

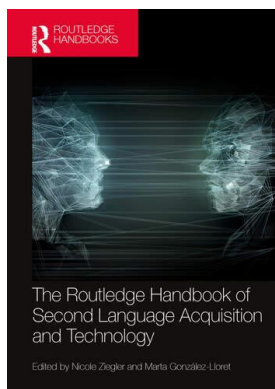
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Nicole Ziegler, Marta González-Lloret

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Alan Taylor

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TECHNOLOGY AND L2 READING

Current Research and Application

*Alan Taylor***Introduction**

L2 reading is an important part of L2 learning research because it provides input into the developing system of the L2 learner, with strong correlations having been found between L2 reading comprehension and other competencies, such as L2 listening comprehension and oral speaking ability (Gottardo & Mueller, 2009; Sparks, 2019). In other words, L2 learners who listen well, read well, and vice versa. However, research suggests that reading online is not the same as print reading (e.g., Ducate & Arnold, 2011; Youngs et al., 2011) and, in some cases, may actually negatively impact learners' ability to concentrate (Carr, 2010; Ya 2015). However, because of the digitized world in which we live, there are a substantial number of resources available for learners to read online in a wide range of target languages, providing learners with numerous choices in terms of genre, level, and topic. This access to a variety of text genres, as well as the availability of extensive reading opportunities, provide learners with exposure to rich L2 input (Taylor, 2019), thereby increasing the potential for subsequent L2 learning (Krashen, 1989). Seeking to better understand the role of technology in fostering and supporting L2 reading, scholars have sought to address a range of research questions on the efficacy of different technologies for improving reading comprehension, and their pedagogical applications across various contexts. This chapter reviews the research on these topics, as well as addresses practical applications and future research directions.

Historical Perspectives***Evolution of CALL Reading***

CALL reading has evolved significantly over the decades. Early computers were used to instruct kindergarteners in learning to decode L1 text in the 1960s. In the 1960s and 1970s, evolving learning systems, such as PLATO by the University of Illinois, were used for L1 and L2 reading instruction and collaboration between schools. This era saw the invention of a plasma screen, a touch screen, and email (see PLATO in references). In the 1980s, researchers generally concluded that reading in paper form was better than on a screen due to the potential eye strain and the limited amount of text that one could put on a screen (Walmsley, 2015). By the late 1980s and early 1990s, programmers started using HyperCard to program more flexible CALL reading programs, such as in the doctorate glossing study by Youngs (1994), in which different aids, such as an electronic dictionary or cultural information, were programmed. Although these early programs were variable in their effectiveness, CALL reading programs became more facilitative of L2 reading comprehension

as they further evolved. For example, in the late 1990s, experimental studies (e.g., Hayden, 1997; Stoehr, 1999) demonstrated that CALL reading could be highly effective with various types of digital aids. Hayden (1997) showed how even when other digital aids were provided, most students simply consulted L1 translations, which in turn facilitated L2 reading comprehension. Building on this work, Stoehr (1999) demonstrated the effectiveness of L1 and L2 glossing in CALL reading contexts. In the 2000s, there were enough CALL studies to start conducting quantitative meta-analytic reviews (e.g., Taylor, 2006, 2009, 2013, 2014b, 2020), providing the field with synthesized conclusions on the extent to which various treatments for CALL reading may be effective.

History of CALL Glossing

In L2 reading, L1 translations or annotations, traditionally occurring in the margin of the L2 text or at the bottom of the page, are referred to as glossing. Glossing can be done in the L1, L2, with pictures, with combinations of pictures and words, or other multi-modal formats. Early computer assisted-language learning (CALL) studies on glossing in the 1990s (e.g., Aweiss, 1993; Goyette, 1995; Hayden, 1997; Stoehr, 1999) and in the 2000s (e.g., Abraham, 2007, 2008) found that glossing can have a significant positive effect on L2 reading, demonstrating the support glossing provides in terms of enabling learners to read authentic texts above their current reading level. For example, Taylor (2002) found that CALL L1 glossing was more effective than paper-based glossing, while Abraham's (2008) more general meta-analysis on the effects of various types of glossing on L2 reading comprehension found that "learners who have access to computer-mediated text glosses perform consistently better on measures of L2 reading comprehension than learners who do not have such support" (p. 210). Similarly, Taylor (2009) studied the general effects of glossing (whether L1 or L2) on L2 reading comprehension, concluding that both traditional, paper-based glosses and CALL glossing were effective. In 2013, Taylor updated the research on CALL L1 glossing, finding that most (90%) L2 readers with CALL glosses performed (and should perform in classroom settings) higher on L2 reading comprehension tasks than L2 readers without CALL L1 glosses. Findings suggest that CALL L1 glosses are more flexible, less intrusive, and give more control to L2 readers than L1 paper-based glosses. Further, CALL glosses also provide opportunities for L2 readers to focus their attention on vocabulary and meaning, potentially supporting subsequent L2 development. In another CALL study, Taylor (2014b) found that the percentage of glossing, as suggested by earlier research (Jacobs, 1994; Taylor, 2002, 2006), was not necessarily the most important consideration in L2 reading. Taylor observed that the presentation of the glossed item, rather than the percentage of text glossed, was the most influential variable in reading comprehension. Taylor also noted that most of the CALL L1 glossing studies with the highest effect sizes had only 5% glossing. This finding suggests that the effectiveness of L1 glossing may be due to attention and noticing (Schmidt, 1990, 1994), as well as the effectiveness of the CALL environment, rather than the quantity of glosses, which was previously claimed to be a key variable in L2 reading (Jacobs, 1994, Taylor, 2002). Although some L1 glossing studies show that lexical aids are not always needed and can occasionally become a distraction (Cheng & Good, 2009; Taylor, 2010), this does not mean that CALL glossing is not effective for supporting L2 reading. Rather, L2 learners' attentional resources may be more effectively exploited with CALL glosses because they are less distracting than paper-based glosses, although this efficacy may be mediated by the location of glosses in relation to the glossed item (Abuseileek, 2008, 2011).

Glossing has also been found to be equally or more effective than reading strategy training. For example, Taylor (2014a) found that glosses are slightly more effective than strategy training in supporting L2 reading comprehension. It is important to note, however, that glossing and strategy training were both substantially more effective for reading comprehension than no treatment. This finding indirectly corroborates claims by Laufer (1996) and Bernhardt and Kamil (1995) that

linguistic knowledge plays a more fundamental role in L2 reading comprehension than other types of knowledge, such as background knowledge or reading strategies, which is also the case for CALL reading studies in general (Chun, 2011).

Generally, the L2 reading field has progressed from experimental to meta-analytic research, and most recently, to second-order meta-analyses. For example, Plonsky and Ziegler (2016) combined four meta-analyses conducted on CALL glossing in a second order meta-analysis, with findings demonstrating a large effect size for the impact of CALL glosses on learners' L2 reading comprehension, suggesting positive developmental benefits. Specifically, results suggest that learners using CALL glosses would outperform nearly 71% of learners who did not use CALL glosses in terms of reading performance. However, these positive effects may be mediated by confounding variables that can minimize the observed effects of CALL glossing, such as requiring glosses to be consulted (Plass et al., 2003), not including enough glosses, providing too many lexical items in the gloss itself (Abuseileek, 2011), or not accurately assessing reading comprehension (e.g., Chen & Yen, 2013; Hayden, 1997; Taylor, 2020).

Overall, past studies of CALL L2 reading have generally shown that L2 reading is often facilitated by CALL resources (e.g., Taylor, 2002), but not always (e.g., Chen & Yen, 2013; Lomicka, 1998); variables such as how texts are enhanced and measured along with the technology used can be critical factors affecting reading comprehension.

Critical Issues and Topics

L2 reading can be categorized as intensive and extensive reading. Intensive reading is attempting to understand a text as much as possible, usually within a shorter period of time, whereas extensive reading is reading as much as possible for enjoyment over a longer period of time without a focus on specific language features. Online reading can be both extensive, with the L2 reader perhaps surfing the net in the L2, etc., whereas intensive reading may involve reading a short article multiple times in order to better understand it or to develop fluent reading skills (Arnold, 2009). These different types of reading are indirectly related to Krashen's distinction (Krashen, 1982) between second language acquisition and learning, with acquisition being more natural (i.e., extensive reading) and perhaps more effective than learning (i.e., intensive, or close reading). A proponent of extensive L2 reading, Krashen claimed that extensive L2 reading could provide much of the input for L2 learning, including increasing L2 spelling competency along with L2 vocabulary learning (Bamford & Day, 2004; Krashen, 1989).

The amount of L2 vocabulary knowledge and the selection of an L2 text in CALL reading are also important considerations that impact learners' L2 reading comprehension. Research has shown that a certain threshold of L2 vocabulary knowledge is necessary if a student is attempting to read a text (Laufer, 1996; Taylor, 2019). Understanding this can help teachers and researchers better select a text that is a better fit for the L2 reader. If a reader is too competent for a certain text, or not competent enough, the effects of different interventions, such as reading strategy training or CALL glossing, could be negligible (e.g., Joyce, 1997; Taylor, 2002, 2010). Research suggests that L1 reading is similar to L2 reading in terms of potential skill transfer between the two languages if there is sufficient L2 vocabulary knowledge. For example, the ability to skim a text or guess the meaning of an unknown L1 word (perhaps while reading an academic article) can, to at least some degree, be transferred to L2 reading if the overall L2 level is high enough (Alderson, 1984; Clarke, 1980). However, L2 reading is different to L1 reading because of word and sentence-level decoding issues (i.e., the inability to understand certain words and sentences in an L2 text). Although these issues can exist in L1 reading, they are more extensive in L2 reading, and thus may have a greater impact on learners' reading processes. In other words, L2 readers may not have the vocabulary nor discourse knowledge necessary for full (or sometimes partial) reading comprehension. Choosing a text at or slightly above learners' level is an effective method for mitigating these L2 associated

decoding issues. Educators, for example, may wish to draw on available CALL resources with which to measure text difficulty such as <https://readable.io/text/> for EFL or ESL texts.

In sum, most issues in technology-mediated L2 reading relate to how to increase reading comprehension and how to best measure reading comprehension. L2 instructors want their students to read better, acquire more vocabulary and grammar, and be able to find out what is comprehended. CALL resources can often be used to improve reading. However, they may not always be the best resource in every context. In CALL reading, certain interventions or treatments (such as glossing) involving technology can facilitate L2 reading comprehension.

CALL Glossing and Vocabulary Learning during L2 Reading

Research suggests that reading may benefit learners' acquisition of L2 vocabulary (Krashen, 1989), which, along with listening comprehension ability, are good predictors of L2 reading comprehension success (Sparks, 2019). Vocabulary is necessary for reading as well, with Laufer (1996) suggesting that unless an L2 reader knows 95% of the words in a text, or about 3,000 for general reading, no amount of strategies can make up for the lack of vocabulary knowledge. The L2 reader cannot recognize words that are unknown visually or audibly. Meta-analytic research has shown that vocabulary knowledge has a high correlation ($r = .79$) to L2 reading comprehension (Sparks, 2019), highlighting the importance of this skill for learners' reading development.

So how might computers facilitate vocabulary learning? Recently, Plonsky and Ziegler (2016) observed a large effect size (1.33) for CALL glossing for vocabulary learning during L2 reading, suggesting that glosses may provide the meaning of words in context, and, because they are essentially like a dictionary, words may be learned even more effectively than text comprehension, although they are likely strongly correlated. Glosses can be highly effective when placed in a text because the words around them provide additional meaning. For example, Abraham's meta-analysis (2008) found that approximately 89% of students with general CALL glossing of various types performed higher on immediate vocabulary tests than those without CALL glossing. For the delayed vocabulary post-test, 87% of L2 readers performed better than those without CALL glossing. Thus, findings suggest that CALL glossing may be conducive to L2 vocabulary learning, which in turn may improve reading comprehension. Abraham also found that intermediate learners not only performed higher than beginning and advanced learners on immediate L2 reading comprehension tests, but also on the immediate vocabulary tests as well, suggesting that there may be a kind of optimal fit between learner level and text level that has to occur in order for CALL to be effective for L2 vocabulary learning. Learning vocabulary while reading in a technology-mediated format can also positively influence other L2 skills, such as listening comprehension (Johnson & Heffernan, 2006). Digital Game-Based Learning (DGBL), which can teach culture, vocabulary, and reading to students, has also been found to support learners' acquisition of L2 vocabulary. By providing learners with an interactive fiction (IF), in which the participants, for example, can adopt the role of an American foreign exchange student in a European context (Neville et al., 2009), the integration of vocabulary in listening, writing, and especially CALL reading skills, may be enhanced (Neville et al., 2009).

Reading Strategy Training

Strategy training has been generally shown to be effective in L2 learning (e.g., Plonsky, 2011), with research on reading strategy training demonstrating efficacy for L2 reading comprehension in paper-based studies (Taylor et al., 2006). Reading strategy training consists of instructing students on how to better approach L2 texts, and thus optimize their L2 learning opportunities, and might include skimming a text, guessing meaning from context or perhaps concept mapping. Although reading strategy training is somewhat under-represented in CALL when compared to traditional

contexts, studies have shown that CALL reading strategy training can be effective in both the short-term and long-term (Huang, 2013).

The effectiveness of strategies in CALL L2 reading relates to the learner level; since 95–98% lexical coverage is necessary for L2 text comprehension (e.g., Chun, 2011; Grabe, 2009; Laufer, 1996; Nation, 2006). Thus, the more initial competency a student may have, the more or less need there would be for using strategies in CALL L2 reading. However, the efficacy and types of reading strategies in a CALL context may also be mediated by the context in which the reading occurs. For example, Iranian readers of English as an L2 used less meta-cognitive strategies than Canadian readers of English as an L1 while reading online (Taki, 2016). This may be an obvious finding, since one would assume that more strategies could be used with full lexical and grammatical capability. It is possible that differences in strategy use may be cultural and linguistic; therefore, some learners may be more encouraged to use meta-cognitive strategies than others, who may be more focused on word meanings and their importance. Thus, Iranian readers may not have had the full automaticity of L2 reading of English-speaking Canadians.

Reading Comprehension Assessment

The type of task provided for participants of experimental and control groups is an important variable in L2 reading comprehension studies because it can influence the results of quantitative experiments on reading comprehension, as demonstrated in studies by Shohamy (1984) and Wolf (1993). In other words, the type of assessment is likely to affect how well learners are measured to perform. Bernhardt (1991) claimed that reading comprehension was best measured through recall protocols. Perhaps in part because of Bernhardt's (1991) influence, many studies in the 1990s specifically comparing glossing conditions have used the L1 recall (e.g., Jacobs, 1994; Joyce, 1997; Luo, 1993) protocol to measure reading comprehension. Through this protocol, idea units (i.e., basic ideas in the content of the text) are assessed in comparison to the template of the total amount of units existing in the text. They are then counted with regard to their correctness and cohesiveness in the context of the “real” meaning of the text. Other studies assessing reading along with vocabulary acquisition have used other receptive instruments, including multiple-choice tests (e.g., Ko, 1995; Kwong-Hung, 1995).

The type of test may help explain why some CALL studies show lesser or non-significant effects of certain treatments on L2 reading comprehension. For example, Stevens and Taylor (2009) found that studies of L1 glossing that measured L2 reading comprehension via L2 multiple-choice tests had much smaller effect sizes than those measuring L2 reading comprehension via the L1 protocol. They observed that L1 glossing, when measured with a multiple-choice test in the L2, resulted in a “marginally significant decrease in L2 reading comprehension” (p. 69). On the other hand, in a quantitative meta-analysis studying the effects of reading strategy training on L2 reading comprehension, Taylor et al. (2006) found that there was no significant difference between productive (i.e., recall protocol, cloze testing, etc.) and receptive (i.e., multiple-choice) tests. When grouping the studies according to the type of tests they administered, whether productive or receptive, Taylor et al. (2006) observed mean effect sizes of .50 for L2 productive tests and .40 for receptive tests. The difference between groups was not even close to being significant ($p = .51$), so it is possible that both groups actually shared the same overall mean effect size, though more research is needed on this question. Taylor et al. (2006) also found that as long as the testing instrument had validity and reliability, there was no difference between studies according to type of test. More specifically, they found that not only was there no significant difference between groups of studies that used different tests, but also no significant difference was found between studies more generally grouped according to whether they were productive or receptive tests. These results are similar to Chun's conclusion (2011) that “a variety of test items should be used” to test L2 vocabulary and reading comprehension in technology-mediated environments (p. 160). In order to more accurately evaluate

the effects of a treatment on L2 reading comprehension, students should take multiple measures to provide a more comprehensive assessment. In other words, when students are tested with different types of tests, the more accurate the results become (Taylor, 2020).

Another variable that can be influential in L2 reading comprehension is the length of the L2 text in the treatment, since research has suggested that glossing, for example, cannot have a significant effect on L2 reading if the text is not long enough for the glosses to influence the results (Taylor, 2002). It is logical to assume, if there is a very short text that is read by the students with very few glosses, that there will not be an accurate statistical measurement of the differences between groups in terms of reading comprehension (e.g., Chen & Yen, 2013).

Other types of tests have been used to assess basic reading comprehension. Chang (2006) compared a L1 recall protocol and a translation test in which the participants simply translated the passage to their native tongue with no other treatments involved. Results indicated that the translation task was a better indicator of L2 reading comprehension than the L1 recall, however, the author acknowledged that both the L1 recall and translation tasks were less feasible than other tests (Chang, 2006).

Much concern about L2 testing of reading depends on how accurately the questions test knowledge (validity concerns) and how consistent the results would be among students (reliability concerns). Multiple-choice tests should be written so that they accurately test reading comprehension. They should be dependent on L2 reading content and not on testing skill. CALL testing goes quite well with multiple choice testing with online programs such as Brightspace, Brainhoney, Blackboard, or Canvas because they can be programmed to grade automatically upon completion of a test. Thus, more lengthy, valid, and reliable items can be included to provide a more accurate picture of student comprehension. The instructor should be ready to correct or change the items based on any validity concerns observed while examining test results, however. As Bernhardt (1983) has claimed, some multiple-choice tests can be taken without any knowledge of the text in question simply because multiple-choice tests, due to their nature, risk not being very valid. This has been shown to often be the case in research in which reading comprehension was a secondary focus, and thus the testing was not extensive (e.g., Chen & Yen, 2013; Ko, 1995). Further, if there are only a few items on a multiple-choice test, there is a much smaller chance of gaining an accurate picture of what the L2 reader truly has comprehended (or the effects of a treatment) before, after, or during L2 reading. Overall, then, careful consideration regarding the construction of CALL reading assessments remains a critical issue, highlighting the need for researchers to make tests that consistently, accurately and practically measure L2 reading comprehension.

Main Research Methods

Quantitative and Qualitative Primary Studies

Both quantitative and qualitative methods are often used in reading research (e.g., Hayden, 1997; Youngs, 1994). For example, Youngs (1994) conducted a quantitative experiment on the effects of a CALL reading program with comprehension aids on the effects of reading comprehension. Near the end of the study, she also conducted interviews (qualitative research) to better understand how the program performed and how the students felt about the program. This multiple methods approach provided a holistic perspective to the research questions, with the quantitative data providing information on how much learners understood and the qualitative data demonstrating to what extent the CALL program may have helped the students (Youngs, 1994).

The research methods used would, of course, be determined by the research question. For example, if the research question were: What are the effects of CALL glossing on L2 reading comprehension? We could use a quantitative approach to examine this question. For example, Stoehr

(1999) studied the effects of different types of CALL glossing (L1 or L2) on L2 reading by randomly assigning participants to different groups with and without glossing. She had students read an authentic L2 text and administered an L1 recall protocol and multiple choice test. Finally, Stoehr statistically compared them, finding that groups with CALL L1 and L2 glosses had a significant effect on L2 reading when compared to a control group with no glosses. A qualitative aspect of a similar experiment is Hayden's (1997) dissertation which, after a quantitative experiment on CALL glossing, interviewed learners to find out what they thought while consulting CALL glossing. The qualitative aspect to Hayden's study provided important data and was a springboard for future quantitative research (e.g., Taylor, 2006) by examining student lookup behavior.

Meta-Analysis

Another research methodology that has gained prominence in SLA is meta-analytic and synthetic research (Norris & Ortega, 2006). The purpose of a meta-analysis is to statistically combine studies with the intent of explaining a relationship, whether it is correlational or causal, between variables. Meta-analyses treat the problem of conflicting results among studies (Glass et al., 1981; Vockell & Asher, 1995). For example, if a researcher desired to know the overall effect of a particular treatment on L2 reading comprehension in CALL, studies can be combined, providing a stronger sample size and more confidence in the results (see Taylor, 2006, 2009). However, there are both advantages and disadvantages to conducting a meta-analysis for answering a particular research question. One disadvantage would be that meta-analysis as a research approach is too general; the nuances of primary studies can be ignored by looking at general, overall results. Indeed, Cronbach (1982) suggested that although an overall effect size in a meta-analysis shows a treatment may be effective, it does not mean that it always is effective among human subjects. On the other hand, an advantage of meta-analysis would be the ability to synthesize contradicting findings in the research literature. In most studies with human subjects, there is variability in findings so meta-analyses will likely be relevant in the future. Of course, no meta-analyses would be possible without the experimental primary studies conducted on various topics. In order for meta-analyses to effectively treat major theoretical questions in CALL reading, primary research will always be necessary and useful for answering pertinent, yet untreated questions that push the field forward.

Recommendations for Practice

Following is a list of some of the most basic recommendations suggested by the results of the current experimental CALL research on facilitating L2 reading comprehension:

- 1 CALL glossing should assist L2 students in L2 reading comprehension and L2 vocabulary learning.
- 2 L1 and L2 or pictorial CALL glosses should be used judiciously by the teacher in the L2 classroom. They are not always beneficial.
- 3 In CALL reading experiments, the L2 text needs to be extensive enough in order for the reading strategy or glossing to have an effect. Short texts can be used; however, they may not show an effect for the treatment.
- 4 Student learning or reading level should be taken into account in CALL studies. Online L2 texts that are too easily comprehended may not show any effect (or maybe even a detrimental effect) for a treatment such as strategy training or glossing because the participant does not need the assistance.
- 5 Mobile devices can facilitate L2 reading comprehension. For example, an iPhone with Google augmented reality (i.e., the phone's camera automatically recognized the language and

- instantly translates it) used on paper or CALL texts should produce results similar to experimental research suggesting CALL glossing facilitates L2 reading comprehension.
- 6 CALL glossing can be very flexible and adaptable to L2 readers' needs. In a classroom with different levels of students, CALL glossing can be very effective.
 - 7 L1 glossing in CALL may not always be better than L2 glossing. For upper-division CALL courses, perhaps L2 or pictorial glossing may be more in line with curricular goals. Students need to learn to guess meaning from context, for example, which may mean L2 glosses or even no glossing should sometimes be used.
 - 8 Large amounts of glossing may not be essential for optimal CALL reading comprehension; moderate or even small amounts of glossing can be more effective.
 - 9 Authentic texts can be very useful in CALL reading. There are now good CALL resources with which to measure text difficulty such as the website Readable: <https://readable.io/text/> for EFL or ESL texts. This could be very helpful with researcher and practitioners for providing texts that are good for reading level of their study or classroom.
 - 10 Strategy training has been shown to positively influence L2 reading comprehension and should make a difference in CALL studies. Instructors can provide strategy training with videos and online information. Practitioners should train students as much as possible to improve L2 reading comprehension.
 - 11 The L1 or L2 recall protocol or a multiple-choice test with an adequate number of test items can accurately assess comprehension. Other types of assessments that do exist take more time (i.e., the oral recall, think-aloud protocol).
 - 12 CALL assessment instruments can be both receptive and productive tests to be effective. Receptive assessments need to have an adequate number of items on them to assess L2 reading.

Future Directions

There are few experimental quantitative studies that have been conducted on the effects of reading strategy training in a CALL context (aside from Liu et al., 2010), and studies without a control group do exist (e.g., Huang, 2014), but they are not generalizable. More experimental research with a control group and randomized assignment of participants (so the results can be generalizable) needs to be conducted on how, in CALL contexts, L2 learners can better use strategy training to read more effectively. Studies on skimming, scanning, predicting, summarizing, looking for the main idea, and using meta-cognitive strategies should be conducted in CALL contexts.

Another important area of study that needs primary research is the differences across various forms of CALL reading assessment. Most of the studies included in the present chapter have looked at L2 reading assessment through meta-analysis and were not necessarily the main focus of the studies cited. Studies comparing multiple choice, L1 recall protocol, L1 translation, cloze testing, true/false, and multiple-choice testing should be conducted and would be very valuable to CALL reading research. These could simply be conducted with participants reading an L2 text online, and then randomly taking different tests of that reading comprehension in varying order to measure how they may differ in their results. The results could also be compared to L2 learner level as well since more advanced learners may perform differently on certain types of assessment tasks than beginning or intermediate-level learners based on various treatments (Taylor, 2010). More studies, such as Chang's (2006) study of translation versus L1 recall, should be conducted in technology-mediated contexts. More specifically, studies on the use of the L1 oral recall should be conducted (e.g., Goyette, 1995), as recall tests have been found to be less effective, although these results are not conclusive (Taylor, 2002).

More studies should also be conducted on the difference between electronic dictionary assistance, in which the L2 reader actually types a word instead of clicking on a word to find a translation or

definition. Typing a word in an online dictionary may take more time and halt the reading process further. Past meta-analyses, (e.g., Taylor, 2020) could be further divided up into instant-glossing versus dictionary glossing and how they affect reading comprehension. Further, there are many studies that include 5% or less of a text glossed (Aweiss, 1993; Bowles, 2004; Salem, 2006; Taylor, 2020; Yanguas, 2009). However, there are much fewer that include, say, 5-10% of the text glossed or above 10%. The remainder of the literature, according to the latest meta-analytic CALL research, shows a lack of gradation of glossing in studies (Taylor, 2020). More studies on the differential effects of the amount of the glossing should be conducted because this question has not yet been resolved; many researchers have claimed that more glossing helps, but this is not always the case, as recent research has shown (Taylor, 2020). In other words, there may be a threshold at which CALL glossing is more or less effective. Many CALL reading studies (on CALL glossing, for example) are conducted with well-chosen L2 texts for the learner level (e.g., Salem, 2006; Yanguas, 2009); future studies showing how an app such as Google Translate could be used with varying textual levels would add a more real-world aspect to the CALL reading research.

Learner proficiency should also be studied more in depth, since past studies (Joyce, 1997; Taylor et al., 2006) suggest that learner proficiency level (i.e., advanced, intermediate, and beginner) or learning context (i.e., EFL or ESL) may strongly influence the effectiveness of various treatments on L2 reading comprehension. The association between language proficiency and CALL reading competency would be another important variable of interest. For example, because many CALL studies have EFL learners who often have more than 10 years of L2 learning experience, there is a need for more research examining the use of glossing or reading strategy training for more skilled learners as well as more novice learners. In other words, the efficacy of strategies and glossing may vary across readers of different skills and proficiencies. In particular, more research examining novice readers or non-university readers is needed to better understand how learner variables may impact L2 reading in technology-mediated contexts.

Finally, as artificial intelligence (AI) becomes a more normalized part of our lives and starts entering the field of education, research on how AI might interact with reading will be necessary. For example, instead of humans having to look up words in a dictionary while reading an L2 text online, it is possible that AI-powered translation such as Google neural machine translation (NMT) and Microsoft's NMT translator (Taylor, 2019) may become so accurate and rapid in technology-mediated environments that L2 knowledge and ability will only be necessary as conversational skills between humans and not necessarily in reading online L2 texts. In addition, CALL resources, such as those identifying text difficulty (<https://readable.io/text/>) or online testing in an LMS such as Canvas, are excellent for conducting research, helping students understand more L2 text, and providing more opportunities for learners to receive L2 input, highlighting potential areas for further exploration.

Further Reading

Bell, F. L., & LeBlanc, L. B. (2000). The language of glosses in L2 reading on computer: Learners' preferences. *Hispania*, 83(2), 274–285.

Bell and LeBlanc's study compares L1 and L2 CALL glossing. The findings indicate that, for third semester students of Spanish, probably the most tested level of glossing, students consult L1 glossing about twice as much as L2 glossing. Also, the authors discuss how glosses fit in a CALL context and the general benefit of glosses.

Chen, I. J. (2016). Hypertext glosses for foreign language reading comprehension and vocabulary acquisition: Effects of assessment methods. *Computer Assisted Language Learning*, 29(2), 413–426. <https://doi.org/10.1080/09588221.2014.983935>

Chen studied how different assessment methods can influence the results of studies. This is quite a rare study because it examines assessment along with the effects of different glossing methods. It was conducted in the context of students learning English as a Foreign Language.

Chun, D. M., & Plass, J. L. (1997). Research on text comprehension in multimedia environments. *Language Learning & Technology*, 1(1), 60–81.

A classic article that provides context to issues in CALL reading. It discusses how textual and pictorial glosses can be important. It addresses dual coding theory and provides a CALL reading model. If a researcher is looking for direction, this article is a good starting point.

Gettys, S., Imhof, L. A., & Kautz, J. O. (2001). Computer-assisted reading: The effect of glossing format on comprehension and vocabulary retention. *Foreign Language Annals*, 34(2), 91–106. <http://doi.org/10.1111/j.1944-9720.2001.tb02815.x>

This study delves into CALL glossing. It also demonstrates how lexical glossing formats are better than sentence-level formats for L2 reading comprehension.

Singer, L. M., & Alexander, P. A. (2017). Reading across mediums: Effects of reading digital and print texts on comprehension and calibration. *The Journal of Experimental Education*, 85(1), 155–172. <https://doi.org/10.1080/00220973.2016.1143794>

An article that shows how participants comprehend printed texts better than CALL texts despite their own preferences and predictions. This article should be the starting point for future CALL reading research because it shows how perception is not always consistent with reality.

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