Comparing semantic fluency in American Sign Language and English

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Abstract

This study investigated the impact of language modality and age of acquisition on semantic fluency in American Sign Language (ASL) and English. Experiment 1 compared semantic fluency performance (e.g., name as many animals as possible in one minute) for deaf native and early ASL signers and hearing monolingual English speakers. The results showed similar fluency scores in both modalities when fingerspelled responses were included for ASL. Experiment 2 compared ASL and English fluency scores in hearing native and late ASL-English bilinguals. Semantic fluency scores were higher in English (the dominant language) than ASL (the non-dominant language), regardless of age of ASL acquisition. Fingerspelling was relatively common in all groups of signers and was used primarily for low-frequency items. We conclude that semantic fluency is sensitive to language dominance and that performance can be compared across the spoken and signed modality, but fingerspelled responses should be included in ASL fluency scores.

Keywords: semantic fluency; lexical access; American Sign Language; bimodal bilingualism; fingerspelling

Comparing semantic fluency in American Sign Language and English

Verbal fluency (phonological or semantic) has been an important component of neuropsychological screening for linguistic abilities, memory organization, and executive functioning in both children and adults. Performance on verbal fluency tasks has been widely used in clinical and research settings as a measure of language proficiency, word retrieval, and lexical organization in diverse populations (e.g., Federmeier, McLennan, DeOchoa, & Kutas, 2002; Friesen, Luo, Luk, & Bialystok, 2015; Lezak, Howieson, Bigler, & Tranel, 2012; Shao, Janse, Visser, & Meyer, 2014; Strauss, Sherman, & Spreen, 2006; Unsworth, Spillers, & Brewer, 2010). Although verbal fluency has been studied for many different spoken languages, it has not been extensively studied in deaf or hearing sign language users with different language backgrounds. For example, it is unclear how language modality or the age of exposure to sign language mediates the speed, accuracy, or pattern of lexical retrieval. Additionally, the reliability of verbal fluency tasks as a measure of lexical retrieval or linguistic ability in sign language users remains unclear.

The verbal fluency test is a word retrieval task that requires participants to produce as many words as possible that satisfy specific semantic or phonological criteria in 60 seconds. In semantic fluency, the primary focus of the present study, participants have to generate as many items as possible from a particular semantic domain, for example, fruits or animals. In phonological fluency, participants have to generate words that begin with a specific letter, for example, F or S. For cross-linguistic comparisons, semantic fluency tasks are generally preferred over phonological fluency tasks because similar conceptual categories are assumed to exist across languages. In the present study, we assessed the impact of language modality and age of acquisition on semantic fluency performance in adult deaf signers of American Sign

Language (ASL) and in hearing monolingual English speakers (Experiment 1), as well as in hearing bimodal bilinguals for both ASL and English (Experiment 2). Additionally, we investigated the occurrence and context of fingerspelled responses when the semantic fluency task was performed in ASL.

Effects of language modality and age of acquisition on semantic fluency

Only a few studies have investigated semantic fluency in sign languages. Marshall, Rowley, Mason, Herman, and Morgan (2013) administered a semantic fluency task in British Sign Language (BSL) to 22 deaf children between the ages of 4 and 15 years. The number of responses was within the range reported for the same semantic categories with hearing children in spoken English and correlated with a measure of receptive BSL abilities. In addition, the authors administered the task to a group of 13 deaf children who were suspected to have Specific Language Impairment (SLI) in BSL. Compared to typically developing deaf children, the children with SLI produced fewer responses and showed sign-finding difficulties. In a companion study, Marshall, Rowley and Atkinson (2014) investigated lexical organization in 30 adult deaf native and early BSL signers using a semantic fluency task. The number of responses in the semantic fluency task was within the range reported for adult hearing English speakers. These studies further revealed that in both sign and spoken language fluency tasks, participants retrieved fewer items over time and clustered their responses by semantic (thematic) relatedness (Marshall et al., 2014). However, BSL signers additionally produced clusters of sign homonyms (signs that are manually identical and disambiguated by mouthing) and also made occasional use of fingerspelling. These results suggest a potential role for fingerspelling or mouthing in semantic fluency tasks for sign languages.

The general findings for semantic fluency in BSL were replicated in a recent study with 68 signers between ages 5-21 years and 18 signers between ages 22-50 years from the US (Beal-Alvarez & Figueroa, 2017). These authors further tested a smaller group (N = 17) of deaf students between ages 13-20 years from Puerto Rico, where ASL is also used. Overall, both groups of ASL signers produced fewer responses in a semantic fluency task than reported in the literature for hearing English-speaking adults and children (cf. Morere, Witkin, & Murphy, 2012) and fewer responses than the deaf adults and children in the two BSL studies (Marshall et al., 2014; Marshall et al., 2013). A weak correlation with age of ASL acquisition was found for the younger US signers but not for the older US or Puerto Rico signers.

Importantly, none of these previous studies included a group of adult monolingual hearing speakers to directly contrast verbal fluency performance between spoken and signed modalities. A large-scale study conducted in the UK compared semantic fluency performance by 106 deaf children (6-11 years old) in BSL and age-matched hearing monolingual children in English (Marshall et al., 2017). They found that deaf children produced fewer responses in BSL than the hearing controls in English, although the two groups of children showed similar semantic clustering patterns. Two years later, the deaf children still scored lower than the hearing children. It is unclear whether this lower performance in semantic fluency persists until adulthood – a question we address in the present study. Moreover, the Marshall et al. (2017) study included a heterogeneous sample of deaf children with varied language experiences; only 29 of the 106 deaf children (27%) used BSL as a main form of communication, and of these, 9 (8%) were native and 20 (19%) were non-native signers. The poorer semantic fluency performance of the deaf children may thus reflect delayed first language acquisition, and not a language modality effect per se. Indeed, the authors reported that the small group of native signers produced more responses than the non-native signers, but they did not conduct a direct comparison between the two groups of children. Thus, it is unclear whether age of language acquisition contributed to poorer lexical retrieval by the deaf children. In the present study, we address this by investigating whether age of ASL acquisition and/or the language modality in which the task is performed, impact semantic fluency performance in adulthood.

In Experiment 1, we compared semantic fluency in adult deaf ASL signers with a group of hearing monolingual English speakers. Based on previous studies with adult signers, we expected comparable performance by deaf signers who use ASL as their primary means of communication and hearing English speakers. We also separately compared the performance of the subgroups of deaf native signers (born into deaf signing families) and deaf non-native, but early-exposed signers (i.e., ASL was acquired after early infancy, but before age 7). Given the established effects of delayed first language acquisition in deaf signers (Boudreault & Mayberry, 2006; Mayberry, 2007; Mayberry & Eichen, 1991), native signers might outperform non-native signers who did not acquire ASL from birth.

In Experiment 2, we compared semantic fluency in the dominant language (English) and non-dominant language (ASL) of hearing ASL-English bilinguals who acquired ASL from birth (hearing native signers) or who acquired ASL as a second language (L2) in adulthood (hearing late signers). Generally, spoken language bilinguals exhibit poorer semantic fluency than monolinguals, particularly when performing the task in their non-dominant and/or less proficient language (Blumenfeld, Bobb, & Marian, 2016; Gollan, Montoya, & Werner, 2002; Rosselli et al., 2002). In the dominant language, speakers benefit from greater lexical depth and can retrieve a larger number of items than in the non-dominant language, particularly low frequency items. The majority of hearing ASL–English bilinguals in the present study were schooled in English and immersed in a spoken language environment, and they are therefore considered English-dominant – even if they were exposed to ASL from birth and continue to actively use ASL on a daily basis (Emmorey, Petrich, & Gollan, 2013; Giezen & Emmorey, 2017; see also Paludneviciene, Hauser, Dagget, & Kurz, 2012). We thus expected the hearing bilinguals to produce fewer responses in ASL than in English. The comparison between hearing native signers and fluent second language learners will yield further insight into the effect of age of acquisition on semantic fluency in ASL. If age of ASL acquisition plays a key role in sign retrieval ability, then hearing late signers should produce fewer correct responses in ASL than hearing native signers. However, because English was the dominant language for both groups, we expected similar performance by the hearing native and late signers when performing the semantic fluency task in English.

The role of fingerspelling in semantic fluency tasks

In spontaneous ASL discourse, the use of ASL fingerspelling is relatively common, yet the precise role of fingerspelling in sign language processing and its frequency and function in verbal fluency tasks remain unclear. Fingerspelling represents English orthography with 26 distinct hand configurations and can be one-handed (ASL) or two-handed (BSL). It provides deaf bilinguals with important cross-linguistic links between sign language and spoken language orthography. Although the use of fingerspelling is infrequent for some sign languages (e.g., Swiss German Sign Language; Boyes Braem, 2001), it is quite common for ASL. Fingerspelling is often used in educational settings in the US (e.g. Humphries & MacDougall, 1999; Stone, Kartheiser, Hauser, Petitto, & Allen, 2015) and also occurs frequently in everyday discourse. For example, in the corpus study by Morford and MacFarlane (2003), fingerspelled words appeared more frequently than classifier constructions in all genres (casual, formal, narrative) and constituted 9% of the sign types in casual conversations. Educational methods in the US (e.g., the Rochester Method in which fingerspelling accompanies speech) or the widespread use of signed systems such as SEE (Signed Exact English) might contribute to the increased use of fingerspelling by ASL signers. In the present study, we examined whether hearing signers, who are dominant in English and native speakers, fingerspelled more than the deaf signers who learned English as an L2 and were dominant in ASL. However, the specific question of whether educational methods that include fingerspelling impact the frequency of fingerspelling in semantic fluency tasks or more generally remains an empirical question.

Fingerspelling (FS) in ASL is used in a variety of contexts, such as expressing proper names (*FS*-SMITH), indicating specific English terms (e.g., technical or academic jargon), or specifying concepts that do not (yet) have a corresponding lexical sign (e.g., *FS*-PANDA). Fingerspelling is also used for emphasis and disambiguation (Padden & LeMaster, 1985). For example, a recent video corpus study by Montemurro and Brentari (2018) found that fingerspelling was often used in focus constructions to emphasize a key point, even when an ASL sign was available. In addition, ASL contains lexicalized fingerspelled loan signs (e.g., #BANK, #OFF, #JOB), in which a fingerspelled word has undergone phonological changes (e.g., movement shortening, handshape deletion) to conform with constraints within the native sign lexicon (Brentari & Padden, 2001). ASL also has 'initialized' signs in which the handshape of the sign is from the manual alphabet and represents the first letter of the English translation (e.g., the ASL sign FAMILY is produced with an F handshape, and NEUTRAL is produced with an N handshape). In our analyses, we considered initialized signs as lexical signs and not as instances of fingerspelling. Brentari and Padden (2001) propose that fingerspelled forms should be treated as foreign vocabulary (following analyses of the Japanese lexicon by Itô & Mester, 1995), and they argue that all of these different types of fingerspelled forms are contained within the ASL lexicon (see also Padden, 1998). Thus, fingerspelled forms are argued to constitute lexical items in ASL and may therefore be retrieved in semantic fluency tasks.

However, Marshall et al. (2014) reported only rare occurrences of fingerspelling by BSL signers in semantic fluency tasks (2.1% responses in the category 'animals' and 1.6% responses in the category 'food'). Many of these were low-frequency items (e.g. *FS*-GECKO, *FS*-MANDRILL) or lexicalized loan signs (e.g. #SEED, #HAM). In contrast, deaf ASL signers in the US used fingerspelling much more frequently – up to 33% of responses in the study by Beal-Alvarez and Figueroa (2017). Furthermore, Padden and Gunsauls (2003) reported that the vast majority of fingerspelled words in ASL are nouns (67.5%), which is the grammatical category elicited by the semantic fluency task. When generating responses for this task, signers might thus retrieve fingerspelled items from the native ASL lexicon (e.g., fingerspelled loan signs) or from the non-native lexicon (e.g., fingerspelled words that have not been lexicalized; Brentari & Padden, 2001).

In sum, the present study aimed to address the following research questions. Do deaf native and early-exposed ASL signers perform similarly to hearing monolingual English speakers on semantic fluency tasks (Experiment 1)? Does language dominance or age of ASL acquisition impact semantic fluency performance by hearing ASL-English bilinguals (Experiment 2)? Finally, data from both experiments was used to examine a) the frequency and distribution of fingerspelled responses produced in the ASL semantic fluency task and b) whether use of fingerspelling is related to the age of ASL acquisition.

Experiment 1: Semantic fluency in deaf ASL signers and hearing English speakers

Method

Participants

Twenty-five congenitally deaf ASL signers (M_{age} = 27 years, SD = 8, 13 female) and 29 monolingual, native English speakers (M_{age} = 29 years, SD = 5, 22 female) participated in the experiment. The two groups did not differ significantly in age (t (52) = 1.6, p = .11), all were college-educated, and the groups did not differ in the number of years of education (an average of 15 years for both groups) (t (51) = .77, p = .44). Fifteen deaf participants were native signers who acquired ASL from birth from deaf parents, and 10 were early-exposed signers who acquired ASL prior to seven years of age (mean age of acquisition = 2; *SD* = 2 years). The native and early-exposed signers did not differ significantly in age (t (23) = 1.6, p = .13) or years of education (t (23) = 1.9, p = .07). Deaf participants were all born with severe to profound hearing loss, reported ASL as their primary and preferred language of communication, and self-rated their ASL proficiency on average as 6.6 (SD = 0.6) on a 1 ('very little') – 7 ('like native') scale. The native and early signers did not differ in their self-ratings of ASL proficiency (t (23) < 1, p = .71).

Materials and procedure

The semantic categories used in the present study were *Animals, Fruit, Vegetables, Clothing*. These categories were selected to enable a comparison with previous studies (e.g., Beal-Alvarez & Figueroa, 2017; Bolla, Gray, Resnick, Galante, & Kawas, 1998; Kempler, Teng, Dick, Taussig, & Davis, 1998; Marshall et al., 2017; Marshall et al., 2014; Marshall et al., 2013; Mitrushina, Boone, Razani, & D'Elia, 2005). Deaf ASL signers provided responses for all categories in ASL, and the hearing English speakers provided responses for all categories in spoken English. Signers were told fingerspelling should not replace known ASL signs. The semantic categories and experiment instructions were provided in person to all participants. Instructions for the deaf participants were given in ASL by a deaf native ASL signer or by a hearing fluent ASL signer. Instructions for the hearing participants were presented in spoken English by a native speaker. Participants were instructed to generate as many items for each category as possible in 60 seconds. The order of the four categories was counterbalanced across participants. A stopwatch was used to mark the start and stop of the response window. Only the experimenter and participant were present in the testing room. ASL and English responses were digitally recorded and glossed/transcribed (in English) for subsequent analysis.

Coding procedure. All English responses were transcribed from the audio recordings and scored by a hearing native speaker of English and reviewed by another native English speaker. All ASL responses were transcribed from the video recordings and scored by a deaf native ASL signer and reviewed by the first author who is a hearing fluent ASL signer. The coding of responses followed predefined coding criteria (see below), and minor discrepancies in coding were resolved by discussion. Each response was coded as correct or incorrect and then the number of correct responses per category was calculated for each participant (Marshall et al., 2014; Marshall et al., 2013; Morere et al., 2012). Following Marshall et al. (2014; 2013), repetitions, responses from different categories, brand names, mythical animals, or unintelligible responses were counted as errors. Both subordinate and superordinate responses were considered correct, for example, responding ‘bird, eagle, hawk, robin’ would receive a score of four. However, color varieties of the same item were all counted as a single correct response. For example, the response ‘pepper’ in addition to ‘red pepper, ‘green pepper’, and ‘yellow pepper’ resulted in a score of one. Pairs of signs with the same manual components (i.e. handshape, movement, and location), but different mouthings, were both scored as correct (cf. Marshall et al., 2014: 590). For example, the signs ‘pumpkin’ and ‘melon’ are manual homonyms in ASL and are distinguished only by English mouthing.

ASL responses were further coded for fingerspelled responses (e.g., *FS*-BEANS; #DOG) or lexical signs combined with fingerspelled responses (e.g., HONEY *FS*-DEW, *FS*-GRIZZLY BEAR). If a participant first produced an ASL sign and then immediately fingerspelled the same item, then the lexical sign was included in the analysis and the fingerspelled response was excluded. If a participant produced a fingerspelled response immediately followed by the ASL sign for that item, then the fingerspelling response was included in the analysis and the lexical sign was excluded. To determine the influence of fingerspelling on ASL semantic fluency scores we calculated two dependent measures for each ASL category and participant: (1) the number of correct responses including fingerspelling and combined ‘sign plus *FS*’ responses, and (2) the number of correct responses excluding fingerspelling and combined ‘sign plus *FS*’ responses.

Results

The statistical package SPSS (version 23) was used for all analyses. The number of responses as the dependent variable was subjected to an analysis of variance (ANOVA). Figure 1A shows that the number of correct responses did not differ between deaf ASL signers and monolingual hearing English speakers when fingerspelled responses were included in the total number of ASL responses (F (1, 52) = 1.72, p = .195, η_p^2 = .03). However, deaf ASL signers produced significantly fewer responses than English speakers when fingerspelled responses were excluded, with a moderate effect size (F (1, 52) = 37.84, p < .001, η_p^2 = .42).

A separate examination of the deaf signer group showed that deaf native signers (N = 15) outperformed deaf early signers (N = 10) when fingerspelled responses were included (F (1, 23) = 5, p = .04; η_p^2 = .18), but no effect of age of acquisition was found when fingerspelled responses were excluded (F (1, 23) < 1, p = .62; η_p^2 = .01) (see Figure 1B). However, comparisons between the native and early deaf signers need to be interpreted with caution because of the small number of participants in each group.

[FIGURE 1 ABOUT HERE]

Experiment 2. Effects of language dominance on semantic fluency in hearing ASL-English bilinguals

Method

Participants

Forty-seven hearing ASL-English bilinguals (M_{age} = 29 years, SD = 8, 33 female) participated in the study. All were immersed in an English-speaking environment from birth and were English dominant. Twenty-three participants were Children of Deaf Adults (Codas) and acquired ASL from birth from deaf parents (hearing native signers; M_{age} = 29, SD = 8, 14 female). The remaining 24 participants acquired ASL as a second language in late adolescence or adulthood (hearing late signers; M age = 29.5, SD = 8, 19 female; mean age of ASL acquisition = 15 years, *SD* = 7 years). Hearing native signers completed on average 16 years of education (SD = 2) and late signers 16.5 years (SD = 1). Native and late signers did not differ significantly in age (F (2, 44) < 1, p = .40) or years of education (F (2, 44) < 1, p = .64), but differed in self-reported ASL proficiency (F (2, 44) = 12.1, p < .001). Native signers reported higher ASL proficiency (M = 6.1, SD = .9) than late signers (M = 5.6, SD = .5); (t (45) = 2.5, p = .02). Unfortunately, objective ASL assessments were not available for these participants at the time of testing. However, we assumed that the hearing late signers had a relatively high level of ASL proficiency because they had been signing for an average of 15 years (SD = 6 years; range 4 - 26 years). Additionally, 17 (71%) were certified ASL-English interpreters, two worked as teachers of the deaf, and all reported using ASL daily.

Materials and procedure

The same materials and procedure were used as in Experiment 1. However, hearing signers completed half of the categories in ASL and half in English. The order of categories and language of response (ASL or English) was counterbalanced across participants. Instructions and semantic categories were presented in the language that corresponded to the language of response (ASL or spoken English).

Results

We analyzed the hearing signers' responses in English and ASL including and excluding fingerspelled responses using a repeated measures ANOVA with Group (native, late) as a between-subjects factor and Language of response (ASL, English) as a within-subjects factor. The number of correct responses did not differ significantly between hearing native and late signers, regardless of whether fingerspelled responses were included (F (1, 94) < 1, p = .94, η_p^2

= 0) or excluded (F (1, 94) < 1, p = .47, η_p^2 < .01). However, there was a main effect of Language, with a medium to large effect size, indicating that the participants produced more responses in English than in ASL, regardless of whether fingerspelled responses were included (F (1, 94) = 33.5, p < .001, η_p^2 = .27) or excluded (F (1, 94) = 107.3, p < .001, η_p^2 = .54). There was no interaction between Group and Language, regardless of whether fingerspelled responses were included (F (1, 94) = 1.5, p = .22, η_p^2 = .02) or excluded (F (1, 94) < 1, p = .65, η_p^2 < .01); see Figure 2.

[FIGURE 2 ABOUT HERE]

Analysis of fingerspelling: Experiments 1 and 2

Fingerspelled responses were common for both deaf and hearing ASL signers; 23% of all responses for deaf signers and 21% for hearing signers. Because the hearing signers completed only two of the four semantic categories in each language (ASL/English), we only included the first two tested categories in this analysis for the deaf ASL signers, to obtain a balanced number of responses across the groups and to ensure appropriate statistical comparisons.

Marshall et al. (2014) reported that when fingerspelling occurred in their BSL semantic fluency task, it was mainly used for items that were fingerspelled loan signs (e.g., #HAM) or low-frequency items without a conventionalized sign translation (e.g., *FS*-ENCHILADA). If

ASL fingerspelling is also primarily used for low frequency items, then fingerspelling should be more prevalent in the second half of participants' responses because lower frequency items tend to be produced later in the fluency trial (Crowe, 1998). Alternatively, if fingerspelled forms are retrieved along with lexical signs in the semantic fluency task, then fingerspelling should be more evenly distributed across participants' responses.

In the final analysis, we examined whether dominance in English (hearing signers: native / late) or dominance in ASL (deaf signers) affected the use of fingerspelling in the semantic fluency task. First, we obtained the lexical frequency of the English translations (log10 word frequency score per million) retrieved from $SUBTLEX_{US}$ (http://expsy.ugent.be/subtlexus/) as a proxy for estimating the lexical frequency of both ASL signs and fingerspelled items. As expected, the estimated lexical frequency was lower for fingerspelled items (M = 2.08, SD = 0.43) than for ASL signs (M = 2.8, SD = 0.12; t (77) = 14.6, $p < .001$). We next analyzed the occurrence of fingerspelling by comparing the number of fingerspelled responses in the first half with the second half of the semantic fluency trial for each signer. The distribution of fingerspelled responses in the semantic fluency task for each group is shown in Table 1.

[TABLE 1 ABOUT HERE]

A 3 x 2 ANOVA with Group as a between-subjects factor (deaf signers, hearing native signers, hearing late signers) and Trial half (first, second) as a within-subjects factor revealed that the groups did not significantly differ in the number of fingerspelled responses ($F\ (2, 69) = 2.13$, $p = .13$, $\eta_p^2 = .06$), and participants produced more fingerspelling in the second Trial half than in the first ($F\ (1, 69) = 90$, $p < .001$, $\eta_p^2 = .57$). However, there was a significant interaction between Group and Trial half ($F\ (2, 69) = 4.2$, $p = .019$, $\eta_p^2 = .11$). This interaction was followed up with a one-way ANOVA for each Trial half: we found a main effect of Group in the first Trial half ($F\ (2, 69) = 4.6$, $p = .013$), but there was no main effect of Group in the second Trial half ($F\ (2, 69) = 1.9$, $p = .15$). Post-hoc tests for the first Trial half revealed that deaf signers produced more fingerspelling than hearing late signers ($p = .015$, Bonferroni corrected) but no other contrasts were significant. Further, paired *t*-tests confirmed that all participants produced more fingerspelling in the second Trial half than in the first (all *p*s < .01). Finally, a separate examination of the deaf subgroups revealed that deaf native signers produced more fingerspelled responses than deaf early-exposed signers ($F\ (1, 23) = 8.3$, $p = .008$, $\eta_p^2 = .27$), both groups produced more fingerspelling in the second Trial half than in the first ($F\ (1, 23) = 10.3$, $p = .004$, $\eta_p^2 = .31$), and there was no interaction between Group and Trial half ($F\ (1, 23) = 2.4$, $p = .13$, $\eta_p^2 = .10$).

In summary, the results support the idea that fingerspelling primarily occurred for items of lower lexical frequency. Fingerspelling was relatively common for both deaf and hearing signers, and the groups generally exhibited a similar distribution of fingerspelled responses across the semantic fluency trial. That is, the number of fingerspelled responses significantly increased in the second half of the fluency trials where deaf and hearing signers retrieved more fingerspelled and fewer ASL sign responses. Interestingly, deaf signers produced more fingerspelling in the first half of responses than the hearing late signers, suggesting that fingerspelling was more evenly dispersed across trials for the deaf group than for hearing late signers. Additionally, deaf native signers produced more fingerspelling than deaf early-exposed signers overall; however, as noted, the comparison between deaf native and early signers must be treated with caution because of the small number of participants in each subgroup.

Discussion

The aims of the present study were to investigate the impact of language modality and age of sign language acquisition on semantic fluency performance. In Experiment 1, we compared semantic fluency scores in ASL and English by deaf ASL signers and hearing English speakers. In Experiment 2, we compared semantic fluency scores in the two languages by hearing bilinguals who were either native signers or late second language learners. Additionally, we examined the frequency and distribution of fingerspelled responses in the semantic fluency task by deaf and hearing signers.

Semantic fluency across language modalities

Experiment 1 revealed that deaf ASL signers and hearing monolingual English speakers retrieved a similar number of items in the semantic fluency task in ASL and English respectively, when fingerspelled responses were included as acceptable ASL responses. This study is the first to our knowledge that directly compared signed responses by adult deaf signers with spoken responses by adult hearing monolingual speakers. Our results provide evidence that semantic fluency scores can be compared across language modalities, but only when fingerspelled responses are taken into account along with lexical signs. Importantly, this result suggests that the lower semantic fluency performance reported for deaf children, as compared to their hearing peers, may not persist into adulthood (Marshall et al., 2017).

The number of correct responses produced by deaf ASL signers in the present study (including fingerspelled responses) resembles those reported in previous semantic fluency studies with adult deaf signers. For example, for the category *Animals*, BSL signers produced on average of 24 correct responses (Marshall et al., 2014), and deaf ASL signers in other studies produced on average of 20-21 responses (Beal-Alvarez & Figueroa, 2017; Morere et al., 2012). Furthermore, based on a meta-analysis of 11 studies of animal naming, hearing monolingual speakers between the ages of 25-29 years old are estimated to produce ~24 correct responses (Mitrushina et al., 2005). Deaf ASL signers and hearing English speakers in the present study produced on average 22 and 23 correct responses for this category, respectively.

The results of Experiment 1 further provided preliminary evidence that delayed first language acquisition might negatively impact semantic fluency performance. Deaf signers, who were exposed to ASL before age 7, but not from birth, produced fewer responses than deaf signers who acquired ASL natively from deaf parents, but only when fingerspelled responses were included as acceptable responses. Although this comparison must be interpreted with caution due to the small sample sizes, our finding suggests that early exposure to sign language may strengthen lexical representations. Interestingly, effects of delayed ASL acquisition were not apparent when fingerspelled responses were excluded, suggesting that fingerspelling may play an important role within the ASL lexicon. Fingerspelling has also been argued to facilitate English vocabulary growth and positively correlate with reading skill (Padden & Ramsey, 1998; Sedey, 1995). Although all deaf and hearing participants were relatively proficient in written English, future research could examine whether English and/or ASL proficiency mediates the use of fingerspelling in ASL semantic fluency tasks. One limitation of the current study was that objective measures English and ASL proficiency were not obtained from participants.

Semantic fluency in hearing ASL-English bilinguals

In Experiment 2, we compared ASL and English semantic fluency performance in hearing ASL-English bilinguals who were either native ASL signers or late L2 learners of ASL. Both groups produced more responses in English (their dominant language) than in ASL, regardless of whether fingerspelled responses were included as acceptable responses. In addition, the hearing native and late signers did not differ from each other in English or ASL semantic fluency.

These findings are consistent with results of a picture-naming experiment by Emmorey et al. (2013). In that study, hearing ASL-English bilinguals named pictures faster and more accurately in English than in ASL. In addition, naming latencies and accuracy were similar for native signers and late L2 signers. Thus, neither semantic fluency nor picture-naming tasks appear to be sensitive to age of ASL acquisition in hearing ASL-English bilinguals. Since the bilinguals in both the Emmorey et al. (2013) study and the present study were highly proficient signers (the majority worked as professional ASL-English interpreters), we suggest that ASL proficiency or dominance has a stronger impact on lexical retrieval than age of acquisition in this population. To confirm whether less-proficient ASL signers exhibit lower fluency scores, future research could examine the correlation between objective ASL proficiency measures and semantic fluency scores for a group of signers who exhibit a wider range of ASL skill than those tested here.

Lower semantic fluency scores in the non-dominant language have also been found for bilinguals of spoken languages and may reflect a smaller vocabulary in the non-dominant language, reduced use of the non-dominant language, or interference from the dominant language (for a discussion, see Blumenfeld et al., 2016; Luo, Luk, & Bialystok, 2010; Sandoval, Gollan, Ferreira, & Salmon, 2010). In some studies, bilinguals also scored lower in their dominant language, compared to monolinguals (Portocarrero, Burright, & Donovick, 2007; Sandoval et al., 2010). In the present study ASL-English bilinguals (Experiment 2) and English monolingual speakers (Experiment 1) retrieved similar numbers of items in English (~18 responses across categories for both groups). It is possible that bimodal bilinguals experience less cross-language interference in semantic fluency tasks than unimodal bilinguals due to decreased competition for articulation (cf. Emmorey, Luk, Pyers, & Bialystok, 2008). However, data on important moderator variables including nonverbal intelligence and vocabulary measures were unfortunately not available for our participants, and thus the comparison between bilinguals and monolinguals should be interpreted with caution.

Frequency and distribution of fingerspelling in ASL semantic fluency tasks

The results of the present study emphasize the important role of fingerspelling in ASL and its impact on measures of lexical access and expressive language ability for ASL signers. In line with previous reports of ASL fingerspelling use, both deaf and hearing signers produced a relatively high proportion of fingerspelled responses in the ASL semantic fluency task. In fact, when fingerspelled responses were excluded from the total number of correct responses, deaf ASL signers' semantic fluency scores were significantly lower than those of hearing English speakers. In Experiment 1 deaf signers fingerspelled 23% of ASL responses, and in Experiment 2 hearing signers fingerspelled 21% of ASL responses. The proportion of fingerspelling within individual semantic categories, for example, *Animals* and *Fruits*, resembles the proportion found by Beal-Alvarez and Figueroa (2017) for ASL: 14% for *Animals* (cf. 5% in Beal-Alvarez and Figueroa) and 39% for *Fruits* (cf. 33% in Beal-Alvarez and Figueroa).

Compared to previous studies, fingerspelling was rare (~2% of responses) in the semantic fluency study with BSL signers (Marshall et al., 2014). Fingerspelling is more prevalent in ASL than in other sign languages (see Nicodemus et al., 2017), which could explain cross-linguistic variation in the use of fingerspelling in semantic fluency studies. However, possible differences in instructions to the participants between the studies may also have played a role. For example, it is unclear whether Marshall et al. (2013; 2014) included any explicit instructions related to the production of fingerspelling for their BSL semantic fluency tasks. In the present study, we neither encouraged nor discouraged participants to use fingerspelling; however, we did instruct them to use existing ASL signs whenever possible and that fingerspelling should not replace a response for which an ASL sign exists.

Fingerspelling is closely associated with the phonological/orthographic representations of English words (Chamberlain & Mayberry, 2000; Haptonstall-Nykaza & Schick, 2007; Sehyr, Petrich, & Emmorey, 2017). As such, in a semantic fluency task, hearing and deaf bimodal bilinguals can produce lexical items from their other language through fingerspelling. This is not possible for unimodal bilinguals; for example, a Spanish word would not be permitted in an English fluency task. However, fingerspelled responses in the present study might have also occurred for reasons other than cross-language intrusions from English or the consequence of unsuccessful retrieval of a lexical sign. For example, fingerspelling in ASL is often used for concepts that have no established lexical signs or when a sign is not commonly used. Indeed, we found that fingerspelled responses were used for items with lower English frequency and occurred primarily in the second half of the trial. In contrast, lexicalized fingerspelled forms such as #DOG were generally produced earlier in the fluency trial (79% of all occurrences of #DOG were produced in the first half of the trial). In addition, it is possible that some participants used fingerspelling to avoid regional signs or signs that the experimenter might not know. Signers may have also preferred fingerspelling over using a lexical sign. For example, even though there is a lexical sign for 'broccoli', many ASL signers may have chosen to fingerspell *FS*-BROCCOLI because that is how they commonly refer to that vegetable. Indeed, we found that some signers produced both the ASL sign and the fingerspelled word for the same item.

Although we did not find overall differences in the frequency of fingerspelling between deaf and hearing signers, deaf signers produced more fingerspelled responses than hearing late signers, especially in the first half of the semantic fluency trials. However, the deaf signers did not differ from hearing native signers, suggesting that ASL acquisition from an early age might strengthen the integration of fingerspelled forms in the ASL lexicon. Similarly, deaf early signers tended to use fingerspelling less frequently than deaf native signers. It may be that non-native signers (both deaf and hearing) did not fingerspell some items because they thought that a lexical sign existed for those concepts, whereas native deaf and hearing signers may have been more confident that a concept should be fingerspelled. Ultimately, the results suggested that dominance in English does not increase the use of fingerspelling because we found no difference in the number of fingerspelled responses by the hearing signers who were dominant in English (and native speakers) and the deaf signers who learned English as an L2 and were dominant in ASL

Finally, it is important to note that ASL signs and fingerspelled words may take longer to articulate than spoken words (Bellugi & Fischer, 1972; Klima & Bellugi, 1979). A cross-linguistic study by Kempler et al. (1998) found an effect of word length on semantic fluency performance: Spanish speakers produced fewer animal names than Vietnamese speakers. Kempler et al. suggested that this result could be due to the fact that responses in the animal category in Spanish were all multisyllabic, while ~80% of responses in Vietnamese were monosyllabic. Moreover, fingerspelled words are likely to take longer to articulate than lexical signs. Although it is possible that differences in the articulatory duration of fingerspelling versus words could influence the number of retrieved items in ASL compared to English, we found no language modality effect when fingerspelled responses were included in the total count. Therefore, articulatory duration does not appear to negatively impact semantic fluency performance in ASL compared to English.

Overall, our results indicate that fingerspelling should be considered when evaluating semantic fluency as a measure of ASL lexical proficiency or when using normed scores from English speakers to evaluate ASL signers' performance. Excluding fingerspelled responses from the total number of responses or explicitly instructing ASL signers not to fingerspell at all during the task could lead to an underestimation of their verbal abilities. An interesting open question for future studies is how users of sign languages that do not have fingerspelling systems would perform on a semantic fluency task compared to users of sign languages like ASL, in which fingerspelling is an integrated part of the lexicon (Brentari & Padden, 2001).

Conclusion

Documenting the generalizability of verbal fluency tests to different languages and populations of language users is critical for researchers and clinicians who rely on these measures as an index of language proficiency, lexical access, or executive functioning. To our knowledge, this is the first study that directly compared semantic fluency in a spoken language and a sign language 1) between adult deaf ASL signers and hearing English speakers, and 2) within hearing ASL-English bilinguals. Our results provide strong evidence that the modality of the dominant language (spoken or signed) does not affect semantic fluency scores in deaf or hearing adults if fingerspelled forms are considered acceptable responses, and that language dominance rather than age of acquisition affects ASL semantic fluency performance in hearing ASL-English bilinguals. The relatively high proportion of fingerspelled responses in ASL semantic fluency tasks highlights an important role for fingerspelling in lexical retrieval and emphasizes the need for the consideration of fingerspelling when assessing semantic fluency in ASL.

References

Beal-Alvarez, J. S., & Figueroa, D. M. (2017). Generation of signs within semantic and phonological categories: Data from deaf adults and children who use American Sign Language. *Journal of Deaf Studies and Deaf Education, 22*(2), 219-232. doi:10.1093/deafed/enw075

Bellugi, U., & Fischer, S. (1972). A comparison of sign language and spoken language. *Cognition, 1*(2-3), 173-200. doi:10.1016/0010-0277(72)90018-2

Blumenfeld, H., K, Bobb, S. C., & Marian, V. (2016). The role of language proficiency, cognate status and word frequency in the assessment of Spanish–English bilinguals' verbal fluency. *International Journal of Speech-Language Pathology, 18*(2), 190–201. doi:10.3109/17549507.2015.1081288

Bolla, K. I., Gray, S., Resnick, S. M., Galante, R., & Kawas, C. (1998). Category and letter fluency in highly educated older adults. *Clinical Neuropsychologist, 12*(3), 330-338. doi:10.1076/clin.12.3.330.1986

Boudreault, P., & Mayberry, R. I. (2006). Grammatical processing in American Sign Language: Age of first language acquisition effects in relation to syntactic structure. *Language and cognitive processes, 21*(5), 608–635. doi:10.1080/01690960500139363

Boyes Braem, P. (2001). A multimedia bilingual database for the lexicon of Swiss German Sign Language. *Sign Language & Linguistics, 4*(1/2), 133–143. doi:10.1075/sll.4.12.10boy

Brentari, D., & Padden, C. A. (2001). Native and foreign vocabulary in American Sign Language: A lexicon with multiple origins. In D. Brentari (Ed.), *Foreign vocabulary: A cross-linguistic investigation of word formation* (pp. 87-119). Mahwah, NJ: Lawrence Erlbaum Associates.

Chamberlain, C., & Mayberry, R. I. (2000). Theorizing about the relationship between ASL and reading. In C. Chamberlain, J. Morford, & R. Mayberry (Eds.), *Language Acquisition by Eye* (pp. 221-260). Mahwah, NJ: Lawrence Erlbaum and Associates.

Crowe, S. F. (1998). Decrease in performance on the verbal fluency test as a function of time: Evaluation in a young healthy sample. *Journal of clinical and experimental neuropsychology, 20*(3), 391-401. doi:10.1076/jcen.20.3.391.810

Emmorey, K., Petrich, J. A. F., & Gollan, T. H. (2013). Bimodal bilingualism and the frequency-lag hypothesis. *Journal of Deaf Studies and Deaf Education, 18*(1), 1-11. doi:10.1093/deafed/ens034

Federmeier, K. D., McLennan, D. B., DeOchoa, E., & Kutas, M. (2002). The impact of Semantic memory organization and sentence context information on spoken language processing by younger and older adults: an ERP study. *Psychophysiology, 39*, 133–146. doi:10.1111/1469-8986.3920133

Friesen, D. C., Luo, L., Luk, G., & Bialystok, E. (2015). Proficiency and control in verbal fluency performance across the lifespan for monolinguals and bilinguals. *Language, Cognition and Neuroscience, 30*(3), 238–250. doi:10.1080/23273798.2014.918630

Giezen, M., & Emmorey, K. (2017). Evidence for a bimodal bilingual disadvantage in letter fluency. *Bilingualism: Language and Cognition, 20*(1), 42-48. doi:10.1017/S1366728916000596

Gollan, T. H., Montoya, R. I., & Werner, G. A. (2002). Semantic and letter fluency in Spanish–English bilinguals. *Neuropsychology, 16*(4), 562–576. doi:10.1037/0894-4105.16.4.562

Haptonstall-Nykaza, T. S., & Schick, B. (2007). The transition from fingerspelling to English print: Facilitating English decoding. *Journal of Deaf Studies and Deaf Education, 12*(2), 172-183. doi:10.1093/deafed/enm003

Humphries, T., & MacDougall, F. (1999). "Chaining" and other links. Making connections between American Sign Language and English in two types of school settings. *Visual Anthropology Review, 15*(2), 84-94. doi:10.1525/var.2000.15.2.84

Itô, J., & Mester, A. (1995). The core-periphery structure of the lexicon and constraints on reranking. In J. Beckman, S. Urbanczyk, & L. Walsh (Eds.), *Papers in Optimality Theory* (Vol. 181-210). Amherst: GLSA.

Kempler, D., Teng, E. L., Dick, M., Taussig, M. I., & Davis, D. S. (1998). The effects of age, education, and ethnicity on verbal fluency. *Journal of the International Neuropsychological Society, 4*(6), 531–538. https://www.ncbi.nlm.nih.gov/pubmed/10050357.

Klima, E., & Bellugi, U. (1979). *The signs of language*. Cambridge, MA: Harvard University Press.

Lezak, M., Howieson, D., Bigler, E., & Tranel, D. (2012). *Neuropsychological assessment*. NewYork, NY: Oxford University Press.

Luo, L., Luk, G., & Bialystok, E. (2010). Effect of language proficiency and executive control on verbal fluency performance in bilinguals. *Cognition, 114*(1), 29-41. doi:10.1016/j.cognition.2009.08.014

Marshall, C. R., Jones, A., Fastelli, A., Atkinson, J., Botting, N., & Morgan, G. (2017). Semantic fluency in deaf children who use spoken and signed language, in comparison to hearing peers. *International Journal of Language and Communication Disorders*. doi:10.1111/1460-6984.12333/epdf

Marshall, C. R., Rowley, K., & Atkinson, J. (2014). Modality-dependent and independent factors in the organisation of the signed language lexicon: Insights from semantic and phonological fluency tasks in BSL. *Journal of Psycholinguistic Research, 43*(5), 587-610. doi:10.1007/s10936-013-9271-5

Marshall, C. R., Rowley, K., Mason, K., Herman, R., & Morgan, G. (2013). Lexical organization in deaf children who use British Sign Language: Evidence from a semantic fluency task. *Journal of Child Language, 40*(1), 193-220. doi:10.1017/S0305000912000116

Mayberry, R. I. (2007). When timing is everything: Age of first-language acquisition effects on second-language learning. *Applied Psycholinguistics, 28*, 537–549. doi:10.1017.S0142716407070294

Mayberry, R. I., & Eichen, E. (1991). The long-lasting advantage of learning sign language in childhood: Another look at the critical period for language acquisition. *Journal of Memory and Language, 30*(486–512). doi:10.1016/0749-596X(91)90018-F

Mitrushina, M., Boone, K. B., Razani, J., & D'Elia, L. F. (2005). *Handbook of normative data for neuropsychological assessment, 2nd ed.* New York, NY: Oxford University Press.

Montemurro, K., & Brentari, D. (2018). Emphatic fingerspelling as code-mixing in American Sign Language. *Proceedings of Linguistic Society of America, 3*(1), 1-13. doi:10.3765/plsa.v3i1.4357

Morere, D. A., Witkin, G., & Murphy, L. (2012). Measures of expressive language. In D. A. Morere & T. E. Allen (Eds.), *Assessing literacy in deaf individuals: Neurocognitive measurement and predictors* (pp. 141-157). New York: Springer.

Morford, J., & MacFarlane. (2003). Frequency characteristics of American Sign Language. *Sign Language Studies, 3*(2), 213-225. doi:10.1353/sls.2003.0003

Nicodemus, B., Swabey, L., Leeson, L., Napier, J., Petitta, G., & Taylor, M. M. (2017). A cross-linguistic analysis of fingerspelling production by sign language interpreters. *Sign Language Studies, 17*(2), 143-171. doi:10.1353/sls.2017.0000

Padden, C. A. (1998). The ASL lexicon. *Sign Language & Linguistics, 1*(1), 39 –60. doi:10.1075/sll.1.1.04pad

Padden, C. A., & Gunsauls, D. (2003). How the alphabet came to be used in a sign language. *Sign Language Studies, 4*(1), 10–33.

Padden, C. A., & LeMaster, B. (1985). An alphabet on hand: The acquisition of fingerspelling in deaf children. *Sign Language Studies, 47*, 161-172.

Padden, C. A., & Ramsey, C. (1998). Reading ability in signing deaf children. *Topics in Language Disorders, 18*, 30-46.

Paludneviciene, R., Hauser, P. C., Dagget, D. J., & Kurz, K. B. (2012). Issues and trends in sign language assessment. In D. A. Morere & T. E. Allen (Eds.), *Assessing literacy in deaf individuals. Neurocognitive measuremement and predictions*. New York, NY: Springer.

Portocarrero, J. S., Burright, R. G., & Donovick, P. J. (2007). Vocabulary and verbal fluency of bilingual and monolingual college students. *Archives of Clinical Neuropsychology, 22*(3), 415-422. doi:10.1016/j.acn.2007.01.015

Rosselli, M., Ardila, A., Salvatierra, J., Marquez, M., Matos, L., & Weekes, V. A. (2002). A cross-linguistic comparison of verbal fluency tests. *International Journal of Neuroscience, 112*(6), 759-776. doi:10.1080/00207450290025752

Sandoval, T., Gollan, T. H., Ferreira, V. S., & Salmon, D. P. (2010). What causes the bilingual disadvantage in verbal fluency: The dual-task analogy. *Bilingualism: Language and Cognition*(13), 231–252. doi:10.1017/S1366728909990514

Sedey, A. (1995). *Fast mapping of novel fingerspelled words by profoundly deaf students*. Unpublished doctoral dissertation: Madison, WI, University of Wisconsin.

Sehyr, Z. S., Petrich, J., & Emmorey, K. (2017). Fingerspelled and Printed Words Are Recoded into a Speech-based Code in Short-term Memory. *Journal of Deaf Studies and Deaf Education, 22*(1), 72-87. doi:10.1093/deafed/enw068

Shao, Z., Janse, E., Visser, K., & Meyer, A. S. (2014). What do verbal fluency tasks measure? Predictors of verbal fluency performance in older adults. *Frontiers in Psychology, 5*(772). doi:10.3389/fpsyg.2014.00772

Stone, A., Kartheiser, G., Hauser, P. C., Petitto, L. A., & Allen, T. E. (2015). Fingerspelling as a Novel Gateway into Reading Fluency in Deaf Bilinguals. *PLOS One, 10*(10), e0139610. doi:10.1371/journal.pone.0139610

Strauss, E., Sherman, E. M. S., & Spreen, O. (2006). *A Compendium of neuropsychological tests: Administration, norms, and commentary, 3rd ed.* New York, NY: Oxford University Press [31 full text instruments].

Unsworth, N., Spillers, G. J., & Brewer, G. A. (2010). Variation in verbal fluency: A latent variable analysis of clustering, switching, and overall performance. *The Quarterly Journal of Experimental Psychology, 64*(3), 447-466. doi:10.1080/17470218.2010.505292

Figure 1. A. Mean number of correct responses including or excluding fingerspelled (FS) responses for deaf ASL signers in ASL and hearing English speakers in English. Error bars represent the standard error of the mean. *B*. Mean number of correct responses including or excluding fingerspelled responses for deaf native and deaf early ASL signers.

Figure 2. Mean number of correct responses in ASL and English for hearing native signers and hearing late signers when including or excluding fingerspelled (FS) responses for ASL (error bars represent one standard error of the mean).

Tables

Table 1. Average number of fingerspelled responses produced in the first and second half of semantic fluency trial for deaf and hearing signers (standard deviation is reported in parentheses).

	1st half	2nd half	All	N partic.
Deaf signers	3.0 (1.9)	4.9 (3.1)	7.9 (4.2)	25
Native	3.5 (1.8)	6.1 (3.1)	9.7 (4.1)	15
Early	2.2 (1.7)	3.1 (2.0)	5.3 (3.0)	10
Hearing native signers	1.8 (1.6)	5.8 (2.7)	7.6 (4.1)	23
Hearing late signers	1.5 (1.9)	4.0 (3.5)	5.5 (4.9)	24