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Computer-assisted vocabulary learning for Deaf learners of foreign sign languages

Benjamin J. Cavaletto

COMPUTER-ASSISTED VOCABULARY LEARNING FOR DEAF LEARNERS OF FOREIGN SIGN LANGUAGES

by

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This thesis meets the standards for appearance, conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.

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Dean of the Graduate School

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PERMISSION

Title	Computer-Assisted Vocabulary Learning for Deaf Learners of Foreign Sign Languages
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ABBREVIATIONS

ASL	American Sign Language
BSL	British Sign Language
CALL	computer-assisted language learning
CAVL	computer-assisted vocabulary learning
L1	first language
L2	second language
LESCO	Costa Rican Sign Language (Lengua de Señas Costarricense)
LIS	Italian Sign Language (Lingua dei Segni Italiana)
LSCh	Chilean Sign Language (Lengua de Señas Chilena)

ABSTRACT

Deaf people have as great or greater need and desire to learn foreign languages as their hearing peers. Currently it is difficult for these learners to find courses and materials that are appropriate for their learning needs. Especially difficult is finding courses or learning materials for learning sign languages, which are more motivating and more accessible for Deaf learners than spoken languages. Additionally, evidence is presented that learning a foreign sign language can act as a bridge to learning a spoken language from the same region. The study presented in this thesis tested the efficacy of a computer-assisted vocabulary learning program designed for learners of signed languages. Participants using the experimental program were able to learn vocabulary from Chilean Sign Language more efficiently than studying vocabulary from a dictionary, the method most commonly available for learning foreign sign language vocabulary at this time. These statistically significant results show that even relatively simple programs can improve upon current vocabulary learning resources.

Chapter 1
INTRODUCTION

As a staff interpreter at the National Technical Institute for the Deaf, I have observed dozens of students close hand, over years of study, as they have engaged in learning foreign languages, both spoken and signed. Though I am often impressed with their accomplishments, I find myself more frequently lamenting the lack of appropriate resources for Deaf learners, and especially the lesser access to learning foreign sign languages compared with spoken languages. An important example of this is the lack of materials for practicing sign language vocabulary through quizzing.

In this thesis, I present evidence from an experiment in which 28 Deaf adults learned vocabulary in Chilean Sign Language (LSCh) using a simple quizzing program on the computer as well as from a sign dictionary. Participants were able to learn more vocabulary using the new quizzing program than from the traditional sign dictionary; this difference was statistically significant. I also argue for the importance of foreign sign language study for Deaf learners, both as a bridge to learning foreign spoken languages and also as a benefit in its own right.

For the purposes of this study, FOREIGN LANGUAGE LEARNING is defined as learning a foreign language (spoken or signed) without traveling to the region where that language is used. This does not include people who are raised in multilingual families or communities who naturally acquire multiple languages. It also does not include those who travel or study abroad to accomplish their language learning. However, foreign language learning often occurs prior to travel as preparation. In the absence of a community of language users, foreign language learners may take formal classes or engage in independent study with books or online resources. While learning in an immersive environment is undoubtedly best, there are a number of good reasons for engaging in foreign language learning.

The remainder of this chapter provides the rationale for the current experiment, by arguing for the importance of foreign language learning for Deaf people, with attention to both spoken and signed languages. It further argues that sign language multilingualism can be a bridge to literacy in foreign spoken languages, and also as an important pursuit in its own right. It reviews the limited opportunities for foreign sign language learning and introduces the computer-assisted vocabulary learning (CAVL) program that was created for this study. The hypothesis tested by this experiment was that the CAVL program allows Deaf adults to learn vocabulary from LSCh more efficiently than does the existing method (that is, by studying vocabulary from an online sign dictionary). Chapter 2 provides the detailed methodology for the experiment, using a within-subjects design. Chapter 3 discusses the results of the experiment, which confirm the hypothesis. Chapter 4 discusses limitations and related issues and suggests steps for future developments of similar programs to increase access for Deaf learners of foreign languages. Chapter 5 summarizes the findings and the arguments.

1.1 Deaf people and foreign languages

Deaf[1] people have at least as much motivation to learn foreign languages as their hearing peers, and arguably more. They share many of the reasons for learning foreign languages that hearing people have. Deaf learners, too, may wish to prepare for upcoming travel, or to improve their economic standing. For example, a rapidly increasing number of Deaf people around the world are gaining access to post-secondary education and many of them are learning English for Academic Purposes in order to do so (Domagala-Zysk 2013). Some Deaf learners may be interested in connecting with their family heritage. Some are required to take

[1] Following convention, I will use capitalization to distinguish between audiological and cultural deafness (Lane, Hoffmeister & Bahan 1996). A lowercase “deaf” is used to refer to the physical characteristic. An uppercase “Deaf” is used when referring to Deaf or Hard of Hearing individuals or Deaf communities.

foreign languages by their school. Others simply may be struck by the desire to study languages (Mole 2005).

However, Deaf people have additional reasons to engage in foreign language learning that their hearing peers do not have. Generally, Deaf children have severely limited access to the spoken language(s) of the home. Even in a monolingual home with hearing parents who speak the national language, the process of learning a spoken language (either through print literacy and/or oral training) greatly resembles a second language acquisition process (Berent 2009).[2] In a home that is multilingual, the need for Deaf to engage in foreign language learning is even greater. When hearing people are born to a multilingual family, they are likely to acquire the family languages without extra intervention. However, as mentioned, Deaf children generally have severely limited access to the spoken languages of the home. h[3] In these cases, for the Deaf child to become multilingual in the family languages, it is typically necessary to engage in foreign language learning.

Furthermore, many Deaf children grow up in homes that do not regularly use the national language, or use it in addition to other languages. For example, in the United States, a recent survey by the Gallaudet Research Institute (2013) found that in 18.4% of homes with a Deaf child, English was not a language used regularly in the home. In 35.0% of homes, parents reported that another language besides English or American Sign Language (ASL) was used regularly in the home, predominantly Spanish (19.4% of homes). These data show that, at

[2] Most Deaf children are born to hearing parents who do not learn to sign. For example, in the United States—a very affluent country, where sign language is growing in positive regard—72.1% of Deaf children and youth live in homes where sign language is not regularly used according to a recent survey from the Gallaudet Research Institute (2013). In many other countries of the world that number is sure to be larger.

[3] When Deaf children are born to families multilingual in *sign* languages, they too, will acquire the family languages without extra intervention.

least in the US, Deaf children are being raised in homes which are not monolingual in the national language.

Some Deaf are able to make use of residual hearing, assistive hearing devices, and oral training to develop facility in one (or more) spoken languages, but many cannot. Even for those who *are* able to learn to speak the national language, the necessary time and training for speaking an additional language is unlikely to be available, either at home or in a foreign language class. For this reason, when this thesis refers to Deaf who are learn a foreign spoken language, I will focus on those who do so through its written form, that is, their goal is to read and write the language, not to speak it.

One way that Deaf students engage in foreign language learning is to enroll in formal classes (usually in secondary and post-secondary settings in the U.S.) but unfortunately these classes are typically not designed to suit the educational needs of Deaf learners. Additionally, there are not many resources for instructors (or access services providers, that is, interpreters or captionists) who wish to adjust their classes to accommodate Deaf learners. It is, no doubt, partly because of this that Deaf learners are sometimes exempted from requirements to take foreign language courses, and in some cases actively discouraged from doing so (Kontra 2013). There are a few pioneering texts that attempt to fill in this gap in knowledge, including Mole (2005) and Domagala-Zysk (2013). Unfortunately, these texts limit themselves to the topic of Deaf learners of *spoken* languages.

I only know of one resource that focuses specifically on the task of Deaf learners becoming multilingual in sign languages. It is a multilingual sign dictionary called the Spread the Sign Web Dictionary. This project was launched in the European Union in 2006 and has now grown beyond Europe to include 25 national sign languages. The intent of the dictionary is to support Deaf learners of sign languages, especially those planning to travel to other countries for vocational reasons. A team from each member country provides the sign videos and sometimes additional features such as a definition in the national spoken language, an audio recording of the word in the national spoken language, and even images. In addition to individual words,

the dictionary also contains phrases. It is possible to browse signs based on a wide range of semantic categories. It is also possible to refine search results based on word class. This website is also available as an app for iPhone and Android platforms, which opens the possibility for the program to be used as a travel phrase book.

Almost all research on second language acquisition relates to hearing learners of spoken languages. This research fails to consider the impacts of second language (L2) learning in a different modality than the first (e.g., learning a sign language after learning a spoken language). Iconicity[4] and space, in particular, likely play roles in sign language learning that will not be accounted for in the existing second language acquisition literature. Chen Pichler and Koulidobrova (to appear) review the research that has been done for L2 learners of sign languages, both those who have a spoken first language (L1) and those who have a signed L1. However, little exists about the latter category, Deaf learners of foreign sign languages. The authors argue that further research in this area is important for the opportunity to test "'typical' patterns of L2 acquisition that have been established almost exclusively on the basis of spoken L2 acquisition by hearing learners."

1.2 Foreign sign languages as a bridge to literacy in other languages

There are a number of reasons to believe that learning a foreign written language could be facilitated by learning the foreign sign language used by Deaf people from that community. The first is that signs might provide Deaf learners with a natural language in an accessible modality so that when they read unfamiliar words in the written language they can decode them using the related signs.

Lane, Hoffmeister, and Bahan (1996: 98–99) describe a study by Shand (1982) which provides evidence that Deaf learners do associate printed words with specific signs as a strategy

[4] The degree to which a word or sign resembles the referent.

of keeping information in their short term memory bank as they read. In the study, congenitally deaf ASL users were asked to remember English word lists in two different treatments. In one treatment, the English words had translations into ASL signs that were similar to each other (like PAPER and MOVIE), while the other treatment did not. Deaf participants had more difficulty in recalling words in the first treatment, suggesting that Deaf people do use signs to store print words in memory.

Further evidence of this comes from Harris and Moreno (2006), who note that some Deaf children in their study made no phonetic errors in their writing, that is, no spelling errors that show phonological awareness such as "plad" for *plaid* or "brutr" for *brother*. This led the authors to conclude the students were coding at the whole-word level, and that these Deaf students associated signs with printed words without understanding the sound-print relationship.

Hermans et al. (Hermans et al. 2008b) agree that some Deaf students associate signs with printed words. They found that Deaf children with larger sign vocabularies also had larger print vocabularies. They hypothesize that having larger sign language vocabularies aids children in their acquisition of print vocabulary, rather than the other way around. Additionally, their reading model hypothesizes that sign languages may also play a role in higher-order levels of language processing than simply sign-word correlation.

This point is also argued by Piñar et al. in a 2001 study in which they used Costa Rican Sign Language (LESCO) to help their ASL-using Deaf students learn Spanish at Gallaudet University. They showed students a video of Costa Rican legends narrated in LESCO with captions in Spanish. The captions in Spanish were also printed in the form of a small booklet that students read. They asked 30 students to read the legends from their booklets in Spanish and answer comprehension questions. Ten days later, 20 of the students watched the LESCO version with Spanish captions. The control group read the booklet again without watching the video. Both groups improved in their comprehension exam, but the experimental group

improved more than the control group, even though both groups had access to the Spanish booklet during the exam.

The authors point out that while most foreign language classes today emphasize a natural approach to language learning, learning a writing system happens with explicit instruction and is therefore not a natural process. Hearing students new at reading depend on the spoken form (that they learned naturally) to help them decode the written form, so for Deaf students to learn a written language with no access to the phonology of that language is problematic. Deaf students, without access to the spoken form of the language, may benefit from an alternative natural language into which they can decode. The study authors felt that Deaf learners can associate new unfamiliar words with visual stimuli, the signs in LESCO (Piñar, Ammons & Montenegro 2008).

The authors gave several reasons why using LESCO would be better for their activity than ASL signs, even though the students knew ASL, not LESCO. First, LESCO and ASL are similar enough (an estimated 70% shared vocabulary) that the signed stories provided a context for students to figure out new Spanish vocabulary using a top-down approach. However, LESCO was different enough from ASL that watching the signed story would not give away the entire story, removing (in the eyes of the authors) the motivation for students to read and understand the Spanish captions. In addition, when the LESCO storytellers used mouthings[5], they would be from Spanish, thus matching the target language, whereas ASL storytellers would use English (Piñar, Ammons & Montenegro 2008).

One might wonder why Deaf learners shouldn't pair signs from their first sign language with new foreign language words (in this case, pairing ASL signs with Spanish words). The

[5] An optional mouth movement in which the signer mouths the spoken word gloss associated with the sign. These are distinct from mouth gestures, which are non-manual markers that modulate or distinguish a sign.

reason, according to interference theory, is that we could expect that learners would suffer from proactive interference, in which learners have difficulty making new associations because of prior associations. For example, it may be difficult for a person to memorize their new phone number because they have already associated a different sequence of digits with the concept "my phone number."[6] In similar fashion, I hypothesize that learners of a foreign sign language would struggle to associate the new signs with written words that have already been associated with signs from the learner's first sign language. In the case above, Deaf learners at Gallaudet would have difficulty associating the ASL sign with a Spanish word because it is already associated with a word in English.

Although I am not aware of this having been tested, there is anecdotal evidence that it is true from interpreters who work in foreign language classes who have decided to make use of a foreign sign language in order to avoid proactive interference in their interpretations. For example, Darroch (2011) reports on the experience of two interpreters at the National Technical Institute for the Deaf who have participated in study-abroad opportunities to Italy where they studied Italian Sign Language (LIS). Back in the U.S., Deaf college students taking Italian classes reported that when the interpreters used Italian mouthings together with ASL signs, the signs triggered English words in the minds of the students. Students then had to mentally translate from the English into Italian, an extra, unwanted step. However, when the interpreters began to incorporate LIS signs into their work, students said the English intrusions were not present. Consequentially, these interpreters began to introduce more and more LIS signs into their work in the following way. They now spell out the new vocabulary word using the ASL fingerspelling system, translate the meaning of the word using an ASL sign, and then

[6] The opposite of proactive interference is retroactive interference, when new memories make it difficult to retrieve older memories. In this case, after successfully memorizing a new phone number, a person might struggle to remember the old one.

demonstrate the LIS sign. In this way the interpreters are able to sign LIS (with Italian mouthings) when the professor speaks Italian, and use ASL mainly for when the professor speaks in English. More recently, they have also recommended to students that they use the Spread the Sign Web Dictionary as a resource for learning LIS signs (Kathleen Darroch, personal communication, 2015). That students prefer this method of incorporating LIS signs, despite the amount of extra effort it imposes both on them and their interpreters, is strong evidence that proactive interference is a real concern for foreign spoken language learners.

Interestingly, this method employed by interpreters is very similar to a vocabulary instruction method called "chaining", observed by Padden and Ramsey (2000) in fluent signing teachers of Deaf children. Chaining occurs when teachers present a word in multiple forms, using print, fingerspelling, and sign in quick succession. Hermans et al. (Hermans et al. 2008b) have found that learning written vocabulary is easier for Deaf children when they already know a sign for the concept. Presumably, students at the National Technical Institute for the Deaf already know an ASL sign for most concepts they will learn in Italian class. However, the experience of these students suggests that they learned written Italian vocabulary more easily when they also knew LIS signs for the concepts.

Hermans et al. (Hermans et al. 2008a) have also found that children have better automatic word recognition if they know the print, spoken, and signed form of a word. I theorize it is automaticity in word recognition that is jeopardized by proactive interference when learners use a sign language that is already associated with another print language.

There are other logical reasons we would expect knowledge of a foreign sign language to aid in learning the associated spoken/written language (and vice versa). The languages are likely to have important commonalities due to influence of the spoken language on the sign language (or from another factor that influences both languages, such as geographical or cultural factors). Deaf learners usually learn the national print language and the national sign language in parallel over many years. It is reasonable to expect a similar pattern for learning a foreign language and foreign sign language simultaneously, that discoveries in one language

might lead to new knowledge in the other, because of their commonalities. These commonalities include lexicalized fingerspellings, initializations, grammatical similarities, parallel lexical semantic structuring, shared concepts, and mouthings. Each of these potential influences will be reviewed below.

LEXICALIZED FINGERSPELLINGS are the first example of how most sign languages contain borrowings from the local spoken language. Because most sign languages have a system of fingerspelling, signers often choose to spell out certain words from the local spoken language (assuming it has a writing system). Over time, some of these borrowings will undergo a process of lexicalization, dropping letters and/or adding extra movements, and become signs in their own right.

INITIALIZED SIGNS are signs that borrow the initial letter of a written word and use that letter's handshape when creating the sign. Examples are the ASL signs PURPLE and YELLOW, which are signed the same in all respects save the handshape. PURPLE is signed with a P handshape while YELLOW uses a Y handshape. Someone trying to learn English who already knows ASL (or trying to learn ASL, already knowing English) will be aided by these shared initials. Conversely, it is more difficult to associate the ASL sign PURPLE with the Spanish word *morado* precisely because the P handshape invokes the P in purple and not the M in *morado*. I can personally attest to difficulty in this area while interpreting for Deaf students in their Spanish classes. One of the interpreting strategies I have employed for some Deaf students is to mouth Spanish words while attempting to produce ASL signs.[7] It is very difficult to mouth the word *martes* while simultaneously signing TUESDAY, precisely because of the initialization mismatch between the languages. A fellow interpreter who works in French classes has related to me that she changes the initializations of days of the week to match the

[7] This method is most effective for students who have some residual hearing and previous ability in lip-reading Spanish.

first letter of the words in French. That is, she has created ad hoc signs that retain the ASL morpheme for days of the week, but use the appropriate letter handshapes to match the French spelling. This removes confusion for her and for her students (Miriam Lerner, personal communication, 2015).

There may be GRAMMATICAL SIMILARITIES between a spoken language and a sign language used in the same region. For example, in LSCh there is an interesting grammatical pattern in which the first person singular form of a verb is signed quite differently than for the non-first-person-singular form. This pattern is not very productive, appearing only with TENER and NO-SABER. This pattern does not conform with the pattern of directional signs observed in many sign languages, and may be a result of a partial influence from Spanish, which conjugates verbs based on person and number. In any event, I observed that American Deaf students learning LSCh were more easily able to grasp this pattern if they were familiar with Spanish than if they were not. Another possible grammatical similarity might include ordering (in cases when the SL has been influenced by the word ordering of the spoken language).

The idea of PARALLEL LEXICAL SEMANTIC STRUCTURING is that a spoken language and a sign language from the same region are likely to have lexical items that are polysymous in a similar way. For example, in English we use one lexical item, *bus*, to refer both to local buses (intra-city) as well as to inter-city buses. In ASL as well, there is one sign, BUS, which refers to both things. However, in Chile, a local bus is known as a *micro*, but an inter-city bus is a *bus*. LSCh shows parallel use of polysemy (or lack of it) by having separate signs, MICRO, and BUS. (ASL also shows parallel lexical semantic structuring with English by having one sign for both concepts.) Another example is the way LSCh has the signs SABER 'to know a fact or information about something' and CONOCER 'to be acquainted with a person, place or object' which pattern after *saber* and *conocer* in Spanish, while ASL lacks the distinction and only uses KNOW for both concepts. Also, LSCh has the signs PEZ 'fish, the animal' and PESCADO 'fish, the food' which pattern after Spanish, while ASL uses FISH for both concepts.

By virtue of being used in the same community, a spoken language and a sign language used in the same region/country will have many SHARED CONCEPTS. For example, in the United States there are signs for elementary school, high school, college, and grad school. In Chile, where the education system is organized differently, there are signs for *educación basica*, *media*, and *universidad*. The ASL sign COLLEGE, or even UNIVERSITY, is not a good translation of the Chilean concept *universidad*, because the concept of post-secondary education is so different between the countries. The LSCh sign is a much better conceptual match for translating the term. As another example, in Chile, empanadas are a common food and there is a commonly used sign EMPANADA. ASL doesn't have a widely used sign for empanada, perhaps because it is not a commonly-eaten food in North America.

Finally, in sign languages there are multiple types of mouth movements which may be obligatory or optional. One type is MOUTHINGS, when the signer mouths the spoken word gloss associated with the sign. Mouthings, though usually not obligatory, are common enough. I myself have experienced numerous times when I was able to understand a new sign in LSCh based on the mouthed Spanish word. Conversely, it is possible to understand a sign in LSCh, and use the mouthing as a reinforcement of a Spanish word. Also, from the point of view of production, it is easier to know what the proper conventional mouthing is that accompanies a sign if one knows the Spanish.

The commonalities between related foreign sign languages and foreign spoken languages detailed above increase the chance that learning done in one language will support learning in the other. Also, the commonalities lead to a strong association between a Deaf learner's primary sign language and primary written language which in turn leads to greater interference when trying to pair a new written language with one's primary sign language. Mouthings and initializations especially strengthen this association and proactive interference. According to Hermans et al. (2008a), "Cummins (2006) has recently proposed that conceptual knowledge, metacognitive and metalinguistic knowledge/strategies, and specific linguistic elements (e.g.,

fingerspelling and initialized signs) can transfer from a sign language to a spoken language." I further hypothesize that knowledge of a spoken language can transfer to a sign language.

There is a potential concern associated with Deaf learners using a sign language as a bridge in learning a spoken language. There are reports, including in Hermans et al. (2008a:158), of situations in which Deaf learners read a printed word incorrectly because the sign associated with the word has a different possible reading. This prompted Herman et al. to comment that spoken language may have a larger role in the acquisition of written language than some give it credit for.

In summary, there is good evidence that one strategy Deaf learners employ is to use signs from a natural sign language when decoding a written system. There is further evidence that suggests that when learning additional written languages after the first, using the same sign language for decoding causes proactive interference in memory, and, consequently, is a less efficient learning process. Finally, the numerous ways that spoken languages and sign languages from the same region are similar to each other provide increased efficiency for a learner who studies both simultaneously.

1.3 Benefits of sign multilingualism

Sign languages are true, natural languages and therefore any benefits we expect from multilingualism can also be assumed true for sign multilingualism. For example, learning sign languages increases a learner's cognitive and linguistic skills (Emmorey 2002). Other examples come from an evaluation of the Spread the Sign Web Dictionary. In this evaluation, Fredäng (2010) collected reports from member countries who participate in the dictionary project to learn about how the dictionary was being used and what its effects were. Some countries reported that Deaf students were able to compare their national sign language with sign languages from other countries, which helped them understand the symbolic nature of signs and words. A report from Germany said that Deaf students were surprised by the diversity of signs, which led to a greater appreciation for their own sign language.

Because sign languages are products of Deaf communities, they are visual languages that can be learned by Deaf people using a natural approach to second language learning in a way that is not possible when they learn spoken languages. Therefore it is not surprising that Deaf learners experience much greater success in learning foreign sign languages than foreign spoken ones. In fact, sometimes the success that Deaf people have with cross-cultural communication leads to the erroneous belief that there is no need for Deaf people to receive second language instruction for foreign sign languages.

Deaf learners are more highly motivated to learn sign languages than spoken, in part because they are interested in connecting with foreign Deaf, who are perceived as belonging to the same international community. Becoming aware of world sign languages has helped some Deaf students to feel less isolated, as they discover the universality of Deaf experience (Fredäng 2010). Learning foreign sign languages increases a Deaf person's mobility, freedom, and participation in international Deaf events. Foreign sign language ability is an important tool for developing Deaf networks (Naturale 2014: 134). The Deaf Community Cultural Wealth Theory (Listman, Rogers & Hauser 2011), adapted from Community Cultural Wealth Theory (Yosso 2005) defines linguistic, social, navigational, resistant, and familial capital. Naturale (2014: 161) adds Deaf Global Community Capital, when Deaf people develop global Deaf communities and an increased sense of belonging. Some examples include organizations like Deaf We Can and Discovering Deaf Worlds, American Deaf non-profits that have done humanitarian work in foreign countries, which required their staff to learn foreign sign languages. Michael Stein (personal communication 2015), executive director of Deaf We Can, is an example of someone who engaged in independent foreign language study, including computer-assisted vocabulary learning, in the early stages of becoming fluent in ASL, Spanish, and LSCh.

Deaf students also find foreign sign languages more culturally relevant, in that cultural situations introduced in the class are appropriate for Deaf people. As an interpreter for Deaf students in foreign spoken language courses, I have seen many times when instructors have

asked the students to practice communication situations that were culturally inappropriate, such as making a phone call, or ordering food from a restaurant (hearing and Deaf people usually have very different strategies for this).

1.4 Current methods of foreign sign language learning

In my experience, foreign sign language courses are rare. Consequently, the materials and technologies designed to support learners of foreign sign languages are few and limited. In this section I discuss the methods of learning foreign sign languages that I have found, along with discussion of their limitations.

1.4.1 Courses taught by a native signer who also shares a common language with students

The National Technical Institute for the Deaf offers ad hoc, one semester courses for languages such as Mexican Sign Language and Russian Sign Language, according to which professors are available. These courses are taught by professors who are native or fluent in the foreign language, who also share common languages (ASL and English) with the students. The main problem with these courses is that one semester is not enough to accomplish much or to establish their legitimacy. For students who have a major that requires foreign language study, one semester of instruction is not enough to satisfy the requirement. For example, the B.S. in International and Global Studies currently requires at least three semesters studying the same language, beginning at the intermediate level. If students do not have prior knowledge of the foreign language this will take five semesters. Further, even if NTID were to offer more

semesters of the foreign sign languages currently offered, these courses are currently not recognized as foreign language courses by the university.[8]

1.4.2 Courses taught by a proctor, while the native signer is video-conferenced into the class

I have observed Deaf students at the National Technical Institute for the Deaf during a semester-long course preparing them for a study abroad to Santiago, Chile. During this course a number of methods were employed to teach the students as much LSCh as possible prior to their travels. Video conferencing with a remote native signer was tried and discontinued because it was found to be unsuccessful. The many-to-one ratio was difficult to manage with video, despite being in a state-of-the-art video conference classroom at NTID with a dedicated lab attendant to set up the connection and monitor video panning and screen sharing. The native signer could not clearly see more than two to three students at a time. To make matters worse, the native signer did not share a language or cultural background with the students. The NTID students didn't read Spanish and she didn't write English. She didn't know what students' knowledge gaps would be. As a result of this lack of shared cultural context, it was hard for her to build new learning on previously known information. Other problems to this approach were posed by internet connectivity, time zone differences, and even different expectations of timeliness. We found using a non-native signer who knows enough of the target foreign sign language to teach was much more successful.

[8] NTID is one of the nine colleges of the Rochester Institute of Technology in New York. Deaf students enrolled at NTID can take degree programs from any of the colleges or other degree-granting units of the university.

1.4.3 Courses taught by a proctor with students using online language content (self-teaching)

In Norway, Deaf students trying to learn British Sign Language (BSL) do not have teachers who know that language; rather, they use online videos for their language models. This is possible for languages like BSL and ASL that have a large amount of online content, but most do not (Pritchard & Vest 2013).

1.4.4 Online sign courses

I am not aware of any reports on online sign courses as they are very new. NTID has recently begun to offer ASL as an online course but do not offer other sign languages. Also, Siglinde Pape (n.d.), a doctoral student at the Language Research Lab of Blaise Pascal University in Clermont-Ferrand, France, is currently doing her PhD work on a Massive Open Online Course for French Deaf and American Deaf to teach each other their sign languages and their written languages. The results of her research are not yet available.

1.4.5 Online sign dictionaries and word lists

Online sign "dictionaries" are more user-friendly than printed books, but usually consist of nothing more than word lists. Most do not have definitions, usage examples, etc. They can be searched, but only by the written language, not the sign language. Some dictionaries allow one to browse signs based on a semantic domain. These dictionaries are hosted by an organization who takes responsibility for making sure they are accurate.

There are also word lists that are posted online on YouTube. These are lists of signs, usually grouped by semantic domain (e.g., country signs). It is much harder to find the vocabulary item one is looking for than in dictionaries, and videos may have errors if made by non-credible authors. Also, there is a concern that learning all vocabulary within a semantic domain at the same time may lead to interference between items in the set, leading to extra learning time (Nation 2000).

1.4.6 Word cards

These are difficult to create and limited in their effectiveness for the study of signed languages. There are some commercially produced word cards for ASL that have a drawing of a sign on one side and a corresponding English word on the other. I have seen NTID students who are learning LSCh attempt to create word cards with an English definition on one side and a description (in English) of how to produce the LSCh sign on the reverse, a solution that could easily lead to learning signs incorrectly.

1.5 The need for computer-assisted language learning for sign languages

An area of sign language learning currently experiencing development is computer-assisted language learning (CALL). This currently includes online course offerings and online dictionaries, as detailed above in §1.4.

While online sign courses show great promise, they will not eliminate the need for sign language students to engage in self-study of vocabulary. Indeed, there are reasons to believe that Deaf students may need to engage in more self-study than their hearing peers. Spencer and Marschark (2010: 96) point out that Deaf children have been found to have smaller print vocabularies than their hearing peers in numerous studies. One of the likely causes is that Deaf children have less access to overhearing conversations in their environment. It is generally agreed upon that to remedy this gap, vocabulary is a topic that must be specifically addressed with direct instruction. Most Deaf children have a smaller print vocabulary than their hearing peers, and likewise we can expect for most that their vocabulary in sign language will not be as large as their hearing peers' spoken vocabulary, because, as mentioned above in §1.1, most Deaf children are raised in families that do not sign. Hermans et al. (2008a: 155) list a plethora of studies confirming that many young Deaf children who have hearing parents are delayed in sign language acquisition.

When studying vocabulary, knowing high frequency words gives a person a good start to further language learning. We know that for spoken languages, foreign language courses

simply do not have the time to teach all the vocabulary (especially low frequency words), so professors teach strategies for learning vocabulary on one's own (Nation 2004: 20–21). These strategies include the use of word cards, dictionaries, and also—for spoken languages—CALL/CAVL programs like Rosetta Stone, Duolingo (n.d.), and BaBaDum (Mizielińska & Mizieliński n.d.). These three programs, and many others, provide opportunities for learners of spoken languages to do vocabulary quizzing activities. In contrast, currently there are not options for learners of foreign sign languages to engage in self-directed quizzing activities (which function like word cards). One possible exception is ASL Pro (n.d.), a free, online vocabulary quizzing program, intended for use by ASL educators and their students. Potentially, a Deaf person could make use of this resource to learn ASL as a foreign language if they had sufficient command of English. To my knowledge ASL Pro is the only sign language vocabulary quizzing program prior to the current study.

1.6 The Dirty Dozen as a computer program

For this thesis I used a vocabulary learning activity called the Dirty Dozen, created by Thomson and Thomson (2009), as a basis for creating a CAVL program. Thomson and Thomson developed the Growing Participator Approach to second language acquisition. Anecdotally, the Dirty Dozen strategy has been reported to be a very successful vocabulary learning activity, even when adapted for use with sign languages. It incorporates several evidence-based techniques, including spaced repetition (spreading out opportunities for retrieval, which is further explained in §4.2.2), total physical response, and the use of multimedia.

In the original version of this activity, a small group of language learners sit in a circle with a native language user who acts as a model for the students. The language model teaches approximately twelve vocabulary items per session, all related to a common semantic category, using props such as dolls, toys, and pictures. To begin, the language model brings attention to only two items. These two items would relate to the topic that is being taught, such as the

figurines of a man and a woman for the semantic domain of “people”. “This is a woman. This is a man,” she would say. Then she would quiz the learners using full sentences to be sure they understand. “Where is the man? Where is the woman?" Learners are expected to point with their finger to the object that matches, without producing the word themselves. When all learners easily distinguish between the two, the language model brings out a third item. “This is a baby. Where is the woman? Where is the baby? Where is the man?” In this way the language model introduces one new word/sign at a time, all the while quizzing learners on previously learned items. After accumulating about twelve items, the process can begin again with a new set of items, or older items can be removed to make way for newer ones. When learning names of items in the room, participants can actually point to the physical objects. For verbs, the native speaker gives full-sentence action commands and learners act out the action. By pointing to objects and acting out commands, language learners employ Total Physical Response, a language learning philosophy promoted by Asher (2009). They are also using practiced retrieval (quizzing) and spaced repetition. Pointing, rather than parroting, gives learners a chance to attend very closely to how new vocabulary is produced, providing enough repetitions to hear or see the subtle differences that make a natural accent in the new language. An additional benefit of using props, pictures, and actions is that learners associate the vocabulary item with the thing itself, rather than with the word/sign they already know from their L1.

Although Rosetta Stone uses a vocabulary learning method that is very similar to the Dirty Dozen activity, to my knowledge, mine is the first attempt to develop the program in a way that is designed for Deaf users and sign languages. In my adaptation I did decide to make some modifications to the original, some of which were necessary because of the change in medium. For example, while the Dirty Dozen activity often uses physical objects as well as images, my program uses only images. In the original Dirty Dozen, learners receive full sentence directions and physically point (or even act out verbs) to maximize Total Physical Response. In my program vocabulary is presented in isolation, rather than in full sentences, and pointing is

reduced to clicking.[9] Other modifications in my adaptation were included because of the needs of the study. For example, although the Dirty Dozen usually has learners practice about twelve items at a time, all from the same semantic category, I needed participants to learn more items than that to tax their memorization abilities. Therefore, I had participants learn forty signs with my program, with items coming from multiple semantic categories. Thomson and Thomson do not justify their decision to learn words from one semantic category at a time. In light of the research by Nation (2000), which suggests that learning words in lexical sets leads to interference, I decided this change was at least not detrimental, and hopefully beneficial.

Although I am not familiar with other attempts to adapt the Dirty Dozen activity to the computer, it should be noted that there are several programs for spoken languages that make use of vocabulary quizzing activities that are similar to those developed for my experimental program. I will describe several of these here.

Rosetta Stone is a proprietary CALL program that uses a trademarked approach called Dynamic Immersion, available for 30 spoken languages. One of the activities in this approach asks users to pair sound or text with an image. Similarly to the Dirty Dozen activity, Rosetta Stone does not use translation into the user's first language for vocabulary learning. Unfortunately, Rosetta Stone is not a Deaf-friendly application. It is not possible to proceed through all of the exercises without doing the listening and speaking components.

Duolingo (n.d.) is a free, online CALL program that currently offers instruction in eleven spoken languages, with more in incubation stages. The program supports itself by harnessing intermediate and advanced users to translate selected sentences from actual websites, and to rate other users' translations. Websites such as CNN pay Duolingo for this crowd-sourced web translation. Duolingo does occasionally ask learners to match sound or text with an image, but

[9] I am unaware if clicking is a less effective memorization activity than pointing, by virtue of being less physical. If so, this quality could be restored to the activity by using a touch-screen device.

the image is always labeled with an L1 translation. These occasional vocabulary picture activities are overshadowed by translation, transcription, L2-L1 matching, and fill-in-the-blank exercises. Duolingo incorporates gamification strategies, as well as social media sharing, to increase user motivation.[10] As users progress through skill trees, they can earn and spend points, see graphs that chart everyday usage, and share on Facebook or Twitter about their recently mastered skills. Duolingo is available as an app for various mobile platforms, and 85% of its usage comes from these mobile devices (Gannes 2014). It also allows users to turn off microphone and speaker activities, making it a Deaf-friendly program.

BaBaDum (Mizielińska & Mizieliński n.d.) is a free online vocabulary quizzing program for fourteen spoken languages. Users can play five different quizzing games to learn 1500 words in each language. The default game offers users a word (in audio and text) and four unlabeled images to choose from. There are two other games that are Deaf accessible. In one an image must be matched with the correct label from a group of four words. In the other an image is offered as the clue to unscramble an anagram. The top value of the site comes from the wonderful graphic design of the images. Unfortunately, the 1500 words chosen probably do not represent the 1500 most high frequency words for each language, and they are presented in random ordering, rather than increasing or decreasing the spacing of word repetition based on the learner's performance on specific vocabulary items as is described in §4.2.2.

[10] Gamification is incorporating game-like elements, such as scoring points and competition, to non-game activities, usually in an effort to increase engagement with a product or service.

Chapter 2
METHODOLOGY

In this section, I first describe the recruitment of participants and their demographics. Next, I detail the two computer programs that were developed for this study, including information about how they were piloted. Finally, I describe the full process that participants went through in the course of the study.

2.1 Participants

For my study I recruited twenty-eight men and women from the campus of the National Technical Institute for the Deaf, ages eighteen and up, who use ASL as their primary language. "Primary language" for this study is defined as "the language you use most". Because about 95% of Deaf people are born to two hearing parents, most Deaf children do not learn ASL from birth (Listman, Rogers & Hauser 2011: 285), so it was impractical to limit the study to native signers.

2.1.1 Recruitment

I recruited participants through fliers, email, social media, and by making announcements. Fliers were posted in public places across the campus, with extra attention paid to buildings frequented by Deaf people, especially those buildings owned or operated by the National Technical Institute for the Deaf. I sent emails to professors I knew across campus asking them to forward the electronic advertisement to their students (or to participate themselves). I contacted moderators of Facebook pages run by NTID clubs and organizations asking to have my advertisement posted on their page. Additionally, I visited a number of classes and two

NTID Student Assembly meetings to announce the study and seek recruits. Potential participants were informed they would not be paid. Instead, those who attended both sessions would be invited to sign up for a raffle for one of two $25 gift cards and also given a resource list of different opportunites for learning foreign sign languages.

2.1.2 Demographics

Participants were asked to complete a demographic questionnaire about their gender, age, and language background. With regard to language background, they were asked what their primary language was, how many years they had been using ASL, and what their proficiency level in ASL was ("fluent, very good, good, fair, poor"). They were also asked what other languages they use regularly and what other languages they have studied in school or on their own, with a proficiency level for each. Finally, this questionaire asked them to confirm that they had no prior exposure to LSCh, which was used for the study.

By chance, the twenty-eight participants in this study were evenly divided by gender, fourteen men and fourteen women. The ages of participants ranged from 18–65 with the median age of 21. The majority were college-aged, as shown in Figure 1 below.

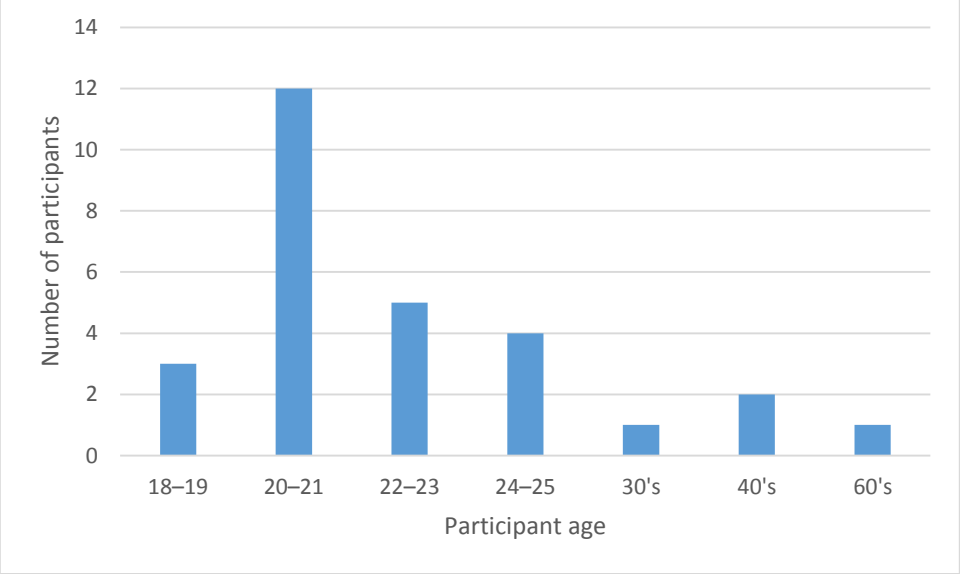


Figure 1: Age of participants

Using the reported number of years participants had been using ASL, I calculated the age at which participants began using ASL, which ranges from age 0–24 with a median of 12 years old. Figure 2, below, shows the age of ASL onset varied widely for participants.

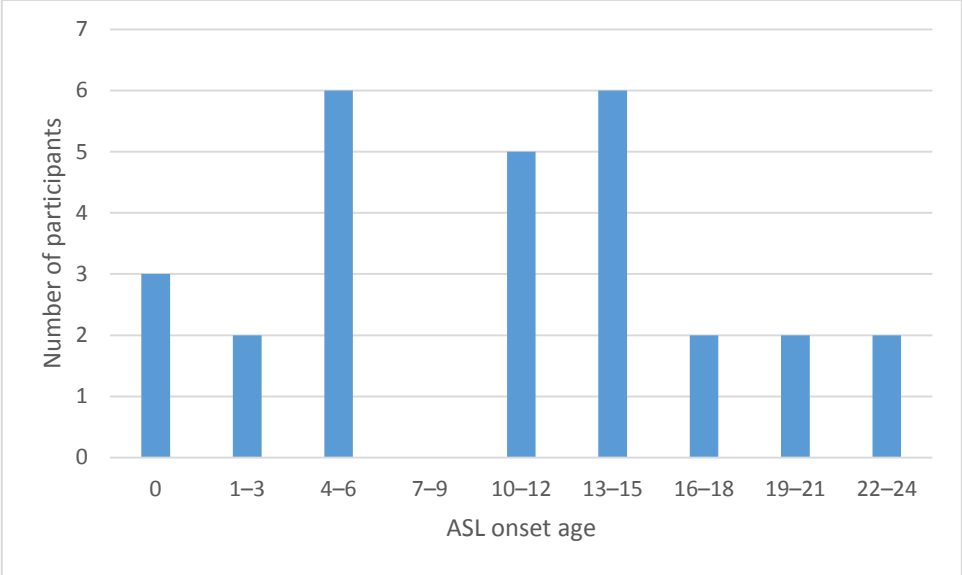


Figure 2: Age of ASL onset

All participants were asked to report their primary language. Thirteen of the twenty-eight wrote simply "ASL", as was expected. Almost half of participants claimed more than one primary language. These break down as follows: Three participants wrote "ASL/English" and another eight wrote "English/ASL". Three participants indicated that they use spoken English and ASL simultaneously ("sim-com") as their primary language. Three participants identified with an English-influenced variety of ASL, including two who wrote "ASL/English Sign Language"[11] and one who wrote "Pidgin Sign English".[12] Also included was one participant who wrote Nepalese Sign Language. He was the newest ASL user in the study (one year). Even

[11] The appellation "English Sign Language" is non-standard, but I interpret it to mean an English-influenced variety of ASL—not British Sign Language.

[12] Pidgin Sign English is an older term that refers to a combination of two different languages (e.g., ASL and English). A newer term for this phenomenon is CONTACT SIGN.

though this participant reported Nepalese Sign Language as his primary language, I decided not to reject his data. I believe that his year of post-secondary education–conducted in ASL–made him sufficiently similar to the other participants. Although never the highest of the sample, his scores were above average for both sessions, in both methods, with consistently one correct answer more in the Experimental Method than in the Control Method.

Except for one person who declined to answer, participants rated their fluency in ASL as "fluent", "very good", or "good". Among these three choices the participants divided almost evenly. None of the candidates who came to the study had to be excluded from participation based on their answers on the demographic form. Table 1 below shows the participants organized by their reported primary language and then by their reported fluency in ASL.

Table 1: Demographics of participants

ID #	Sex	Age	ASL onset age	Primary language	ASL proficiency
7089	M	19	11	ASL	Fluent
7387	F	18	1	ASL	Fluent
4658	F	42	22	ASL	Fluent
2661	M	21	0	ASL	Fluent
3548	F	46	14	ASL	Fluent
5452	F	20	15	ASL	Very Good
2279*	F	20	12	ASL	Very Good
5325	F	20	6	ASL	Very Good
1975*	F	21	0	ASL	Very Good
4002	F	22	12	ASL	Good
6107	M	23	13	ASL	Good
1346	F	32	20	ASL	Good
4177	F	22	3	ASL	Good
3656	M	22	12	ASL and English	Fluent
7221	M	24	18	ASL/English Sign Language	Very Good
9484	M	65	12	ASL/English Sign Language	Good
6223	F	21	0	ASL/English	Fluent
5341	M	24	13	ASL/English	Good
1452	M	20	15	English & ASL	Very good
3188	F	21	5	English & Signing at same time	Good
6178*	M	21	19	English voice and sign	Good
4898	F	19	5	English/ASL	Fluent
8880	M	21	6	English/ASL	Very Good
7240	F	21	17	English/ASL	Good
4333	M	25	24	Nepali Sign Language	Good
6818	M	24	4	Pidgin Sign English	(no answer)
2187	M	21	15	Sim-Com	Fluent
6318*	M	23	6	Spoken English and Signed English (same time)	Very Good

*Did not return for Session 2

Participants were also asked if they use any other languages regularly and/or have studied other languages and what is their proficiency level in each. Only one participant rated herself "Fluent" in another language (Russian Sign Language). Please note, however, that the participant who claimed Nepalese Sign Language as his primary language (ID# 4333) did not rate his fluency in that language. He may also consider himself to be fluent. Two other

participants rated themselves as “Very Good” in a foreign language. One of those who rated herself “Very Good”, did so in both Dominican Sign Language and Spanish, a spoken language-sign language pairing. Three other participants rated themselves as “Good” in one or two languages, and many rated themselves as “Fair” in one or more languages, as show in Table 2 below. Not included in the table are languages in which competency was rated as “Poor” or languages that are not considered foreign languages for the purpose of this study, that is, English (written or spoken), “English Sign Language”, or home signs.

Table 2: Demographics cont., foreign language abilities

ID #	Sex	Age	Other languages used regularly	Other languages studied
7089	M	19	■Bulgarian	
7387	F	18	■Spanish	■Mexican Sign Language
4658	F	42	■■■■Russian Sign Language	
2661	M	21		
3548	F	46		
5452	F	20		
2279*	F	20		
5325	F	20		■Hindi (spoken)
1975*	F	21		■■Russian Sign Language
4002	F	22		
6107	M	23		
1346	F	32		
4177	F	22		■Spanish (written), ■Mexican Sign Language, ■Honduran Sign Language
3656	M	22		
7221	M	24		
9484	M	65		
6223	F	21		■■Spanish, ■■Mexican Sign Language
5341	M	24		■Russian Sign Language
1452	M	20		■Spanish (written)
3188	F	21		■■■Dominican SL, ■■■Spanish (written)
6178*	M	21	■■■Spanish (spoken, written)	■ Mexican Sign Language, ■Cambodian (spoken)
4898	F	19		■Spanish (written, spoken)
8880	M	21	■■Spanish (spoken)	
7240	F	21		
4333	M	25		■Nepali
6818	M	24		
2187	M	21		■Swedish Sign Language
6318*	M	23		■French (spoken)

■■■■Fluent, ■■■Very Good, ■■Good, ■Fair, * Did not return for Session 2

2.2 Materials

I created two computer programs for vocabulary learning. One incorporated the Experimental Method based on the Dirty Dozen, and the other incorporated an activity that simulated learning vocabulary through an online dictionary. Both programs are detailed below in the sections on piloting and procedures (§2.3 and §2.4, respectively).

I also created a computer evaluation to test how many vocabulary items participants could correctly identify, both immediately after learning and one week later. The evaluation had a paper answer sheet for participants to mark their answers.

Vocabulary for the computer learning activities was taken from an online LSCh dictionary produced by the Universidad Metropolitana de las Ciencias de la Educación (UMCE) of Santiago, Chile and the Chilean National Disabilities Service under the Ministry of Social Development (Universidad Metropolitana de las Ciencias de la Educación & SENADIS - Ministerio de desarollo social n.d.). Vocabulary was chosen from four semantic categories: foods, animals, colors, and household objects. I chose these categories because the vocabulary items within each can generally be represented clearly by an image, even without a label.

Because the UMCE dictionary makes use of several different people to model the signs, for my experiment I had the vocabulary reproduced using one person as a model for all of the videos to remove the possibility of participants responding to stimuli correctly based on who the signer was, rather than what they signed. The signer used in the videos for this experiment was Juan Luis Marin Claro, a native user of LSCh (Deaf and born to Deaf parents).

The UMCE sign videos were problematic for another reason as well: Spanish mouthings. Early piloting of the program (which is described more fully below in §2.3) revealed that some of my pilot participants had some familiarity with Spanish and were able to better guess the meaning of signs based on the mouthings made by the signer. Fortunately, for the present experiment, Marin Claro reproduced the content from the LSCh dictionary but without mouthings. He also provided a large number of “distractor” signs which were used to make the evaluation harder (signs that are true LSCh signs that are very similar to vocabulary items, and

also fabricated signs that maintained most features of an original vocabulary item, but differed in at least one significant feature).

All trials occurred at the Rochester Institute of Technology, in a computer lab located in the library of the Henrietta, NY, campus.

2.3 Piloting

As the experimental program was being developed I did repeated piloting with Deaf testers. One of my reasons for doing so was to develop learning activities and an evaluation that would be sufficiently challenging. If the evaluation proved easy for all users to complete with high scores then it would be hard to see a difference between methods. One simple way to increase difficulty was to increase the number of items to be learned.

Another was by using lexical items that were not overly iconic or similar to ASL signs. For signs that can be easily guessed by iconicity (or previous knowledge of ASL) participants would likely perform equally well on the evaluation, regardless of the learning method. To test the iconicity of signs, I had Deaf pilot participants who matched the requirements of my participant pool (primary language is ASL, 18+, no exposure to LSCh) engage in the quizzing activity without any vocabulary instruction. That is, pilot participants would see a sign and be asked to guess its meaning by choosing the right answer from a group of twelve images. Signs that were more commonly guessed by multiple pilot participants were removed.

I also removed signs if they were compound signs that shared a morpheme with another vocabulary item in the list. This was done to keep vocabulary items independent of each other and not allow learning of one item to affect the learning of another. There was originally a list of 157 possible signs for the study, but piloting helped me to weed out about half of them to get the final 80 signs used (40 for each method).

It was during piloting that I chose to make another modification to the Dirty Dozen activity. Thomson and Thomson (2009) have a maxim, “Start with two words, and only add one new word at a time,” that I chose to abandon. With the increased amount of vocabulary

being learned and the goal to increase the difficulty of the task, I designed the program to start with three signs before quizzing learners on them, and continue to teach three new signs in a row in between quizzing activities. Subsequent to the change, pilot participants did not seem to struggle with the new format.

As I was increasing the difficulty of the activities I had to be sure that participants had a sufficient amount of time in which to do the learning. It was important that all users, regardless of their pace, would have sufficient time to learn all forty vocabulary items taught in each method. If they ran out of time before being exposed to all the vocabulary, then their evaluation would be compromised. In piloting, I noticed that pilot participants took as long as 14.2 minutes to work their way through all forty signs in the Experimental Method, with its repeated quizzing between learning new signs.. Therefore, I considered 17 minutes as the minimum necessary time to ensure that even slow-paced participants would be exposed to all of the signs.

I also found a way to make the evaluation itself more difficult. I originally planned to have participants view a sign and choose the correct answer from a group of possible answers. (Each of them consisted of an image paired with a written word, since participants might have learned the sign as associated with either the image or the word, depending on whether they learned with the experimental or control method.) However, a friend pointed out that the evaluation would be more difficult for participants were I to present the image-word pair and ask subjects to pick out the correct sign. Eventually I refined the idea further: participants would be presented with the image-word pair along with a sign which they had to judge as a correct or incorrect. The incorrect "distractor" signs were chosen to be very similar to the correct answer: either a true LSCh sign that is very similar to the sign in question, or else a fabricated sign that maintained most features of the original but differed in at least one significant feature.

Further details of how the program works can be found below in the next section.

2.4 Procedures

Upon arrival, participants were asked to read and sign the informed consent form and to fill out the demographic questionaire (see Appendix A). This experiment was conducted with the approval of the institute review boards of the University of North Dakota (IRB-201408-046) and the National Technical Institute for the Deaf.

I provided, in ASL, a brief background of the purpose of the study and instructions for the activities to follow. Instructions in English with pictures and examples were also on the screen prior to each activity (both vocabulary learning methods and the evaluation).

Participants engaged in vocabulary learning activities on the computer using two different methods. The study used a within-subjects design; that is, all participants were tested in both methods so their performance across methods could be compared with a paired-samples *t*-test. Participants were asked to continue using each method for 17 minutes to learn forty signs per method. Following the learning exercises, the participants were tested on their recall of all eighty signs. They then returned one week later to retake the test portion.

In the Experimental Method, participants engaged in vocabulary learning based on the "Dirty Dozen" technique (explained in §1.6), which I adapted for computer use. To begin, participants were shown a video of an LSCh sign paired with an image that represented the sign's meaning. Participants were instructed to click on the image to proceed as shown below in Figure 3.

Figure 3: Learning vocabulary in the Experimental Method

In this fashion participants learned to associate three new signs with their appropriate images. After the third new vocabulary item, participants were quizzed on what they had learned. In random ordering, one of the sign videos would play and loop while participants chose the corresponding image from a selection of twelve images as shown below in Figure 4.

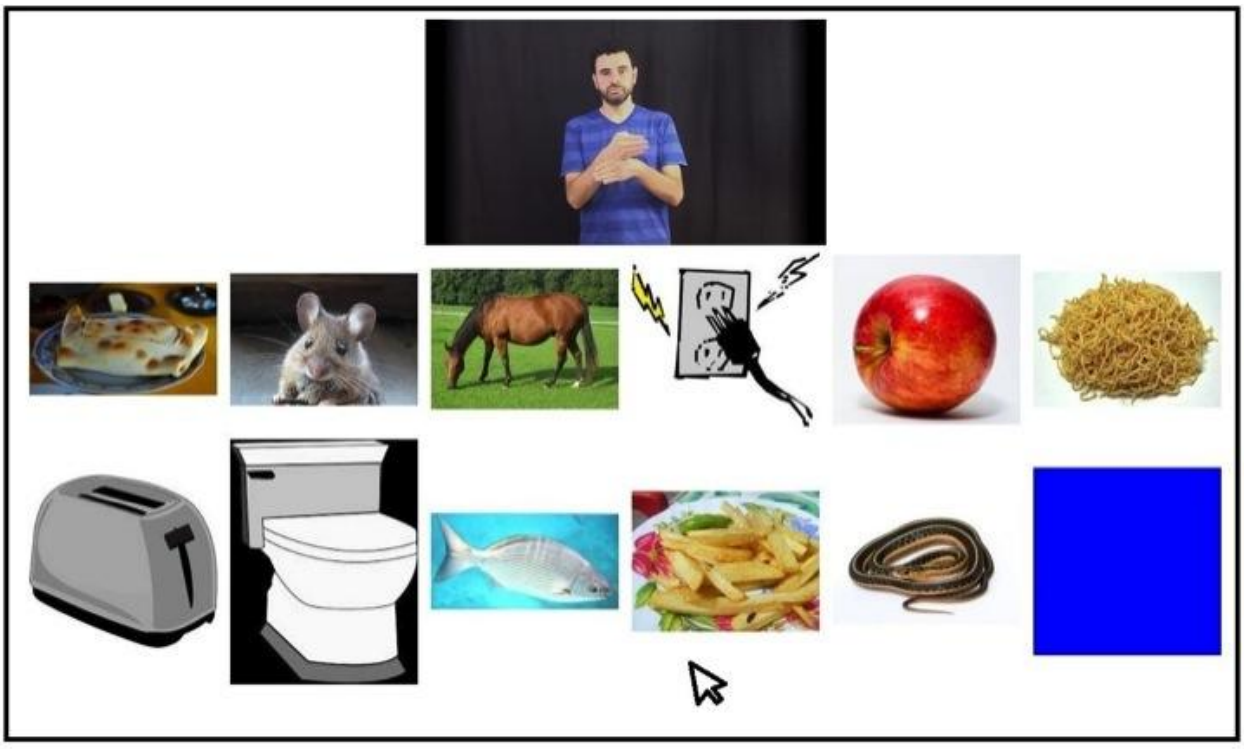


Figure 4: Quizzing vocabulary in the Experimental Method

If participants clicked on the correct image for a sign they would proceed to the next. If a participant made a mistake, and clicked on the wrong image, a dialogue window would appear, reinforcing the correct answer as shown below in Figure 5.

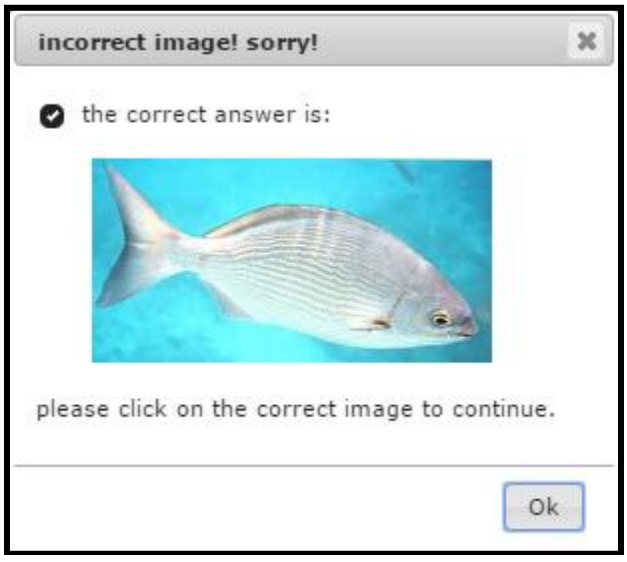


Figure 5: Incorrect quiz answer in the Experimental Method

The participants clicked “OK” and then had another opportunity to click on the correct picture and move on.

After quizzing on the first three vocabulary items, three new sign-image pairings were presented and the process was repeated, this time quizzing the participants on all six signs they learned. Then they learned three more and were quizzed on nine, and learned three more and were quizzed on twelve. At this point, participants were quizzed on the most recent twelve signs learned. For every three new signs that they learned, a set of three older signs dropped out of the quiz. After participants cycled through all 40 vocabulary items, no new signs were taught, but they continued to quiz on all of the 40 signs in random ordering until the 17 minutes had elapsed. Participants were quizzed on each sign-image pairing a minimum of four times, but some participants answered quickly enough that they saw each pairing more times than four before the time ran out. The computer program kept track of the participants’ clicks, allowing me to count how many quizzes they completed, accuracy rate, amount of time per quiz item, and total time spent on the activity. (All participants continued the full 17 minutes for the Experimental Method.)

In the Control Method the learning activity was to view an English-LSCh video word list. This activity was meant to simulate one of the common ways of presenting sign language vocabulary in online dictionaries. Participants read the English word and clicked on the corresponding video to view the sign as many times as they wished as shown below in Figure 6. Participants were asked to study the forty word-sign pairs presented for 17 minutes. During that time they were permitted to view any or all of the signs as many times as they wished.

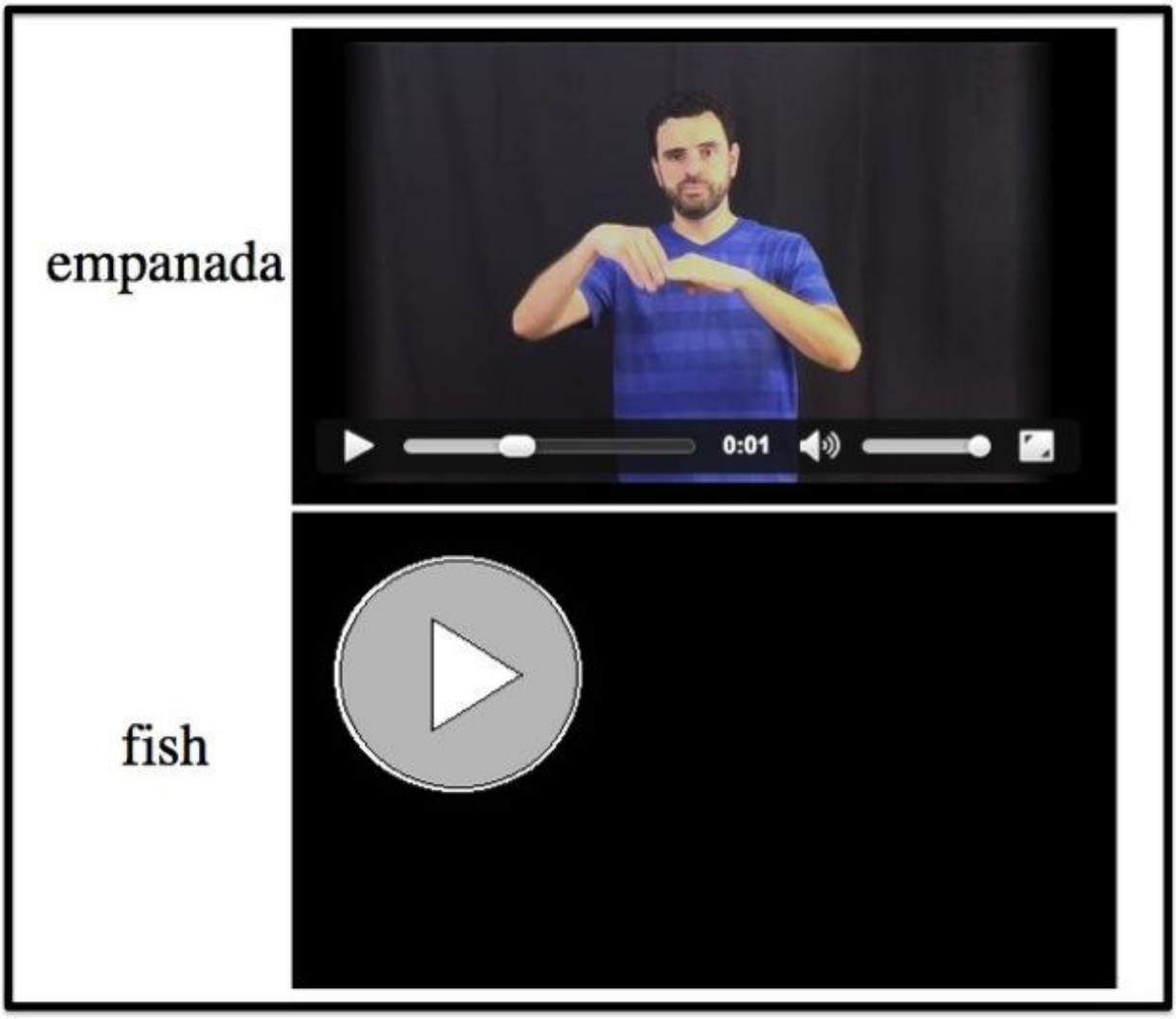


Figure 6: Learning vocabulary in the Control Method

Participants were asked to monitor their own time using an online countdown timer set for 17 minutes. This timer, shown below in Figure 7, was in its own browser window, positioned below the language learning activities where it could be seen throughout the experiment. When the timer ran out, it would visually alert participants by flashing red. I also monitored participants' screens to be sure their timers were started correctly, that they continued to run (participants were encouraged to pause the timer if they had a question or needed a break), and that they effectively stopped participants upon completion of the 17 minutes.

Figure 7: Timer used for methods 1 & 2

Participants were divided into four groups to allow the investigation of ordering effects. The order of the methods and the order of vocabulary sets was counter-balanced between the groups as shown below in Table 3.

Table 3: Orderings of method and vocabulary set

	First	**Second**
Group Exp.-A/Cont.-B	Experimental Method, Vocabulary Set A	Control Method, Vocabulary Set B
Group Exp.-B/Cont.-A	Experimental Method, Vocabulary Set B	Control Method, Vocabulary Set A
Group Cont.-A/Exp.-B	Control Method, Vocabulary Set A	Experimental Method, Vocabulary Set B
Group Cont.-B/Exp.-A	Control Method, Vocabulary Set B	Experimental Method, Vocabulary Set A

At the end of Session 1, participants were evaluated on all eighty vocabulary items that they had been exposed to. They were shown a video of an LSCh sign, and they were asked to determine if it matched the image and English word as shown below in Figure 8.

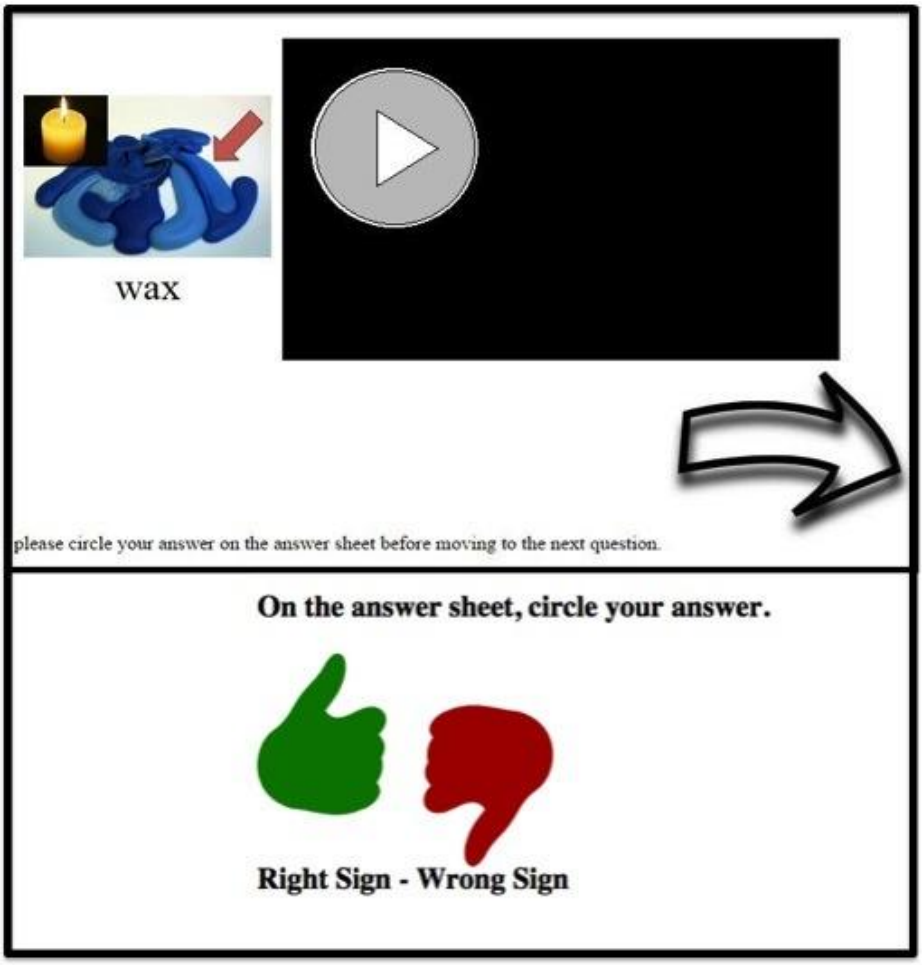


Figure 8: Evaluation of vocabulary retention

65% of the image-word pairings were shown with an incorrectly matched sign. In these cases the distractor sign was either a true LSCh sign that is very similar to the sign in question, or else it was a fabricated sign that maintained most features of the original but differed in at least one significant feature. For seven of the image-word pairings that were shown with an incorrectly matched sign, the distractor was not only a true LSCh sign, but one that has the correct meaning but comes from a different region of Chile and is pronounced differently. Participants indicated that they had no prior knowledge of LSCh, and were therefore expected to identify these as wrong signs. For another six of the image-word pairings that were shown with an incorrectly matched sign, the distractor was one that participants had learned as a correct answer for another concept. This was done for three signs from each vocabulary set.

For example, the signs for WAX and MUD (both from vocabulary set A) are very similar, so I intentionally mismatched the words and signs with each other to increase the difficulty of the evaluation. I did the same for the signs MEAT and COW (both from vocabulary set B).

Participants marked their answers on a paper answer sheet. Later, I input all of the answers to the computer. Subsequently, all 4,160 answers were checked for accuracy.

At the end of Session 1 participants were asked to write their name next to their participant ID# on a separate sheet of paper so that when they came back the following week they could use the same ID#. After all experiments were finished the Participant/ID# key was destroyed to ensure anonymity.

Participants returned seven days later at the same time of day to complete Session 2. In this session participants repeated the evaluation. Participants were not paid, however, following their second evaluation they were invited to sign up for a raffle for one of two $25 gift cards and also given a resource list of different opportunites for learning foreign sign languages.

Chapter 3
RESULTS

In this thesis, my intention is to show that Deaf people can learn foreign sign languages more easily when presented with a different method than what they currently have. The statistically significant results of the experiment support this hypothesis. This chapter begins with the results of the evaluations, first by individual participants, then by ordering group, and finally for the entire cohort. This is followed by a justification for pooling participant data across ordering groups. Finally, I report on the time participants spent on each method.

3.1 Evaluation Results

Participants completed two evaluations of their ability to remember the new vocabulary presented in each method. The Session 1 evaluation took place immediately after the learning activities, and Session 2 was one week later. For Session 1, most participants correctly remembered more vocabulary items learned in the Experimental Method than they did in the Control Method, as shown below in Table 4. In the differences column, positive numbers indicate better performance in the Experimental Method, negative numbers show better performance in the Control Method.

Table 4: Session 1 correct answers

ID #	Sex	Age	Experimental Method	Control Method	Difference
4002	F	22	36	28	8
6178	M	21	34	27	7
6107	M	23	27	21	6
6818	M	24	40	35	5
1975	F	21	26	21	5
5341	M	24	36	32	4
5325	F	20	32	28	4
4177	F	22	32	29	3
5452	F	20	39	37	2
7240	F	21	34	32	2
2661	M	21	34	32	2
7387	F	18	38	36	2
6223	F	21	36	35	1
3188	F	21	28	27	1
4333	M	25	39	38	1
1452	M	20	38	37	1
2279	F	20	39	38	1
7221	M	24	37	37	0
8880	M	21	33	33	0
3656	M	22	35	35	0
6318	M	23	37	37	0
2187	M	21	38	39	-1
4898	F	19	38	39	-1
3548	F	46	34	35	-1
7089	M	19	39	40	-1
4658	F	42	36	39	-3
9484	M	65	27	31	-4
1346	F	32	28	34	-6

Note that there are more positive than negative numbers, and the range of positive numbers (0 to 8) is greater than the negative numbers (0 to -6), indicating that those who benefited from the Experimental Method, benefited more than those who benefited from the Control Method. In Session 2, again, most participants performed better in the Experimental Method than the Control Method as shown below in Table 5.

Table 5: Session 2 correct answers

ID #	Sex	Age	Experimental Method	Control Method	Difference
3548	F	46	27	20	7
2187	M	21	38	32	6
7221	M	24	36	31	5
5325	F	20	31	26	5
4002	F	22	24	20	4
7240	F	21	27	23	4
6818	M	24	33	30	3
7387	F	18	33	30	3
6223	F	21	31	29	2
3188	F	21	33	31	2
8880	M	21	32	30	2
2661	M	21	32	30	2
5341	M	24	27	26	1
4333	M	25	37	36	1
9484	M	65	23	22	1
4177	F	22	30	30	0
6107	M	23	17	17	0
3656	M	22	33	33	0
4898	F	19	36	38	-2
7089	M	19	37	39	-2
1346	F	32	23	26	-3
5452	F	20	33	36	-3
4658	F	42	30	33	-3
1452	M	20	24	29	-5
6178*	M	21	no data	no data	no data
1975*	F	21	no data	no data	no data
2279*	F	20	no data	no data	no data
6318*	M	23	no data	no data	no data

* Did not return for Session 2

In Session 2 also, there are more positive than negative numbers in the difference column, (more people performed better on the Experimental Method than the Control Method) and the range of the positive numbers (0 to 7) is greater than the negative ones (0 to -5), indicating that the benefit was greater in the Experimental Method than the Control Method. However, note that in both instances the range is slightly smaller than in Session 1.

It is interesting to compare the participants' relative performance on each method across both sessions, which is shown in Figure 9 below. This figure takes data from the last column of the preceding two tables and plots it to show how their performance varied on the two tests. All points to the right of the Y-axis represent participants who performed better on the Experimental Method than the Control Method for Session 1, whereas points to the left indicate better performance on the Control Method, and points on the line indicate no difference between methods. All points above the X-axis represent participants who performed better on the Experimental Method than the Control Method for Session 2, whereas points below indicate better performance on the Control Method and points on the line indicate no difference between methods. Therefore, points in the upper-right quadrant represent participants who performed better on vocabulary in the Experimental Method than the Control Method for both sessions. Points in the lower-left quadrant represent participants who did the opposite, performed better in the Control Method than the Experimental Method across both sessions. Points in the lower-right quadrant and the upper-left quadrant, however, represent participants who flip-flopped, that is, performed better in one method than the other for the first session, but the reverse for the second session, indicating that although one method was more successful for immediate recall, the other was more effective for long-term retention. For example, note the oldest participant in the study (ID# 9484), marked with a triangle found at (-4, 1). This 65-year-old man initially performed better in the Control Method, scoring four correct answers greater than in the Experimental Method in Session 1. However, in Session 2, his performance was better in the Experimental Method, scoring one correct answer greater than in the Control Method.

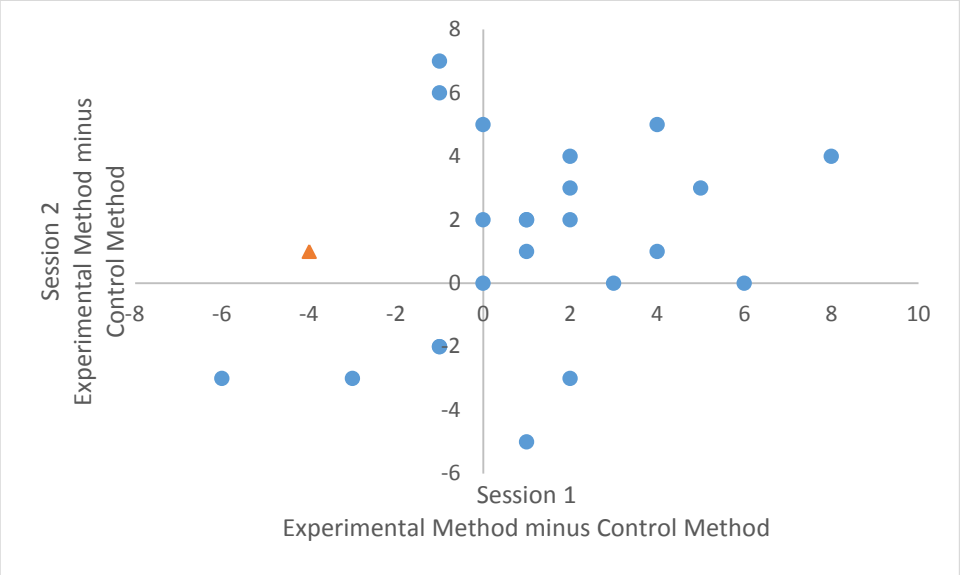


Figure 9: Comparison of Session 1 and Session 2 differences between methods

Only twenty-four participants returned for the second session, so the four non-returners are omitted from the Session 2 statistics and from this figure. Please note that a majority of these twenty-four participants performed better in the Experimental Method for at least one of the sessions, with only three participants performing better in the Control Method for both Sessions and one participant who performed equally well in both methods for both sessions. The most populated quadrant is the upper-right, where nine participants performed better in the Experimental Method for both sessions.

As described in §2.4 above, participants were randomly divided into four groups to balance the ordering of the different methods and different vocabulary sets, which is shown below in Table 6.

Table 6: Individual results by ordering group

				Session 1		Session 2	
ID #	**Order**	**Sex**	**Age**	**Experimental Method**	**Control Method**	**Experimental Method**	**Control Method**
6223	Group Exp.-A/Cont.-B	F	21	36	35	31	29
9484		M	65	27	31	23	22
3548		F	46	34	35	27	20
3656		M	22	35	35	33	33
4658		F	42	36	39	30	33
1452		M	20	38	37	24	29
1975		F	21	26	21	(no data)	(no data)
2279		F	20	39	38	(no data)	(no data)
4002	Group Exp.-B/Cont.-A	F	22	36	28	24	20
6107		M	23	27	21	17	17
2187		M	21	38	39	38	32
1346		F	32	28	34	23	26
8880		M	21	33	33	32	30
2661		M	21	34	32	32	30
3188	Group Cont.-A/Exp.-B	F	21	28	27	33	31
6818		M	24	40	35	33	30
5452		F	20	39	37	33	36
7240		F	21	34	32	27	23
7387		F	18	38	36	33	30
7089		M	19	39	40	37	39
6178		M	21	34	27	(no data)	(no data)
4177	Group Cont.-B/Exp.-A	F	22	32	29	30	30
5341		M	24	36	32	27	26
4333		M	25	39	38	37	36
7221		M	24	37	37	36	31
4898		F	19	38	39	36	38
5325		F	20	32	28	31	26
6318		M	23	37	37	(no data)	(no data)

Fortunately, those who returned were evenly divided among the four ordering groups, as shown below in Table 7.

Table 7: Number of participants in each ordering group

	Session 1	Session 2
Group Exp.-A/Cont.-B	(n = 8)	(n = 6)
Group Exp.-B/Cont.-A	(n = 6)	(n = 6)
Group Cont.-A/Exp.-B	(n = 7)	(n = 6)
Group Cont.-B/Exp.-A	(n = 7)	(n = 6)

With one exception, the group mean score of correct answers was higher for vocabulary learned in the Experimental Method than for the Control Method, for both sessions, as shown below in Table 8.

Table 8: Mean correct answers across methods

	Ordering	Experimental Method Mean	Control Method Mean	Difference
Session 1	Exp.-A/Cont.-B	33.88	33.88	0.00
	Exp.-B/Cont.-A	32.67	31.17	1.50
	Cont.-A/Exp.-B	36.00	33.43	2.57
	Cont.-B/Exp.-A	35.86	34.29	1.57
Session 2	Exp.-A/Cont.-B	28.00	27.67	0.33
	Exp.-B/Cont.-A	27.67	25.83	1.83
	Cont.-A/Exp.-B	32.67	31.50	1.17
	Cont.-B/Exp.-A	32.83	31.17	1.67

Note that within the Exp.-A/Cont.-B group, no difference was found between methods at the first evaluation, but a small difference arose in the second evaluation one week later. By chance, that group had the oldest three participants in the study (ages 42, 46, 65). Interestingly, all three were among the subset in Session 1 that remembered more items from the Control Method than the Experimental Method. Two of these three age outliers flip-flopped in Session 2 to remember more vocabulary from the Experimental Method than the Control Method (the upper-left quadrant of Figure 9 above), while for the third person the relationship between methods was unchanged across sessions (the lower-left quadrant of Figure 9 above). With only these few age outliers it is impossible to know if this trend would hold for the general population. Perhaps a larger sample would find evidence of an age effect on results.

Having looked at the performance in both methods for each of the ordering groups, I now present the pooled results in Table 9 below.

Table 9: Pooled results

	Session 1		Session 2	
	Experimental Method	**Control Method**	**Experimental Method**	**Control Method**
Mean correct answers	34.56	33.29	29.04	27.63
Standard Deviation	4.16	5.19	6.13	5.75
Range	26–40	21–40	17–38	17–39

Note that the mean correct answers in the Experimental Method is higher for both sessions. This can also be seen below in the box plots in Figure 10, which additionally presents the range and the interquartile range (middle 50%) of the data.

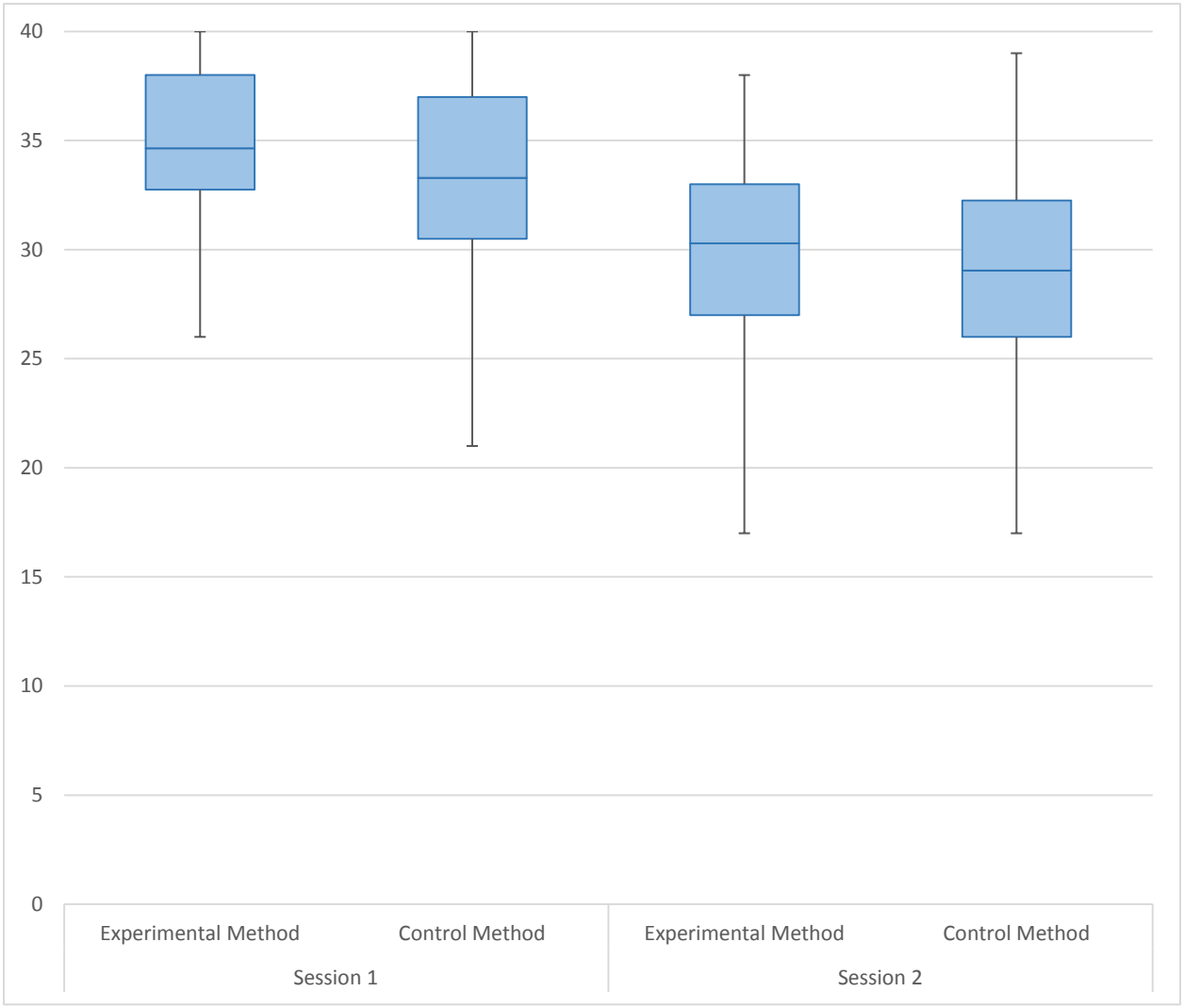


Figure 10: Mean, interquartile range, and range of correct answers in each method

Keep in mind, Table 9 and Figure 10 show a comparison simply at the group level. To take the analysis one step further, I conducted a paired samples *t*-test which compares the number of correct responses for each method within each individual for Session 1 (see Table 4 for individual scores).[13] The resulting p-value of 0.033 indicates that the difference in correct responses is statistically significant at the 0.05 level. With a p-value of 0.040, this was also

[13] $t = 2.253$, $df = 27$

true for the evaluation done one week later in session two (see Table 5 for individual scores).[14] This supports the hypothesis that the Experimental Method is more effective for vocabulary learning than the Control Method.

3.2 Justification for pooling data

The above discussion depends on the assumption that it was legitimate to pool participants' data together, that is, that there is no evidence that participants' placement in one of the four groups significantly affected their performance. So, it is necessary to examine the data more closely to rule out this possibility.

First, vocabulary set (A or B) was compared and found not to be significant to performance, that is, they were roughly equal in difficulty. Participants' data was divided into groups based on the method (experimental or control) and the ordering of that method (first or second). Table 10 and Table 11 below shows the sum of the rank orderings for each subgroup, with smaller sums indicating better performance. Because of the small numbers of participants in each cell, nonparametric Mann-Whitney U tests were used. The high p-values indicate insufficient evidence of a significant difference between vocabulary sets A and B.

Table 10: Comparison of vocabulary sets A & B at Session 1

	Exp. Method first	**Exp. Method second**	**Control Method first**	**Control Method second**
Vocabulary set A	64.5 (n = 8)	47.5 (n = 7)	47.5 (n = 7)	36 (n = 8)
Vocabulary set B	40.5 (n = 6)	57.5 (n = 7)	57.5 (n = 7)	69 (n = 6)
p-value	0.29	0.27	0.27	0.14

Also, the fact that neither vocabulary set A or B is consistently producing better performance than the other is further evidence that there is no difference between sets. That is, in Table 10

[14] $t = 2.177$, df = 23

above, in the first column, vocabulary set B is resulting in better performance, but in the remaining columns it is set A that does better.

Table 11: Comparison of vocabulary sets A & B at Session 2*

	Exp. Method first	Exp. Method second	Control Method first	Control Method second
Vocabulary set A	38	39	40	35.5
Vocabulary set B	38	39	38	42.5
p-value	0.47	0.53	0.47	0. 29

*n = 6 for each cell

In Session 2, again, neither vocabulary set consistently produces better performance than the other. In the first two columns they are equal and in the second two columns it is first B that is best, then A.

Based on this lack of evidence for a significant difference between vocabulary sets A and B, the A and B groups were pooled for further analysis.

Next, the ordering of method (first or second) was compared using an independent samples *t*-test of the mean correct answers for each subgroup as shown below in Table 12 and Table 13.

Table 12: Comparison of method ordering at Session 1*

	Experimental. Method	Standard Deviation	Control Method	Standard Deviation
First	33.36	4.50	32.71	5.84
Second	35.93	3.47	33.86	4.61

*n = 14 for each cell

The p-value for the Experimental Method at Session 1 was 0.29 and the p-value for the Control Method at Session 1 was 0.76. These large p-values do not provide evidence that the groups were significantly different based on ordering of the method.

Table 13: Comparison of method ordering at Session 2*

	Experimental. Method	Standard Deviation	Control Method	Standard Deviation
First	27.833	5.83	26.75	5.61
Second	30.25	6.44	28.5	5.99

*n = 12 for each cell

The p-value for the Experimental Method at Session 2 was 0.88 and the p-value for the Control Method at Session 2 was 0.87. Again, these large p-values do not provide evidence that the groups were significantly different based on ordering of the method.

However, it is interesting to note in Table 12 and Table 13 above that in all instances the method that was performed second led to higher mean scores. It seems logical that participants would experience a recency effect, that is, remember items better from the method they had just completed prior to the evaluation (at least for Session 1). Perhaps with a larger sample it would be possible to find evidence for this hypothesis.

In the current sample, finding no evidence that vocabulary set and ordering of method were significant allows all participants' data to be pooled, as reported above in §3.1.

3.3 Time spent studying in each method

Unexpectedly, although they were encouraged to do so, not all participants spent equal time studying in both methods. Although all participants spent the full 17 minutes studying in the Experimental Method, ten participants decided to stop studying in the Control Method before the full 17 minutes had elapsed. The reasons they gave were that they had studied enough to know all of the vocabulary and/or that they were bored. Some participants who *did* study the Control Method for the full 17 minutes nevertheless complained that it was boring and continued because I encouraged them to do so. Those who shortened their study time spent between 5.68 minutes and 16.38 minutes on the Control Method. The mean length of time for all participants was 15.35 minutes on the Control Method. This leads to the possibility that the poorer performance on vocabulary learned in the Control Method might be a result of

less time studying. There is some evidence of a correlation between the amount of time spent on the Control Method and performance in that method. In Figure 11 below we see a weak positive correlation.

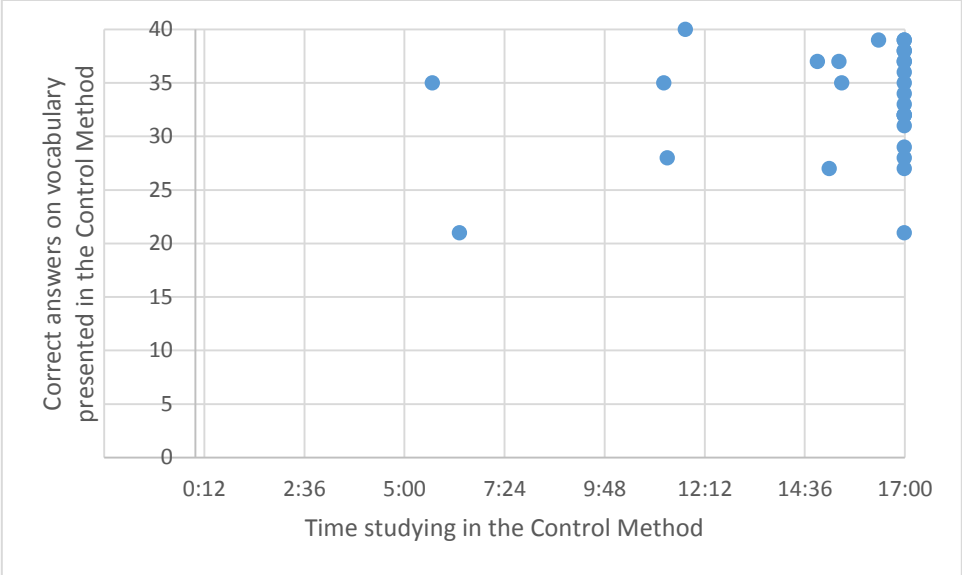


Figure 11: Time studying and correct answers in the Control Method for Session 1

The Pearson correlation between these variables in Session 1 is 0.201. In Session 2 the correlation is slightly higher (0.278), but still weak, as shown in Figure 12 below.

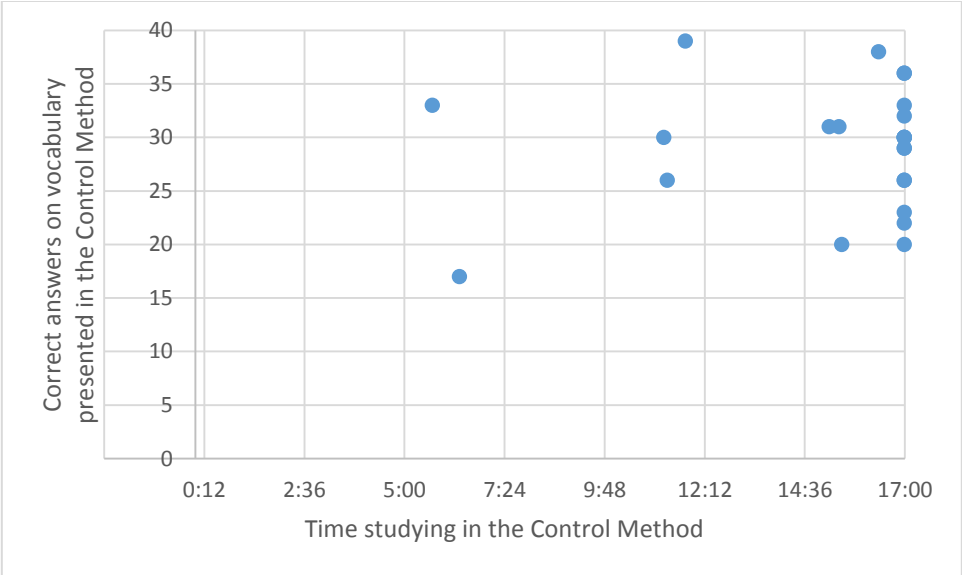


Figure 12: Time studying and correct answers in the Control Method for Session 2

Both of these represent only a weak positive correlation. Still, it is reasonable to hypothesize that more time spent studying in a method would lead to more correct answers. If a correlation had been found, it would have given evidence for a mechanism by which the Experimental Method is more effective than the Control Method, that is, by sustaining the interest of participants for longer. With the current sample, we cannot be sure whether the Experimental Method is more effective than the Control Method by virtue of being more efficient, by sustaining the participants' interest longer so they can learn more, or by a combination of both.

Chapter 4
DISCUSSION

The results of this study support the hypothesis that a simple computer-assisted vocabulary program (CAVL program) could significantly improve the ability of Deaf learners to memorize vocabulary from a foreign sign language by vocabulary quizzing. The CAVL program employed for this study was simple, being built by amateur programmers. Even so, the experimental program not only led to a greater number of correct answers, for more than one-third of participants it sustained their interest for longer than the Control Method. Sustained attention to learning vocabulary is an important part of successful foreign language learning. We know from Nation (2004: 20–21) that it is not possible for language learners to acquire all vocabulary from classes alone. Activities such as word cards and CAVL can play an important role. This new evidence suggests that CAVL programs similar to the one used for this study could be more effective than traditional dictionary study in two different ways, by being more efficient as well as being more motivating..

The success of the CAVL program in this study is in line with other things we know about foreign language learning. The program was developed based on the Dirty Dozen activity because that activity uses techniques supported by the literature, including spaced repetition, practiced retrieval (quizzing), and the use of multimedia.

4.1 Limitations

There were a number of limitations to the current study. Due to the low prevalence of Deaf persons in the general population, recruitment of participants was difficult. Fortunately, this study was conducted at the National Technical Institute for the Deaf, which has over 1,200

Deaf students, as well as several hundred Deaf faculty and staff. Every effort was made to advertise widely. Even so, given the time asked of my participants and the modest incentive offered, this study was only able to recruit a small group of participants through convenience sampling. Of the twenty-eight people who came to the first session, only twenty-four returned to complete the second. For scheduling reasons, two of those twenty-four participants returned for their second session on the eighth day following Session 1, rather than the seventh.

There were a couple of technical glitches as well. Participants were asked to manage their own timers for the study, allowing them to pause the time if they had a question or needed a break. Unfortunately, early on in the study, two participants who paused their timers accidentally reset them back to 17 minutes, so they didn't know how much further time they had to study. Luckily, in both cases these participants started at the same time as their neighbors and the time could be reset based on that. In future sessions I was more explicit that participants should be careful not to reset the timer.

Also, for the Experimental Method the sign videos were meant to auto-play and also to loop until the participant makes a selection. For some participants the first time they loaded the videos they would auto-play but not loop. These participants were instructed to use the refresh key when this happened. After reloading, the problem was resolved and the video behaved as expected. The extra time needed to reload (as many as forty pages), was very short and presumably insignificant to the results.

The issue of primary language was less clear-cut than anticipated. Rather than having participants check a box, the demographic form allowed them to write in their response. As mentioned in §2.1.2, only thirteen of the twenty-eight wrote simply the expected "ASL". Almost half of participants felt the need to indicate more than one primary language, even though they knew from all recruiting materials and the permission form that they had just completed that having ASL as a primary language was a prerequisite of participation.

4.2 Further enhancements

There are a number of possible enhancements to the experimental program as currently designed. The first of these relates to the way vocabulary meanings are represented as images.

4.2.1 Representing the meaning of vocabulary

The vocabulary meanings were not as clear as they could have been. During their learning activities, participants asked me for clarification of the meaning of vocabulary taught with both methods. In the Experimental Method, four different participants made queries about one or more pictures. Most participants asked about only one picture, but participant 7089 asked about eight different pictures just to be doubly sure he was understanding them correctly (his overall score was the highest in the study). For the Control Method, six different participants asked about the meaning of one or more English words. Queries about English words were limited to four vocabulary items.[15]

In future iterations of CAVL programs such as this one, I recommend all pictures be labeled with a translation. Nation (2004: 85–86) posits that all ways of communicating the meaning of a word—even if we use an object, picture, or other observable form—are indirect and open to misinterpretation. However, Nation argues that using the L1 is efficient with few drawbacks. For the sake of keeping the program as accessible as possible for users who do not have strong command of a written language, I think it important not to remove images altogether. Also providing the meaning of the sign in two forms allows learners to use dual encoding (learning through multiple channels), which could improve their memorization (Nation 2004: 85). For hearing users, the most efficient label for images would be a text translation into the user's L1. For Deaf users, the choice is less clear. There are some Deaf people who claim a spoken language as their L1, or at least they consider themselves very fluent in the written form of

[15] Fuchsia (4 queries), empanada (2), crude oil (2), and nectarine (1).

one, and for this population a good option is to translate into that language. However, throughout the world there are many Deaf people who claim a sign language as their L1, with a spoken/written language as a substantially weaker L2, if at all. To provide an L1 translation into sign for this group, it would possible to "label" the twelve pictures on the screen with videos of signs. However, it might prove technically difficult, and it would certainly produce a very busy screen. An improvement of one step on the current program would be to label the pictures with the translations in the spoken language that the Deaf user knows best (English, for my participants). If users wish to learn a foreign spoken language, they could elect to have that language be used for the translation labels, with a toggle button for switching back and forth between languages.

4.2.2 Ordering and spacing of vocabulary

The ordering and spacing of vocabulary can have a significant impact on learning. Repeated retrieval of vocabulary is necessary because much is forgotten soon. Words need to be retrieved a number of times to be transferred into long term memory. Many studies in memory and second language acquisition show that spaced repetition is more effective than massed repetition (Nation 2004: 76). That is, it is better to spend a few moments at a time spaced over minutes, hours, or days, rather than spending all of those moments back-to-back in a single study session. Because much is forgotten soon, early repetitions should be relatively closer together and then increasingly farther apart. Ideally, repetitions are not so close together that they are too easy, nor too far apart that retrieval is not successful. Repetitions offer the learner an opportunity to strengthen the retrieval route. It may also be possible to increase efficiency of time spent studying vocabulary by increasing or decreasing the spacing based on the learner's performance on specific vocabulary items (Nation 2004: 76–77).

In the current experiment, all participants experienced an identical order of quizzing, with no extra repetitions provided for signs that were more difficult to learn. However, for some program users, certain signs will likely be harder to learn, and those signs should be repeated

more frequently. For the sake of efficiency, other, easier, signs should repeat less frequently. One way to achieve this for word cards is proposed by Mondria and Mondria-de Vries (1994). In the "hand computer" method, five groups of word cards are stored in a box, with the first group being the smallest and each subsequent group larger than the previous. New vocabulary words begin in group 1, but once they are known they are advanced to group 2. When group 2 is full those cards are reviewed. Items still correctly remembered in group 2 can be advanced to group 3 and so on. Any item in a higher group that cannot be remembered returns to group 1. I recommend that this method be computerized and applied to future sign language quizzing programs.

Some additional ideas for increasing spaced repetition come from Duolingo (n.d.), a CALL program that makes heavy use of it. One of the ways it achieves this is by encouraging users to practice daily through reminder emails, and also a "streak count" that keeps track of how many days in a row you practice. Also, Duolingo uses tricks learned from addictive games like Candy Crush that follow a missed question with an easy one to help restore the user's confidence (Gannes 2014).

4.2.3 Multiple senses and synonyms

Although the experimental program for this study did not make use of translations into a written language, I have recommended that this feature be included in future quizzing programs above in §4.2.1. However, it is often the case that a single sign could be translated into several different words. These words could be synonyms of each other (in a sign with only one sense), or they can represent multiple senses of a sign. Conversely, there are also signs that are synonyms of each other, which can be translated into the same word. When these appear in dictionaries, usually one sign is chosen as the default and the synonyms are labeled "variants". What follows are some suggestions for how future quizzing programs could teach multiple senses and synonyms more capably than the current experimental program, and more capably than current dictionaries as well.

First, consider a sign with multiple translations that are synonyms of each other. For example, the LSCh sign for DOG might be translated into English as *dog*, *doggy*, *pup*, *pooch*, *hound,* etc. Here I suggest borrowing a feature currently offered by Duolingo (n.d.). In that program certain words are marked as having extra content with a dotted underline. When a user clicks on the word (or even mouses over it) a speech bubble appears below the word with multiple translations and even extra grammar information. In similar fashion, I recommend that with a click or mouse-over of written translations users have access to a short list of synonyms for the word. Looking across multiple online sign language dictionaries, it is rare to find one that offers synonyms of the written word definitions.

When it comes to signs that are synonyms of each other, online dictionaries do commonly offer synonyms, often labeled as variant signs. Because viewing the variant signs requires extra clicks, they are not likely to be learned as frequently or as well as the first sign in the list, which means a popular dictionary could have an impact on which signs become recognized as the standard. If a vocabulary quizzing program wishes to present synonym signs, I recommend that for the learner's first exposure they be presented side-by-side, displayed above the image (and word). Subsequently learners would be quizzed on either sign associated with the image and word.

There should also be a clear way to represent to learners that some signs have multiple senses. Unfortunately, I have never seen a sign dictionary that acknowledges this, I think due to limitations in their design. Currently, all online sign dictionaries are organized alphabetically by the gloss for each sign. Some dictionaries have created ways of dividing the main dictionary into smaller parts based on semantic category or part of speech, but no online dictionaries are indexed by the sign itself. This means that dictionary users have to search by the written word gloss associated with a sign, and would not be likely to recognize words with different senses that could be translated into the same sign. For example, in ASL the signs for DEMOCRACY and DEMOCRAT are produced in the same fashion: the D handshape is wiggled from side-to-side in neutral space in front of the body. In the first case the sign is a noun, and

refers to a political system of democracy used in many countries, while in the second the sign is an adjective, and refers to the American Democratic Party or a member of it. In the Spread the Sign Web Dictionary these glosses are recognized as distinct senses, and listed separately, but there is no recognition that they are in fact the same sign. Instead, two different sign models show the exact same sign, one for each gloss. In a future quizzing program, I recommend that the learner's first exposure to the sign occur with multiple pictures below it, one for each sense. Subsequently, learners would be quizzed on the sign with any of the corresponding images. As always, images would be also have a translation into a written language.

4.2.4 Vocabulary production for dual encoding and pronunciation feedback

Some participants wanted to copy sign during the activities, but were asked to refrain from doing so in order to keep consistency between the methods and the participants. In the future it might be beneficial to encourage learners to copy sign to achieve dual encoding (learning through multiple channels). One concern is that the users might articulate the sign incorrectly and practice the wrong thing. In order to provide feedback on pronunciation, some CALL programs for spoken languages like Duolingo (n.d.) and Rosetta Stone quiz users on their productive skills by recording the student's voice and evaluating the pronunciation. While this is not currently possible for sign languages, we can easily imagine the day technology will allow a computer with a standard webcam to record a signer and then evaluate the sign pronunciation. Until that time, a good solution is to use humans to do the evaluating.

I recommend establishing a crowd-sourced model that would have the CAVL users evaluating each other's pronunciation. This could operate in similar fashion to Duolingo's web translation activity, in which language learners collaborate to come up with accurate translations for web sites. For the current proposal, users who opt-in to receiving feedback on sign production would have their videos shared with several other users for an up or down vote. This feature would need to be elective, because not all learners will be willing to share videos of themselves signing to other users. When users find an error in someone's production,

they would be prompted to provide additional information about which sign features are incorrect (e.g., hand shape, location, movement, orientation, non-manual markers). In Duolingo, translators receive up-votes and down-votes from the community for their work and with enough up-votes their competency is recognized by promotion to the next "translation tier". For the current proposal, users who give accurate pronunciation feedback would have their evaluations up-voted by others, allowing the system to know which users are better evaluators.

4.3 Related issues

4.3.1 Leverage sign dictionaries

This study suggests that CAVL programs such as the one used in this study could profitably be developed and incorporated into existing sign language dictionaries. It is clear that these dictionaries are being used not only as a reference for the occasional unknown sign, but also as a way to learn large swaths of foreign sign language vocabulary in order to develop multilingualism. Not only are these dictionaries being used by Deaf people who want to travel, and by hearing people who want to learn the local sign language, but also by Deaf people who have late access to the local sign language due to their upbringing. Parents of Deaf children have good reason to learn a sign language in a hurry, and for many parents around the world sign classes are inaccessible for reasons of distance or cost. Additionally, I showed above in §1.2 that some students and their interpreters have been using sign dictionaries to support their communication in foreign spoken language classes.

For all of these audiences, CAVL would be a more efficient way to learn, and one likely to sustain interest for longer, as was shown in this study. The idea of using quizzing to increase learning occurs to many people as the next logical next step. Indeed, while studying in the Control Method, participant #4898 of this study appeared to notice the lack of practiced retrieval in the activity; she used a piece of paper to cover up the English words to engage in

self-quizzing. Furthermore, Spread the Sign Web Dictionary (described above in §1.1) has an internal evaluation of the program in which they report that in the Czech Republic, classes of Deaf students have used the dictionary content for quizzing activities in the classroom (Fredäng 2010).

Building CAVL applications for existing sign dictionaries is an efficient way to proceed. For example, Spread the Sign already has a database of hundreds of thousands of signs from twenty-five sign languages. That existing infrastructure could be leveraged to provide the pre-existing user base with a free CAVL application.

4.3.2 Mouthings

As noted above in §2.2, some signers in dictionaries will co-articulate signs with mouthings of words from the national spoken language. This would have been problematic for the current study (which is why this study used a signer without mouthings) but if a future CAVL program contained mouthings it could have both positive and negative effects. For a user who already knows the spoken language being mouthed (e.g., a parent who is learning sign to communicate with a Deaf child), the mouthings might give away the answer, an unwanted crutch for the learner. However, for a foreign language learner, interested in learning both the sign language and the spoken language, it might possibly be reinforcement for both languages. In either event, signs accompanied by mouthings might encourage learners to think there is an exact equivalence between the sign and the word. In fact, this danger already exists for sign dictionaries that give definitions of the sign as a translation into another language (Nation 2004: 85–86).

ASL Pro (n.d.), the online dictionary that does offer a quizzing feature, made an effort not to have any mouth movements in their vocabulary items. They did this to avoid quiz takers, who they expected to be hearing people who know English, from using the mouthings to help them answer. However, it has had some unintended negative results. According to the FAQ page, the website has received criticism about sign models not having appropriate non-manual

features. Besides the desire to remove mouthing clues, another reason hinted at in the FAQ is the use of sign models who are not native signers. For these reasons, I recommend not putting an artificial ban on mouth movements, but instead allowing the native sign models to produce signs in the way they feel most appropriate. Therefore, it will not be necessary to record signs for quizzing programs that are different from online dictionaries.

4.3.3 Vocabulary sets grouped by short stories

As mentioned above in §1.6, learning words in semantic sets has been reported to lead to lexical interference and a slower learning process. This is especially true in cases when words are in a class to replace one another, such as synonyms, antonyms, or taxonomic sisters. One strategy offered by Nation (2000) to avoid this kind of interference is to have first exposures to new words in semantic sets occur with contexts, collocations, and visual representations which are as different as possible from each other. West, cited by Nation (2000), says spreading out exposure to vocabulary within a semantic set also improves learning efficiency because all the words in a semantic set do not have equal usefulness to a learner. That is, some items have higher frequency use than others. Stories intended for new learners should have high frequency vocabulary items pulled from many different semantic sets. New learners should be encouraged not to collect all the words within a semantic set just for the sake of knowing them all, and should be told the reason why (Nation 2000). With this in mind, it could be beneficial to prepare lists of vocabulary items grouped not by semantic set, as some sign dictionaries are doing now, but rather by their appearance in small-to-medium length texts, such as a short story.

There are many possible benefits to providing these texts. For example, learners could quiz on the appropriate vocabulary before and after watching the story in which that vocabulary appears. This would provide an organization for learning vocabulary based on a situation, rather than based on semantic set. Another benefit of organizing vocabulary by its appearance in a short text is that it provides natural groupings of vocabulary items. As

mentioned above in §2.2, I found benefit in having one consistent signer perform all of the vocabulary within a quizzing activity. This is because pilot participants of my program discovered that when there are multiple signers in a quizzing situation, it is sometimes possible to associate the signer with the correct answer, even before the sign is produced. Using vocabulary lists grouped by their appearance in a text could give the application producers the opportunity when filming to use a consistent sign model for each vocabulary list. Another solution that would provide a consistent sign model is the use of 3D animated signers, for which the necessary technology is developing rapidly.

Learning from short texts also gives learners practice in using top-down strategies for figuring out vocabulary, and allows them to see vocabulary used in natural contexts. Finally, it will be more compelling to learn vocabulary when the user knows it will be applied immediately to understand a text. Signed texts can also be captioned with the written language for learners who have this as a goal.

Piece by piece, dictionaries can be developed not only into CAVL programs, but full-fledged CALL programs that would give foreign sign languages learners resources similar to those that can be found in a free program like Duolingo (n.d.), described above in §1.6. These programs could be used by Deaf and hearing alike, by those intending to use the foreign sign language to support foreign spoken language learning, and also by those who are learning the foreign sign language for its own sake. Additionally, the programs could support the learning process of those learning the national sign language within their own country, especially parents of Deaf children.

Chapter 5
CONCLUSION

Even more than their hearing counterparts, Deaf people are foreign language learners. Without full access to auditory environments, they must study to learn the spoken languages of their nation and of their home. While educational systems make it their primary goal to teach Deaf children the national language—often at the expense of teaching them an accessible natural sign language—opportunities for Deaf students to learn additional languages are not equal to what their hearing peers receive.

Foreign language learning for sign languages is especially underdeveloped. Foreign sign languages are not afforded equal respect within educational systems; they almost never offered as classes, and when they are, they are not given equal weight toward degree requirements. Missing is an understanding of how foreign sign languages can be used to facilitate foreign spoken language learning. Foreign sign languages provide language in an accessible modality that Deaf can use for decoding a written language. Foreign sign languages are especially suited to decoding foreign spoken languages from the same region because of the important commonalities which facilitate the learning of both languages at the same time. Interpreters working in foreign language classrooms have already been using foreign sign languages, which Deaf students report as very helpful. However, other than online sign dictionaries, there are no CAVL/CALL resources intended for Deaf to learn foreign sign languages.

The creation of these resources, while innovative, would not be difficult, and they could be especially efficient by collaborating with existing online sign dictionaries. As shown by the

results of this experiment, even a rudimentary vocabulary quizzing program significantly improves the ability of Deaf learners to memorize and retain sign vocabulary.

APPENDICES

APPENDIX A

DEMOGRAPHICS QUESTIONAIRE

Participant ID#:_____ First Activity/Vocab Set___ Second Activity/Vocab Set___

☐ Male ☐ Female

Age:_____

What is your primary language? (the language you use most often):_____

How many years have you been using American Sign Language?:_____

What is your proficiency at American Sign Language?

Fluent Very Good Good Fair Poor

What other languages do you use regularly?:

_____

What other languages have you studied (either in school or on your own):

_____

What is your proficiency in the languages mentioned above?

Language:_____

Fluent Very Good Good Fair Poor

Language:_____

Fluent Very Good Good Fair Poor

Language:_____

Fluent Very Good Good Fair Poor

Language:_____

Fluent Very Good Good Fair Poor

Have you ever learned any Chilean Sign Language before?_____

You may now read the instructions on the screen, but please don't begin until Ben tells you to.

APPENDIX B

VOCABULARY SET A

empanada

carpet

fish

rug

horse

tiger

toilet

metal

mouse

animal

snake

juice

electricity

octopus

toaster

cherry

noodles

tomato

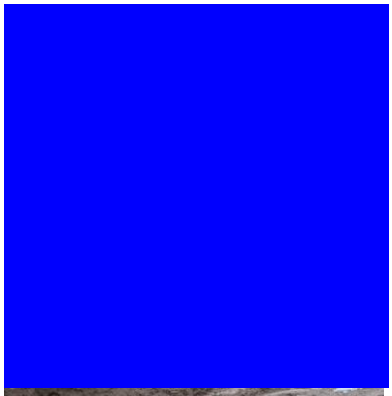
french fries

mayo

apple

yellow

blue



water

mud

teacup

shrimp

avocado

crude oil

brown

fuchsia

fruit

wax

electric kettle

cake

alcoholic beverages

apron

cat

nectarine

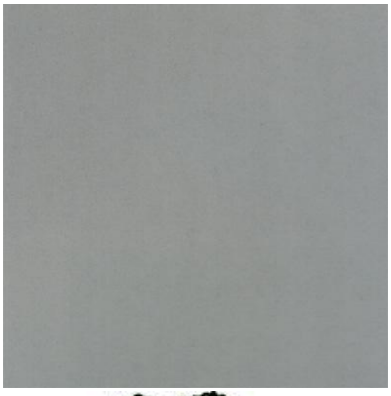
milk

APPENDIX C

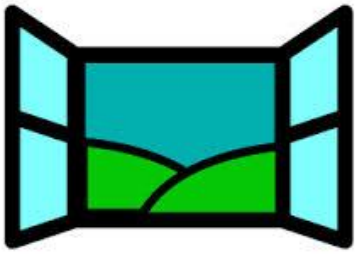
VOCABULARY SET B

ink

gray



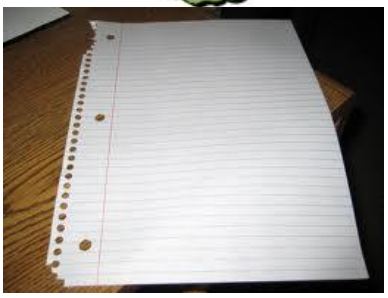
window



broccoli

artichoke

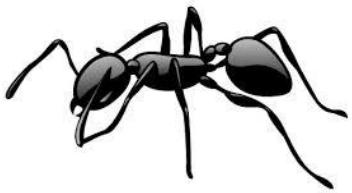
paper



garlic

bread

ant



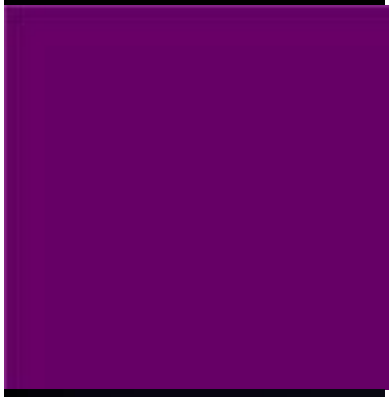
glass

cow

black

measuring tape

purple



fabric

clothes brush

tea

beverages

chocolate

egg

potatoes

ice cube

thread

orange

cheese

garden

salt

clay

dog

giraffe

sugar

sand

colors

meat

red

sheep

whale

white

pink

matchstick

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