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Abstract: This study investigated whether student interpreters encode and recall words differently in signed and spoken languages. Participants viewed and then recalled word lists, half of which were related through specific encoding strategies (i.e., experimental lists), and half of which lacked the availability of those strategies (i.e., control lists). Total words recalled and the temporal recall order were compared across experimental and control lists. Student interpreters utilised different strategies to remember words in English and American Sign Language (ASL), suggesting that student interpreters do not default to first-language (English) spoken strategies when encoding second-language (ASL) signed lists. However, the total number of recalled words was lower in ASL than in English despite students' use of encoding strategies in ASL that have been shown to be adaptive to signed languages. These findings underscore the need to provide memory training to student interpreters in order to improve recall ability as part of interpreter education.

Keywords: interpreter training, sign language, short-term memory, working memory

Introduction

Researchers frequently evaluate sign language interpreter training programs (ITPs) to improve the quality of the educational process (e.g., see Commission on Collegiate Interpreter Education, 2010; Davis, 2005; Napier, 2004; Shaw & Hughes, 2006; Shaw & Roberson, 2009), and in response to the common perception that many ITPs do not adequately prepare students for the field (Patrie, 1994; Schornstein, 2005; Winston, 2004). Recent graduates often perform poorly on standardised tests, such as the Educational Interpreter Performance Assessment (Winston, 2004) and the National Interpreter Certification (Registry of Interpreters for the Deaf, 2008), and self-report that several years experience is required before they can interpret comfortably in a variety of situations (Gammlin, 2000). Although students may have insufficient sign language skills when they enrol in an ITP (Winston, 2005), the tendency of those students to encode and retrieve signs using strategies that are more appropriate for spoken languages may also contribute to difficulties in learning to interpret between sign and speech.

Possessing advanced memory skills is imperative to interpreters of any language (Moser-Mercer, 2000) and skilled interpreters perform better at word recall and sentence processing tasks than do beginning interpreters (Signorelli, 2008; Tzou, 2009), fluent bilinguals (Christoffels, de Groot, & Kroll, 2006; Tzou, 2009), and other non-interpreters (Signorelli, 2008; Vallandingham, 1991). Interpreters' memory skills appear to develop naturally with experience (Tzou, 2009), but the encoding strategies most adaptive for interpreters may actually be different than the strategies used by other bilinguals. For instance, interpreters rely less on phonological encoding than do bilingual non-interpreters, a preference that may develop because phonologically encoded memories are more susceptible to interference and disruption than memories encoded using other strategies (Köpke & Nespoulous, 2006). However, to our knowledge, general differences in encoding between interpreters and non-interpreters have not been systematically investigated, and the specific encoding strategies used by non-native sign language interpreters have not been investigated at all. Therefore, the hypotheses of the current study were formulated based on findings from memory studies of native signers and speakers, but future research will need to empirically test the extent to which non-native interpreters utilise encoding strategies similar to those used by native signers.

Memory assessments of native signers and speakers have revealed that such individuals have equivalent span sizes for signed and spoken information (Bavelier, Newport, Hall, Supalla & Boutla, 2008; Hanson, 1982, 1990). Therefore, if student interpreters utilise the same encoding strategies for sign and speech that native signers and speakers use, they should have similar span sizes in both language modalities. Previous research has shown that native English speakers use phonological (Moulton & Beasley, 1975; Watkins, Watkins & Crowder, 1974) and semantic (Fliessbach, Buerger, Trautner, Elger, & Weber, 2010; Roediger & McDermott, 1995) encoding strategies during recall of spoken words whereas native Deaf signers encode signs formationally (i.e., signs with similar hand formations and signing space; Krakow & Hanson 1985) and semantically (Siple, Fischer, & Bellugi, 1977).

Converging evidence also suggests that native speakers encode information temporally while native signers encode spatially. For example, when hearing native signers (i.e., individuals native to both ASL and English) were allowed free recall of target lists in each language, they spontaneously recalled spoken lists with a higher proportion of temporal organisation than signed lists (i.e., the order of recalled words corresponded with the order of the words in the target list in English, but not in ASL; Bavelier et al., 2008). Likewise, the spatial nature of sign language may be reflected in the additional activation of the inferior temporal cortex when native signers produce sign blends as opposed to either signed or spoken prepositions (Emmorey, Damasio, McCullough, Grabowski, Ponto, Hichwa, & Bellugi, 2002). Sign blends occur when the spatial relationships between signs in the classifier signing space correspond to the spatial relationships between the actual objects in the real world—a characteristic unique to signed languages (Dudis, 2004). These studies suggest that while semantically related encoding strategies are shared by both signers and speakers, other strategies may be differentially preferred, based, in part, on the modality of the language (i.e., spoken or signed).

Hanson (1982) suggested that the preference for a temporal encoding strategy in English might arise from the sequential, temporal presentation of spoken languages in general (i.e., sentences comprised strings of words, grouped in a specific temporal order). In contrast, signed languages lend themselves to spatial encoding because they simultaneously relay multiple pieces of information through facial expressions, sign directionality, and the use of sign blends. Consistent with the theory that spoken but not signed languages are encoded temporally, several studies comparing native speakers with native signers have demonstrated that, when serial recall of a previously presented list is required, memory for sign is poorer than for speech (Boutla, Supalla, Newport, & Bavelier, 2004; Wilson, Bettger, Niculae, & Klima, 1997; Wilson & Emmorey, 1997a, 1997b). In contrast, when free recall is allowed, the total span size of recalled items is equivalent between language modalities (Bavelier, et al., 2008). Thus, free recall may be essential to observe either the naturally-preferred encoding strategies of specific populations or the encoding strategy to which a language modality naturally lends itself.

Different classifications of memory may also play distinct roles in the language encoding component of interpreting. Short-term memory (STM) tasks reflect storage capacity over the span of several seconds. In comparison, working memory tasks, or more accurately, tasks that require "working with memory" (Eichenbaum, 2002, p. 311), reflect the simultaneous storage and manipulation of information (Becker & Morris, 1999). Even though working memory tasks have greater external validity to the task of interpreting than do STM tasks, the current study employed a STM task consistent with previous investigations in this field. Selecting a task for study that does not require executive processing permits any differences between span sizes or encoding strategies observed between language modalities to be attributed to fundamental differences in storage capacity rather than disparities in the manipulation and use of that stored information. Furthermore, by isolating memory from the other cognitive components in the interpreting process, the current study can better estimate whether small storage capacities might impact students' ability to interpret. The answer to these questions will suggest directions for ITPs to remediate the gap between the interpreting skills of recent graduates and the professional standards in the field.

Goals of the current study

The current study compared the STM encoding strategies that student interpreters use to remember lists of words in English and ASL. It was hypothesized that student interpreters would have similar span sizes of recalled items in ASL and English if they utilised the same encoding strategies previously shown to be employed by native signers and speakers. We addressed this hypothesis in three steps:

1. We first examined the impact of language modality on memory performance in student interpreters.

2. We next investigated the effects of mnemonic strategies on recall. We compared memory performance between experimental lists that provided an encoding strategy that was either compatible or incompatible with the language being used (i.e., formational and semantic strategies were anticipated to be compatible with ASL, whereas phonological and semantic strategies were anticipated to be compatible with English) and control lists that were matched for characteristics of the words or signs on the corresponding experimental list but that did not provide an encoding strategy.

3. Finally, we assessed the effects of language modality on temporal order encoding to determine if the extent to which student interpreters rely upon temporal encoding differs between signed (i.e., ASL) and spoken (i.e., English) languages.

Methodology

Participants

Twenty-nine participants (twenty-one women, eight men) were recruited from two ITPs in ASL/English interpreting in Washington State, USA. Participants were paid $20 each. Deaf students and hearing native signers were not recruited. Following the exclusion of five participants (see Results section for exclusion criteria and details), twenty-four participants remained. These participants ranged in age from eighteen to forty-one (M = 24.75, SD = 5.35) years. The age at which participants began learning ASL ranged from twelve to thirty-nine (M = 18.93, SD = 6.27) and the approximate age when participants self-identified as "conversationally fluent" ranged from sixteen to forty-one (M = 20.78, SD = 4.38). The number of years each participant self-identified as being fluent in ASL did not correlate with ASL memory scores, $r(22) = .351$, *ns*. Of the twenty-four participants, eighteen were in the first year of their program and six were in the second year. ASL memory scores did not differ between the participants in their first and second year, $t(22) = .05$, *ns*.

The programs from which participants were recruited are both two years in length, with Deaf and hearing instructors, and offer courses in interpreting, Deaf culture, discourse analysis, ethics, and transliteration. However, the programs differed in their requirements. Nine participants were in a program that did not have a proficiency test for admittance but did require students to complete one year of ASL education prior to enrolling with an additional year of ASL education to be completed during the program. Twenty participants were recruited from a second program that required students to complete at least two years of ASL education and pass a placement test prior to admittance. There were no differences in ASL memory scores between participants recruited from the two schools, $t(22) = 1.47$, *ns*.

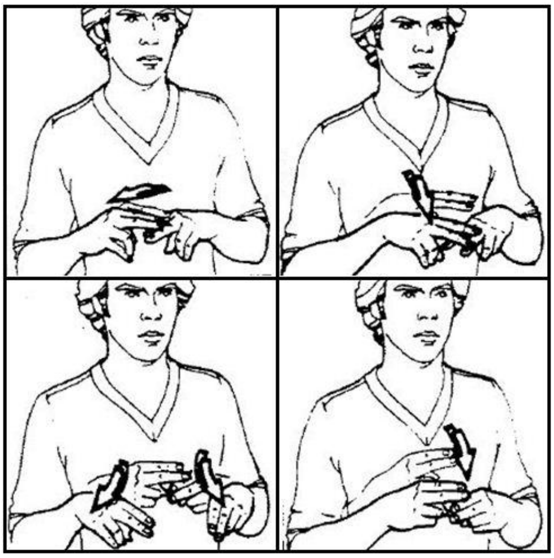

Figure 1. An example of four formationally similar signs. The English glosses (or translations) for the pictured signs are (from upper-left to lower-right): TRAIN, SALT, EGG, and NAME. Formationally similar signs share hand-shape and signing space with each other (Adapted from Hanson, 1982, with permission from the author and the publisher, the American Psychological Association).

Materials

Twelve lists, consisting of twelve words each, were created for this study (see Appendix A). Six of the lists (i.e., experimental lists) consisted of words that were related in one of three ways: (a) phonologically (e.g., blue, true, do, who); (b) formationally, in which the hand-shapes and signing space of the ASL signs were highly related (e.g., train, salt, egg, name; see Figure 1); or (c) semantically (e.g., tail, lion, claws, bite). The other six lists (i.e., control lists) were each matched word-for-word with a specific experimental list for factors such as part of speech (e.g., noun, verb, adjective), the frequency of occurrence in spoken English, the word length in English syllables, and the sign length in ASL. Unlike the experimental lists, words on the control lists were formationally, phonologically, and semantically dissimilar. Table 1 outlines the list conditions.

Because the characteristics of each experimental list (i.e., word frequency rates, word lengths, etc.) were different from the other experimental lists, performance on each experimental list could only be interpreted in relation to its matched control (see Hanson, 1982, for a model of similar procedures). Semantically-related experimental lists and their matched controls were constructed by the current authors. The phonologically- and formationally-related experimental lists were modified from Hanson (1982) to account for the local ASL dialect and to allow for presentation in a video format (i.e., replacing words in Hanson's phonologically related lists that were homophones). New control lists were constructed using updated word frequency data (Davies, 2010) and were matched for spoken frequency rather than printed frequency as in Hanson (1982).

Formational:	1(a) Experimental 1(b) Control	Formational:	4(a)Experimental 4(b) Control
Phonological:	2(a) Experimental 2(b) Control	Phonological:	5(a) Experimental 5(b) Control
Semantic:	3(a) Experimental 3(b) Control	Semantic:	6(a) Experimental 6(b) Control

Table 1: Word list conditions for the current experiment.
Note. Six pairings of experimental and control lists were constructed for a total of twelve lists. All lists were recorded in both English and ASL. Each participant was presented with all twelve lists, half in English and half in ASL, with the language of each list counterbalanced across participants.

Lists were presented to participants as video recordings on a 17" MacBook Pro laptop computer. A model fluent in both languages presented the items in each list visually or verbally at a rate of one item per second; a visual metronome ensured precise timing of word/sign production. For each participant, half of the paired experimental and matched control lists were presented in signed ASL; the other half were presented in spoken English. Each list pair was filmed in both languages, but each participant saw a given list in only one language. Each experimental list was presented consecutively with its matched control list, with order counterbalanced across participants.

Participant responses, in the form of recalled words or signs, were video-recorded on an 8GB Flip UltraHD Video Camera for later coding.

Procedure

To increase the probability that participants would utilise naturally-occurring encoding strategies, instructions emphasised that list items could be recalled in any order with no time limit. Participants controlled the initiation of the video presentation of each target list. At the end of each list, a black screen with a row of asterisks signalled the participant to recall as many items from the target list as possible. Participants were asked to recall items in the same language as the target list. When recall was complete, participants started the next list. In total, participants recalled items from each of the twelve lists that combined to form six paired experimental and matched control lists. Following recall of the final target list, demographic information was collected (i.e., participant age, sex, length of enrolment in the ITP, and the age of 'conversational fluency').

At the conclusion of the session, each participant reviewed the ASL target lists with the experimenter and identified unfamiliar signs. In order to avoid the potential confound of low memory scores with poor sign proficiency, participants' data were removed if they knew fewer than the minimum criteria of 95% of the presented signs.

Video coding and scoring

Participant responses were coded by two independent coders, who initially agreed on 98.4% of English responses and 96.3% of ASL responses. When coders disagreed, the word or sign in question was discussed until consensus was reached. For each participant, data were collected on (a) the number of items recalled from each target list, and (b) the order in which the items were recalled. To calculate total recall scores, intrusions and repetitions were removed and one point was awarded for each correct, unique item reported from the target list. The temporal order of the recalled items was scored by awarding one point for each response that consisted of a consecutive pair of recalled items from the target list (i.e., the second item of the recalled pair had appeared at *any* point after the first item in the original target list). To adjust the temporal order score to account for differences among participants in the total number of recalled items, the total temporal score was divided by the total number of possible pairs from each participant's recalled list (i.e., the participant's total score minus one), resulting in a percentage score. This method of temporal order scoring is consistent with Bavelier et al. (2008) and, because it awards points for both adjacent pairs from the target list and remote pairings that occur in the correct temporal order, temporal order scores of 50% reflect chance ordering.

Results

Of an original twenty-four participants, data from four participants (three women, one man) were excluded because of unfamiliarity with more than 5% of the signs used in the experiment. Data from one additional male participant was excluded for recalling ASL lists in English. To maintain complete counterbalancing, additional participants were recruited to perform the list sequences of excluded participants, resulting in a total of twenty-nine participants but analysed data from only twenty-four of them.

Step 1: Memory span sizes in ASL and English

A one-way, dependent sample *t* test, comparing the average total recall scores between ASL (*M* = 4.29, *SD* = 1.62) and English (*M* = 5.80, *SD* = 1.70) lists revealed that, overall, participants recalled more items from lists presented in English than from lists in ASL, $t(142) = 8.99$, $p < .001$. To determine whether fluency levels were responsible for this difference, a mean split of the student interpreters by number of years fluent in ASL was performed (*M* = 2.76) and an independent *t* test revealed that participants with above average experience did not have better memory scores in ASL than students with below average experience, $t(22) = 1.14$, *ns*.

Step 2: Mnemonic encoding strategies

As previously noted, each experimental list was matched to a control list for language elements except for the presence of a common theme (i.e., formational, phonological, or semantic similarity) in the experimental list. Therefore, improvements in recall between the experimental and control lists could be attributed to the specific encoding strategy made available in the experimental list. In order to investigate the effect of those strategies on recall, separate two-way repeated measures ANOVAs, comparing recall scores in both languages (ASL, English) for both list conditions (experimental, control), were conducted for each pair of experimental and control lists that represented an encoding strategy.

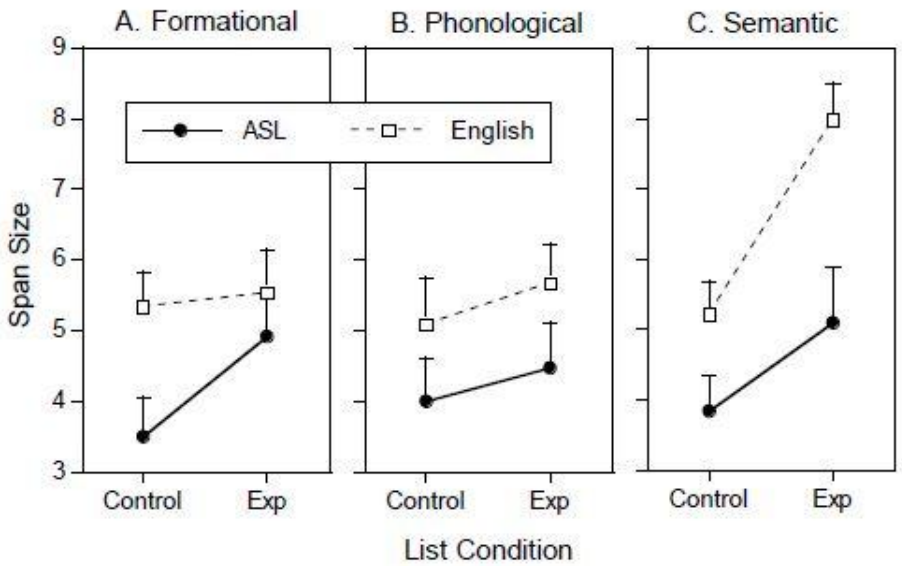

Figure 2. Figure 2 shows mean total recall scores for each list condition and language, separated by encoding mechanisms. Error bars represent the 95% confidence interval. Experimental (related) lists in each panel are contrasted with matched but unrelated control lists to observe the improvement in memory span sizes afforded by the related lists. Panel A: Items presented in the ASL experimental lists were formationally similar; items on the English experimental lists were translations of the ASL lists. Panel B: Items presented in the English experimental lists were phonologically related; items on the ASL experimental lists were translations of the English lists. Panel C: Items in the experimental lists were semantically related in both languages.

For the formational experimental and control list pairs, there were significant main effects of language, $F(1, 23) = 27.81$, $p < .001$, and list condition, $F(1, 23) = 10.01$, $p = .004$, as well as a significant language by list condition interaction, $F(1, 23) = 6.02$, $p = .022$, $\eta^2 = .21$ on total recall score (see Figure 2, Panel A). Newman-Keuls post hoc analysis of the interaction revealed that the formationally-related experimental list resulted in greater recall than the control list in ASL, $p < .001$, but not in English, $p > .05$, suggesting that, as expected, formational encoding was only utilised to improve recall in ASL.

For the phonological list pairs, there was a main effect of language, $F(1, 23) = 16.02$, $p < .001$, with English resulting in higher recall than ASL; however, there was no main effect or interaction involving list condition, $F(1, 23) = 2.813$, *ns* (see Figure 2, Panel B), suggesting that, contrary to the original prediction, phonology was not utilised to enhance recall on the experimental lists in English.

Lastly, for semantic list pairs, there was a significant main effect of language $F(1, 23) = 58.47$, $p < .001$, and a language by list condition interaction, $F(1, 22) = 4.62$, $p < .05$, $\eta^2 = .17$ (see Figure 2, Panel C). Post hoc analysis of the interaction revealed that, for both ASL and English, the semantically-related experimental list resulted in higher recall than the matched control list, *p*s < 0.05. Furthermore, recall was better in both English conditions than the corresponding ASL conditions, *p*s < 0.05. Although participants utilised semantic encoding in both languages, visual inspection of Figure 2C and the presence of the interaction suggest that participants used semantic encoding to a greater extent in English than in ASL.

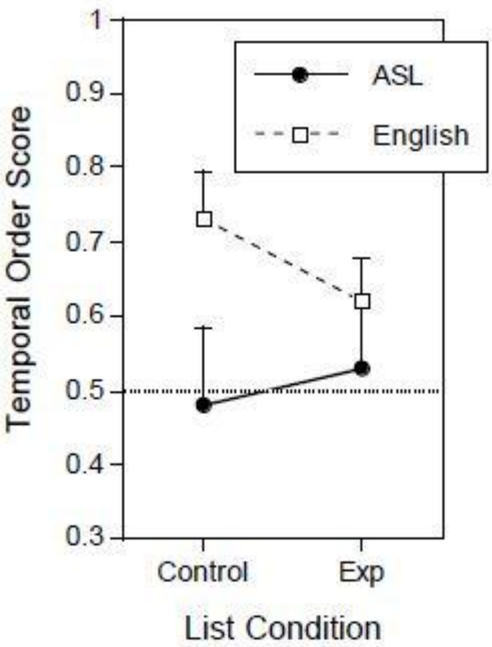

Figure 3. Figure 3 shows mean temporal order scores for each list condition and language. Error bars represent the 95% confidence interval. The dashed line at 0.5 represents chance performance and the lack of temporal coding. No differences were found between temporal ordering of control and experimental lists in ASL, but experimental lists (collapsing semantic, formational and phonological lists) resulted in lower temporal ordering than control lists in English. Overall, English was temporally encoded to a greater extent than ASL.

Step 3: Temporal order encoding

A two-way repeated measures ANOVA comparing temporal order percentage scores in both languages (ASL, English) and list conditions (experimental, control) revealed a significant main effect of language, $F(1, 23) = 19.64$, $p < .001$, $\eta^2 = .46$, as well as a language by list condition interaction, $F(1, 23) = 7.42$, $p = .012$, $\eta^2 = .24$. Post hoc analysis of the interaction revealed that, although the temporal order scores between control and experimental lists presented in ASL were not statistically different (see Figure 3; $M = .53$ and $M = .48$, respectively), the temporal order scores for experimental lists presented in English were significantly lower than scores for the control lists in English ($M = .62$ vs. $M = .73$; $p < .001$), indicating that, in English, participants used non-temporal strategies to a greater extent in experimental than control lists. Importantly, both control and experimental lists presented in ASL had lower temporal order scores than lists presented in English (ps < .05), suggesting that, overall, English resulted in greater temporal encoding than did ASL.

Correlations

Average recall on lists presented in English correlated with recall on lists presented in ASL, $r(22) = .57$, $p = .004$, and temporal order scores in English correlated with temporal order scores in ASL , $r(22) = .49$, $p = .015$. However, temporal order scores did not correlate with total recall in English or in ASL, suggesting either that temporal order encoding did not enhance overall recall in either language, or that any enhancement temporal encoding did provide was masked by other factors.

Intrusion Errors

An aggregate of 288 lists, with 3,456 words, were shown to the participants in this study. During coding, 199 total intrusion errors were identified, averaging 0.69 per list and 8.30 per participant. Of those 199 errors, seventy-eight (39%) were formational, fifty-two (26%) were phonological, and thirteen (7%) were semantic in nature. Of the remaining errors, thirty-eight (19%) were caused by proactive interference,[1] in that recalled words on a trial had actually been presented to the participant in a previous target list. An additional eighteen intrusions (9%) could not be categorised.

Discussion

Overall, findings from the current study indicate that: (a) student interpreters had lower total recall scores (i.e., smaller memory span sizes) when performing in ASL than in English; (b) the availability of a semantic encoding strategy, but not a phonological encoding strategy, improved overall memory span sizes on English trials, whereas the availability of formational and semantic encoding enhanced memory span sizes to a similar degree on ASL trials; and (c) student interpreters temporally-encoded lists in English to a greater extent than lists presented in ASL. Given previous research, we had hypothesised that free recall procedures would result in similar memory span sizes in ASL and English; however, as mentioned, total average recall scores in the current study were lower in ASL than in English. Furthermore, we had anticipated that differences in memory span sizes between languages would result from the use of encoding strategies inappropriate or suboptimal for each language modality, but (as we will detail, shortly) interpreting students appeared to use encoding strategies most appropriate to each language.

Although it is possible that the difference in STM span sizes resulted from lower fluency in ASL than in English among the student interpreters, several factors suggest otherwise. First, the majority of participants passed a fluency test prior to enrolling in their ITP. Second, self-reported years of fluency did not correlate with performance in ASL and there were no ASL performance differences between the self-reported high and low fluency groups. Considering the exclusion criteria and the relatively simple items selected for the lists used here, participants should have been able to perform the tasks equally well in both languages. Together, these results support the conclusion that span size differences could not be attributed to differences in skill level in the two languages but to deficiencies in STM capacity for signed information.

As expected, the availability of a formational encoding mechanism enhanced memory span size only in ASL. Several factors may contribute to the effectiveness of formational encoding in this context. In part, an emphasis on formational similarity in ASL classes and culture (e.g., in the form of alphabet stories; Padden, 2005) may arise because formational encoding is, in general, an adaptive strategy for encoding information in signed languages. Alternatively, student interpreters may rely upon formational encoding strategies because they have not yet developed more adaptive strategies to encode in ASL. Given students' reliance on formational encoding in the current study, future research could investigate (a) whether formational encoding is utilised in signed languages other than ASL, (b) whether experienced sign language interpreters persist in their use of formational encoding over time, and (c) whether formational encoding might be adaptive to interpreting signed languages.

With regard to phonological and semantic encoding, there was no evidence in the current study that the availability of phonological encoding significantly enhanced memory span size in English. Although this conflicts with previous findings that phonological similarities improve recall in normal native speakers (e.g., Hanson, 1982), it is consistent with studies of phonological encoding in interpreters (Köpke & Nespoulous, 2006). In contrast to phonological encoding, the availability of semantic encoding strategies improved memory in both languages, although this effect occurred to a greater extent in English than in ASL. Importantly, only 7% of intrusion errors were semantic in nature, suggesting that a semantic encoding mechanism may be particularly effective because it enhances memory while also reducing errors in recall. This may explain why successful interpreting is said to derive from the ability to focus on the essence or gist (i.e., semantic content) of what is being said (Ericsson, 2000; Lee, 2011; Liu, Schallert, & Carroll, 2004).

These findings clearly suggest that student interpreters tend to rely on encoding strategies specific to and compatible with each language modality. As previously noted, temporal encoding also appears to be used more consistently by native speakers than native signers (Bavelier et al., 2008). The current results correspond to those findings, in that student interpreters temporally encoded English lists more than ASL lists. Despite this emerging pattern in the literature, however, researchers should be cautious in generalising their conclusions about temporal order recall in ASL until word frequency can be better controlled. Merritt, DeLosh, and McDaniel (2006) state that, in related lists (like the experimental lists of the current study), low-frequency words are remembered better than high-frequency words because low-frequency words require less processing power. In turn, they found these differences affected the order of recall such that, in mixed lists with both high- and low-frequency words, the spontaneous use of temporal order encoding declines.

Controlling word frequency among the lists in this study was exceedingly difficult, as no published data on the frequency of ASL signs currently exists.[2] It is possible that using the same matched list pairs for presentation in both ASL and English resulted in different sign frequency rates across some ASL lists and temporal order scores that are close to chance, as found in the current study. A published, detailed corpus of ASL is, therefore, greatly needed. Until such data are available, it is difficult to assess the manner or degree to which imprecisely controlled word frequency rates may have affected the current findings and those of previous studies investigating ordered memory for ASL. Once a corpus is constructed and word frequency data are published for ASL signs, this confound could be easily minimised. Despite this caveat, the temporal encoding findings provide additional support for the notion that student interpreters utilise encoding strategies that are adaptive to each modality.

Interestingly, the current results also revealed that, on English tasks, temporal order encoding strategies were utilised to a lesser extent on experimental than on control lists. This finding suggests that, in English, when competing mnemonics were available, the naturally occurring temporal order encoding strategy was attenuated in favour of other available strategies. In other words, the mnemonics of the experimental lists (i.e., semantic, phonological, and formational) could not be used compatibly with the strategy of recalling words in forward temporal order, underscoring the importance of identifying successful encoding strategies for student interpreters.

Overall, with the exception of an under-utilisation of phonological encoding in English, interpreting students encoded material using the same encoding strategies enlisted by native signers and speakers, suggesting that student interpreters shift their encoding strategies depending upon the language modality. However, despite these encoding shifts, span sizes were larger in English than in ASL. Two possible explanations may account for this discrepancy. First, although previous research has shown that native signers utilise formational encoding, the reliance on formational encoding for interpreters in sign may be maladaptive in much the same way that phonological encoding is maladaptive for interpreters because it increases the risk of interference (Köpke & Nespoulous, 2006). If future research reveals that experienced interpreters cease to rely on formational encoding, ITPs could place additional emphasis on practicing alternative encoding strategies in interpreting (e.g., semantic encoding, wherein students focus on extracting the critical points of the discourse to be interpreted). This technique is often called "chunking" in the interpreting literature (Bartlomiejczyk, 2006) and can be practiced in ITPs by including memory exercises designed to facilitate chunking, such as those described in Ersozlu (2005).

One further possibility in explaining the larger span sizes for speech than sign could be that interpreting students have a deficient capacity for storing signed information early in their training. In order to help students expand their memory capacity, ITPs could incorporate STM/working memory training as part of their curriculum. One type of training, the *n*-back task, would be optimal in this case for two reasons. First, its nature is strikingly similar to the nature of simultaneous interpreting. Simultaneous interpreting requires that interpreters convey what they heard several seconds ago, while holding in their mind what the speaker is currently saying, so that several seconds in the future, they can convey the current information. In much the same way, participants performing the *n*-back task are presented with a series of stimuli and answer whether each stimuli is the same as the one presented *n* items previously. The *n*-back task would also be particularly beneficial for interpreting students because it is the only task, to date, that has been shown to improve both general fluid intelligence and working memory capacity (Jaeggi, Buschkuehl, Jonides, & Perrig, 2008; Jaeggi, Studer-Luethi, Buschkuehl, Su, Jonides, & Perrig, 2010). The difficulty of the task can be adjusted by changing the value of *n* and, importantly for ITPs, can be modified to include signs (e.g., see Rudner, Fransson, Ingvar, Nyberg, &

Rönnberg, 2007). Performing such mental exercises has been shown to improve working memory capacity in typical college students and could, therefore, help interpreting students expand their short-term and working memory capacity for sign language as well.

Conclusion

In conclusion, the results of the current study showed that student interpreters shifted their use of encoding mechanisms for enhanced compatibility with the language of list presentation. However, in spite of language modality-based changes in encoding styles, total recall was still lower in ASL than in English. These findings suggest that student interpreters may benefit from explicit memory training as part of their ITP curriculum. Importantly, such training could be designed to encourage interpreter-specific encoding strategies (e.g., encode the key components of a message), to expand the capacity of working memory for sign language (e.g., practice the *n*-back task), or a combination of both techniques, which may improve interpreter performance and the ability to pass professional certifications.

Endnotes

[1] Proactive interference resulting from the repeated measures design used in the current study appears to have had only a minor effect on performance, consistent with previous studies showing release of proactive interference when participants shift from speech to sign and vice versa (Hoemann & Keske, 1995; Hoemann & Koenig, 1990). Comparing the current data with previous research on proactive interference in ASL students is difficult, because rather than measuring proactive interference with intrusion errors, previous research on the phenomenon measured it in the traditional manner—with diminishing accuracy rates across trials of shorter lists. After four trials of related (animal) words, Hoemann and Keske (1995) reported an 80.95% decrement in their continuous language groups compared to the groups where the language switched on the fourth trial. In the present study, only 1.10% (thirty-eight out of 3,456) of the words presented were recalled in a later, incorrect recall session. It appears, then, that the constant switching from ASL to English in the current study, combined with interspersing unrelated and related lists, helped to diminish the effects of proactive interference.

[2] The best approximation we could manage for sign frequency was to use *spoken* English word frequency data to match the experimental and control lists that would be presented in ASL. Although the frequency with which an individual sign is used will not be perfectly reflected in the spoken frequency of its English gloss, it is probably a better reflection of a sign's actual frequency than the *printed* English word frequency would be, because ASL does not have a print form.

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Appendix A

Word Lists

Formationally similar list 1:	MONTH, DURING, HAPPEN, ALSO, MEET, VARIETY, DEPEND, TEMPERATURE, REGULAR, STAR, PAIN, SOCK
Formational control list 1:	KID, AROUND, BELIEVE, NEVER, SPEAK, EXPECTATION, REMOVE, PHILOSOPHY, NEGATIVE, PLANE, PAGE, CROSS
Formationally similar list 2:	NAME, RAILROAD, CHAIR, SALT, EITHER, EGG, HURRY, SHORT, WEIGHT, UNIVERSE, INCREASE, VERY
Formational control list 2:	HAND, LEMON, FARM, SELF, OFTEN, RING, COUNSEL, CLOSE, DEBT, FANTASY, VISIT, TODAY
Phonetically similar list 1:	BLUE, CHEW, DO, THROUGH, NEW, SHOE, WHO, TRUE, FEW, TWO, YOU, ARGUE
Phonetic control list 1:	SMART, SHINE, HAVE, OUT, BIG, WIND, US, HARD, MOST, FIRST, I, ACCEPT
Phonetically similar list 2:	FREEZE, PLEASE, SEIZE, PEAS, EAST, TEASE, CHEESE, GREASE, PEACE, NIECE, DECREASE, PRIEST
Phonetic control list 2:	TASTE, SOON, SMILE, SACK, NORTH, BRAG, MILK, FLUTE, PRICE, JEWEL, RETREAT, HAT
Semantically similar list 1:	ANIMAL, TIGER, CAT, CLAWS, JUMP, TAIL, KILL, BITE, LION, TEETH, RUN, STRONG
Semantic control list 1:	DISCUSSION, PEANUT, PROOF, CLAM, BLAME, DIRT, CHANGE, PRAISE, CUSTOM, CUP, SHOW, LATE
Semantically similar list 2:	CANDY, STICKY, SWEET, DESSERT, CAKE, FAVORITE, CHOCOLATE, DELICIOUS, COOKIE, WARM, BAKE, PIE
Semantic control list 2:	GUITAR, WORTHLESS, CHEAP, SANDWICH, QUEEN, CAREFUL, CONTENT, FRUSTRATED, MONSTER, BRIGHT, AID, GRASS