3	0.22	0.12	1.84	0.066
Session 2–Session 3	0.14	0.12	1.15	0.251

The results demonstrated that the connective *or* received the lowest mean score across the three experimental sessions ($M = .75$, 95% CI [.63, .86]), followed by *suivant que* “depending on” ($M = .76$, 95% CI [.65, .87]) and *au fur et à mesure que* “as” ($M = .82$, [.72, .92]) (see Table 4 for the estimates and Figure 1 for the visualization of the results).

The post hoc pairwise comparison of the performance between the three experimental sessions (see Table 5 for the statistics) showed that teenagers scored significantly higher between Sessions 1 and 2 only for the connective *or* (see Table S4 in the Supplementary Materials for the mean scores per connective and per session). In contrast, the score of the connective *au fur et à mesure que* “as” significantly decreased, while the connective *suivant que* “depending on” received a similar score.

The comparison of the scores between Sessions 1 and 3 revealed that the long-term effect of training remained only for the connective *or* that also received higher scores during the last session than during the first session. The scores for *au fur et à mesure que* “as” remained unchanged and that of *suivant que* “depending on” decreased.

Effects of training type across the different connectives

Prototypical connectives

Session 2. The correctness of responses directly after training during Session 2 was analyzed in order to examine whether the type of training (productive or receptive) fulfilled by participants predicted the performance on the sentence-completion task. The model’s fit improved after adding Connective ($\Delta\chi^2 = 37.58$, $\Delta df = 4$, $p < .001$) and then Correctness Score during Session 1 ($\Delta\chi^2 = 30.86$, $\Delta df = 1$, $p < .001$). In contrast, after including Type of Training (productive vs. receptive), it did not show a better fit ($\Delta\chi^2 = 0.04$, $\Delta df = 1$, $p = .836$). Given that adding random slopes prevented the model from converging, the final model included Connective and Correctness Score during Session 1 as fixed factors and Item, Participant, and Age as random intercepts (see Table 6).

Session 3. The correctness of responses during Session 3 was analyzed to verify whether the type of training had a long-term effect, or a “sleeping” effect (meaning that it did not occur during Session 2, but could appear during Session 3), and predicted the performance on the sentence-completion task, fulfilled four weeks after the training activity. The final model was similar to the one comparing Sessions 1 and 2 and included Connective and Correctness Score during Session 1 as fixed factors and Item, Participant, and Age as random intercepts (see Table 6). The model’s fit kept improving after first including Connective ($\Delta\chi^2 = 50.71$, $\Delta df = 4$, $p < .001$) and then Correctness Score during Session 1 ($\Delta\chi^2 = 24.33$, $\Delta df = 1$, $p < .001$). Similarly, the model did not show a better fit after we added Type of Training ($\Delta\chi^2 = 0.92$, $\Delta df = 1$, $p = .339$) and stopped converging when random slopes were included.

In all, neither did a productive or a receptive training activity predict the performance in the sentence-completion tasks during Sessions 2 or 3. To put it differently, the type of training activity did not affect the use of prototypical connectives either immediately after the training or four weeks after. It was the type of connective that explained most of the variation in the performance on the

Table 6. Estimates of the final models for prototypical connectives, comparing the contribution of the type of training between Sessions 1, 2, and 3

	Estimate	SE	z	p
Session 1 versus Session 2				
(Intercept)	1.27	0.24	5.20	<.001
<i>aussi</i> “therefore”	-1.97	0.29	-6.79	<.001
<i>dans la mesure où</i> “in so far as”	-0.55	0.29	-1.91	0.056
<i>en outre</i> “moreover”	-1.71	0.29	-5.93	<.001
<i>hormis que</i> “except”	-0.63	0.29	-2.19	0.029
Correctness score in Session 1	0.46	0.08	5.62	<.001
Session 1 versus Session 3				
(Intercept)	1.42	0.23	6.06	<.001
<i>aussi</i> “therefore”	-2.17	0.27	-7.96	<.001
<i>dans la mesure où</i> “in so far as”	-0.73	0.27	-2.72	0.007
<i>en outre</i> “moreover”	-2.63	0.27	-9.61	<.001
<i>hormis que</i> “except”	-0.60	0.27	-2.24	0.025
Correctness score in Session 1	0.42	0.08	5.00	<.001

sentence-completion tasks. Finally, these analyses also showed that participants who initially scored better during Session 1 continued having higher scores also during Sessions 2 and 3 (see Table 6 for the statistics of an estimated increase).

Non-prototypical connectives

Session 2. The model’s fit improved after adding Type of Training ($\Delta\chi^2 = 4.48$, $\Delta df = 1$, $p = .034$). Since including other factors did not further improve its fit, the final model included Type of Training as a fixed factor and Item, Participant, and Age as random intercepts (see Table 7).

Session 3. The model’s fit did not improve after including Type of Training ($\Delta\chi^2 = 0.002$, $\Delta df = 1$, $p = .967$), Connective ($\Delta\chi^2 = 4.35$, $\Delta df = 2$, $p = .114$), or Correctness Score during Session 1 ($\Delta\chi^2 = 1.79$, $\Delta df = 1$, $p = .181$).

Overall, results revealed that following a receptive training (and only a receptive training), performance in the sentence-completion task with non-prototypical improved during Session 2 (see Table 7), yet it did not stabilize to Session 3.

Descriptive analyses of different tasks in productive training

The analysis of the participants’ performance during productive training revealed that the task of completing the grammatical rule and the continuation exercise resulted in different performances. For most of the connectives, namely *aussi* “therefore,” *hormis que* “except,” *étant donné que* “given that,” or “and,” *au fur et à mesure que* “as,” *suivant que* “depending on,” teenagers found it more challenging to

Table 7. Estimates of the final models for non-prototypical connectives, comparing the contribution of the type of training between Sessions 1 and 2

	Estimate	SE	z	p
Session 1 versus Session 2				
Productive training	1.64	0.22	7.55	<.001
Receptive training	0.60	0.28	2.15	.032

Table 8. Mean correctness score in the productive training activity, fulfilled by teenagers, per type of task (reconstruction of the rule vs. continuation exercise) and connective

	Rule	Continuation exercise
<i>dans la mesure où</i>	.81	.83
<i>aussi</i>	.49	.58
<i>hormis que</i>	.20	.45
<i>étant donné que</i>	.72	.85
<i>en outre</i>	.81	.53
<i>or</i>	.22	.38
<i>au fur et à mesure que</i>	.60	.84
<i>suivant que</i>	.34	.83

build the rule than to complete the continuation, as hinted by lower mean scores on the rule than on continuation exercise (see Table 8). This finding may suggest that an implicit knowledge of the use of these connectives is stronger than an explicit metalinguistic one. In contrast, *en outre* “moreover” is the only connective that received lower scores on the continuation task than on the rule reconstruction task. This may stem from the fact that, according to the cognitive complexity framework by Sanders et al. (1992), this connective signals a less complex coherence relation of addition that participants understand well and therefore can explain better its functioning from a metalinguistic point of view. It is interesting to point out that, except for the case of *en outre*, the connectives with the highest scores on the rule exercise are the ones with compositional, or transparent meaning, namely, the connectives *dans la mesure où*, *étant donné que*, and *au fur et à mesure que*.

However, the fact that our participants still found it difficult to complete the continuation task, although they could successfully reconstruct the rule about its functioning, suggests that their metalinguistic understanding was not transferred to the ability to use this connective. Finally, the connective *dans la mesure où* “in so far as” seems to be well acquired on both implicit and explicit level, as it received comparable scores for the rule and continuation tasks.

Discussion

The goal of this paper was twofold. First, we assessed the ability to use infrequent connectives in French, signaling prototypical and non-prototypical coherence

relations in a sentence-completion task among teenagers. Second, we tested the role of two types of instruction activities for improving the ability to use infrequent connectives in French. We also examined whether the use of these connectives varied depending on teenagers' degree of exposure to written language, as measured by the ART-F-CL.

Performance with infrequent connectives in French

Our findings revealed that the infrequent connectives tested in this study did not receive comparable accuracy scores on the sentence-completion tasks. The prototypical connectives *aussi* “therefore” and *en outre* “moreover” and the non-prototypical connective *or* got the lowest scores even compared to other infrequent connectives of the same type (see Figure 1 and Table 4). This result suggests that the difficulty with these connectives was not necessarily associated with their low frequency or prototypicality, but rather with a combination of other characteristics of these specific connectives. The challenge of using *aussi* likely stems from a low distribution of its consequence function, which appears in only 10% of uses in corpora compared to its dominant additive function, which appears in 90% of uses. Furthermore, its additive function is prevalent in both oral⁵ (196.5 occurrences per million words) and written⁶ (1191.43 occurrences per million words) modes, while its consequence function is mostly limited to the written mode (40.65 occurrences per million words) and is not really used in oral speech (no occurrences found in corpus data). This disparity may hinder the mastery of the less frequent consequence function, especially for those with limited exposure to written language.

The difficulty of the connective *en outre* probably arises from its rarity in oral speech (1.75 occurrences per million words in oral corpora vs. 91.29 in written corpora) and from being predominantly used in very specific contexts of formal and administrative writing. Moreover, the additive relation it encodes is often conveyed by alternative signals rather than connectives (Das & Taboada, 2018), making participants search for a different interpretation of the coherence relation, where a connective marker would be more informative and expected. As for the connective *or*, its challenge may be explained by the less dominant character of the tested function (30% of the uses in corpora) and by its predominant and specific use in the context of narrative discourse.

Moreover, the fact that the prototypical connectives *aussi* “therefore” ($M = .38$) and *en outre* “moreover” ($M = .38$) on average received twice as low scores as the non-prototypical connective *or* ($M = .75$) across all three sessions indicates that the type of relation did not really condition the connective use. If it were the case, the performances should have been inverted. In other words, prototypical connectives, which have a clear label, at least one more frequently used equivalent connective, and therefore can be more easily described, are not necessarily better mastered by teenagers and easier to train. We hope that our preliminary study on prototypicality will spark interest in further understanding its theoretical and empirical significance.

The role of training versus print exposure

As for the general effect of instruction, only three connectives, namely *aussi* “therefore,” *en outre* “moreover,” and *or*, benefitted from it and received higher scores on the sentence-completion task during Session 2, held immediately after training, than during Session 1 (see Figure 1 and Table 5). However, the beneficial effect of the training activity remained four weeks later only for the connective *or*, which received higher scores also during Session 3. It is possible that the training was efficient on a short term for *aussi* “therefore” and *en outre* “moreover” because the implicit knowledge of these connectives was the lowest, as revealed by the mean scores on the sentence-completion task already in Session 1 ($M_{aussi} = .36$ and $M_{en\ outre} = .38$). Therefore, activating the explicit knowledge system by explaining the functioning of these connectives helped teenagers to perform better on the second sentence-completion task but apparently was not enough to solidify the implicit knowledge and perform on the same level also during the third sentence-completion task. In comparison, probably since the initial knowledge of the connective *or* was higher ($M = .68$), it provided a more solid basis for the training, ensuring that its effect remained four weeks later.

The analysis of the effect of two types of instruction revealed that productive or receptive training did not affect the performance with prototypical connectives on the sentence-completion task neither immediately after the training (Session 2) nor four weeks later (Session 3) (see Table 6). As for non-prototypical connectives, we observed a general beneficial effect of the receptive training immediately after the training but not in the long term (see Table 7). This means that, for most of the connectives, both types of training tasks seemed to have a similar lack of effect on the ability to use infrequent connectives in French. One explanation for the limited effect of instruction activities is that they relied on written materials. Therefore, these activities probably were not as interactive as if the instruction was held in person. Another explanation could be that the training task—a sentence continuation task—was not easily transferable to a slightly different testing task—a sentence-completion one. In other words, participants may not explicitly or implicitly build a connexion between the tasks.

The degree of exposure to print, in contrast, predicted an important part of inter-individual variations in the ability to use both prototypical and non-prototypical infrequent connectives (see Table 3). This result suggests that the ability to use infrequent connectives depends on implicit acquisition through long-term exposure to extensive written input rather than on explicit instruction in form–function relations of such elements. In other words, activating the explicit knowledge of a connective was not sufficient to convert it into implicit knowledge, at least not on the task used in this study. It is apparently not sufficient to explain the connectives’ meanings with a higher or lower degree of involvement, in the same way that it can be done for lexical items encoding a conceptual meaning (Hulstijn & Laufer, 2001). The ability to use infrequent connectives most probably comes from exposure to an extensive and repeated input that allows teenagers to internalize the procedural meaning they convey. In this respect, the acquisition of connectives is closer to the acquisition of grammar than to the acquisition of lexicon. Their procedural meaning involves usage rules that are not easily accessible to consciousness, just like is the

case for other elements of grammar (Wilson, 2011). However, it is possible that combining exposure to written language with the repeated form-focused instruction activities may facilitate the process of acquisition of connective functions in a longer perspective. Further work needs to be carried out to establish which alternative instruction techniques are better suited to enhance the intake that can take place from the input to which speakers are exposed.

Finally, the existing difference between explicit and implicit knowledge of connectives was also hinted at in the exploratory analysis of the performance in the productive training (see Table 8). This analysis revealed that participants performed better on the continuation insertion task than on the rule reconstruction activity for the majority of connectives. This finding suggests that teenagers (and adult speakers for that matter; see Supplementary Materials) have different levels of implicit and explicit knowledge about the use and functioning of certain connectives, as the implicit knowledge of the connective use in context was stronger than an explicit metalinguistic knowledge about their functions. These results indicate that learning how to use connectives in writing may involve explicit and implicit knowledge systems similar to those that may be at play during the learning of a second language (e.g., Ellis, 1994). To put it differently, learning rules of written language may in some way be comparable to learning a second language, at least when it comes to learning the functioning of discourse connectives found mostly in writing for which teenagers cannot rely on spoken input. The involvement of explicit and implicit knowledge systems in the development of the competence with discourse connectives should be further examined in future research, especially by using implicit tasks, allowing to have a more direct access to the implicit knowledge system.

Conclusion

The current study provided several important findings regarding the developing competence with prototypical and non-prototypical infrequent connectives during teenage years. First, the connectives *aussi* “therefore” and *en outre* “moreover” received the lowest scores on the sentence-completion task, even among connectives with comparable or lower frequencies. This result suggests that the frequency of these connectives was not the relevant factor explaining the difficulties observed in previous studies (Tskhovrebova, Zufferey & Gygax, 2022; Zufferey & Gygax, 2020a, 2020b), making them particularly challenging to use.

Second, results for prototypical and non-prototypical connectives were perfectly in line, hinting that the unique character of the coherence relation type could not predict whether infrequent connectives can be mastered. This outcome is in line with previous findings on the diminishing role of the cognitive complexity of coherence relations during teenage years (Tskhovrebova, Zufferey & Gygax, 2022; Tskhovrebova, Zufferey & Tribushinina, 2022; Tskhovrebova, Zufferey & Tribushinina, 2023; Zufferey & Gygax, 2020a, 2020b). That is, coherence relation type is no longer relevant for the use of connectives in a sentence-completion task by teenagers, whether we conceptualize it from the point of view of cognitive complexity as in the cognitive coherence relation approach (Sanders et al., 1992) or

from the perspective of prototypicality as we did in the present study. Therefore, future studies interested in the sources of difficulty in using certain connectives during teenage years and adulthood should analyze those connectives case by case, considering the unique combination of factors that make each specific connective particularly challenging.

Third, we observed that training activities may have a limited impact on the performance with connectives. It is rather exposure to written input that fosters the acquisition and mastery of infrequent connectives in discourse.

Replication package. All materials, data, and code are available on the OSF repository <https://osf.io/9fx6u/>.

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Competing interests. The authors declare none.

Notes

- 1 Frequencies per million words were calculated based on the English Web Corpus (Jakubiček et al., 2013).
- 2 We will use the term *teenagers* to refer to this group of participants for convenience.
- 3 The cut-off for considering the connectives infrequent was based on previous studies assessing the effect frequency on the mastery of connectives in French (see, e.g., Wetzel et al., 2020; Zufferey & Gygax, 2020a).
- 4 Bolding, italics, and highlights in the examples correspond to the style of the materials provided to participants.
- 5 The frequency in oral speech was calculated based on the oral sub-corpus of French Orféo (Benzitoun et al., 2016).
- 6 The mean frequency in writing was calculated based on three corpora, namely journalistic (Le Monde corpus), argumentative (the French part of the Europarl corpus, Koehn, 2005), and a corpus of literary texts (the Frantext corpus, ATILF, 1998–2022).

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