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Multimodal Visual Languages User Interface, M3UI

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Abstract

Previous research has shown that deaf users spend more effort compared with their hearing peers while seeking for information in signed modality articles when compared to written modality articles. That is, if a deaf user consumes information in a signed modality, they have to invest more effort into information seeking due to lack of options and technology available for signed modality information. In other words, user effort in finding and consuming information plays a large role in successful information retrieval and consumption, with increased effort more likely to lead to failed information searches. One way to examine and reduce the disparities in deaf user's effort is to develop an improved user interface (UI) for academic articles in signed modality such as Deaf Studies Digital Journal (DSDJ). We developed and validated a multimodal visual languages user interface that makes searching for academic information in signed-modality articles easier for college-educated deaf users, and found that they can effectively scan and understand information faster by utilizing the advantages of both signed and written modalities through the M3UI interface.

Keywords

Deaf, Hard of Hearing, Accessible Technology, ASL, English

Introduction

Studies have reported an increase in deaf users' effort while seeking for information in signed modality articles when compared to written modality articles (Kushalnagar et al., 2015). Thus, if a deaf user needs information in signed modality, they have to invest more effort into information seeking due to lack of options and technology available for signed modality information. User effort in finding and consuming information plays a large role in successful information retrieval and consumption, with increased effort more likely to lead to failed information searches (Yilmaz et al., 2014). One way to examine and reduce the disparities in deaf user's effort is to develop an improved user interface (UI) for academic articles in signed modality such as Deaf Studies Digital Journal (DSDJ). The initial version is shown in Fig. 1, nd the current version is shown in Fig. 2. One purpose of academic articles and written modality is to present information in an easily consumable and searchable form (Ong, 2002). Developing an UI that reduce deaf user's effort while searching for information in academic ASL articles will provide with a model of accessible information for deaf users.

Fig.1. Initial UI in DSDJ for Academic Articles in Signed Modality.

However, designing an UI that meet the needs of deaf community requires being conscious of the neurodiversity of deaf community, as cognitive neuroscience and behavioral research on signing deaf population has shown that there are a tremendous diversity in background and ability. For instance, the age of acquisition of first language and second language along with language and social environments has been shown to be a strong predictor of cognitive and language ability, and possible risk factors in deaf community (Mayberry 2007, Sehyr, Glezen & Emmorey, 2018; Kushalnagar et al., 2018). Those findings suggest that deaf community is not a monolithic population with uniform needs; instead the deaf community's needs are varied, making it difficult to design accessible technologies that is able to meet the wide range of user needs. Taking the neurodiversity of deaf community into consideration of what accessible information could look like is an important step toward bridging the gap of accessible information for signing deaf community.

Discussion

Based on deaf users' feedback on the initial version of DSDJ, Multimodal Visual Languages User Interface, M3UI, was developed (figure 2).

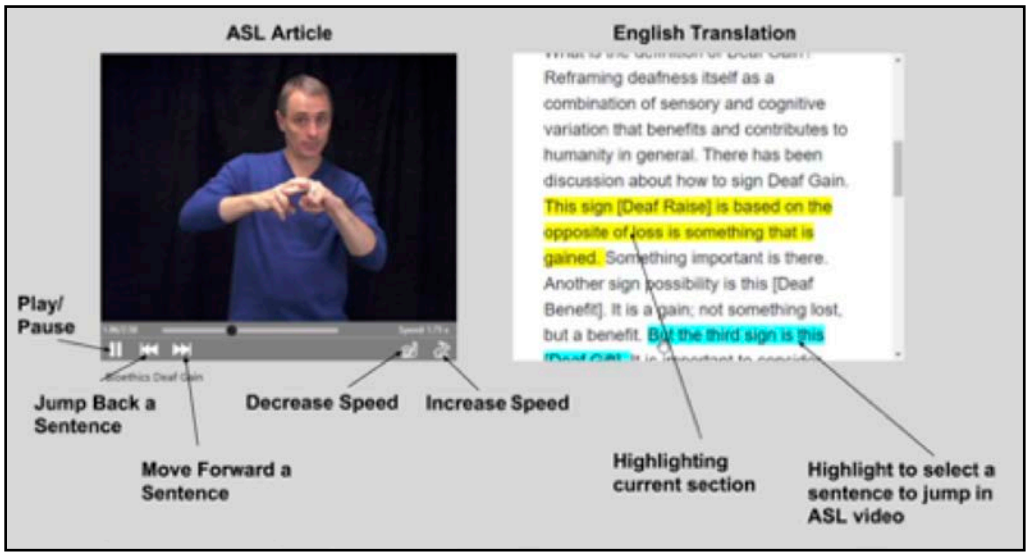

Fig 2. The Current UI Used in this Study, M3UI.

This UI has four technological features that was not present in the original DSDJ UI: multimodal visual languages, speed control, sentence synchronization, and highlighting. Those different UI technologies presents the deaf user with the opportunity to utilize different information seeking behaviors. Those technology features, along with possible information seeking strategies, are listed below: 1) Multimodal Visual Languages: ASL articles with written English translation presented next to it. Providing signed and written modality together produces a third visual modality; 2) Speed control: Control over the speed of information stream allows the user to modulate the speed of video and text, based on their perception abilities; 3) Sentence synchronization: Allows the user to scan sentences and jump to a specific sentence in both modalities; and 4) Highlighting: Visually aligns both modalities by highlighting current Written English sentence translation with its corresponding ASL sentence, allowing for ease of switching attention between modalities.

Hypothesis

The current study hypothesize that searching for information with M3UI is significantly easier than searching with a monomodal ASL UI due to different types of information searching behaviors made possible by the addition of written modality. Thus, we predict that deaf users will rate the amount of effort needed to find information with M3UI to be significantly easier than finding information with monomodal ASL UI.

Hypothesis

We recruited 21 participants; all were college educated and ASL-fluent deaf. They were divided into L1 (=0yo; N = 9) and L2 (>0yo; N = 11) groups. In terms of age distribution, it was fairly evenly distributed, with around one-third in their 20s, one-third in their 30s, one-third in

their 40s, and a couple in their 50s. In terms of the participants' gender distribution, there was a disparity in favor of females, with 61.9% females, 33.3% males and 4.8% non-binary.

In terms of the participants' education, there was a fairly even distribution that mirrored the general population distribution, with one-third having completed some school, one third having completed high school, and the remainder having attended or completed college.

In terms of communication effectiveness distribution, about half got some information through listening and lipreading, while one-third got most of the information, and 5% got no information at all. Interestingly, none of the participants got all of the information, which is consistent with the fact that they are deaf or hard of hearing and are aware that they are missing information during conversation, and in terms of hearing identity, 95% identified as Deaf and 5% identified as hard of hearing.

In terms of the participants' first language, about half of the participants noted that their first language was American Sign Language; 15% noted their first language was spoken English; 24% noted their first language was Signed English; and around 5% each noted their first language was lip-reading and home signs, pidgin sign language and cued speech. Then when asked what language they preferred, 85% preferred ASL, while 10% preferred Pidgin Sign Language, and 5% preferred English and ASL, which appears to correspond with their hearing identity, in which 95% identified as Deaf and 5% as hard of hearing. Interestingly, all participants reported that they used ASL to communicate all the time.

Methodology

Instruments: Windows 10 virtual machine was used to host a custom built website that runs on AMPPS, which is an all-in-one web server and database solution. We also used several

iPads to provide respondents with an easy to respond survey using google forms to provide relevant demographics, tasks, and effort judgement ratings.

Task: For each trial, the participant was instructed to find information in ASL chapters that they feel will satisfy the predetermined search queries that were provided by the researchers. After the participant feels satisfied with their information seeking, they record with a timestamp of the location of the most relevant information in the ASL chapters. Then, they answered effort judgment ratings on how easy it was to find information related to the search query in the ASL chapter.

Stimulus: Two different search queries (total of 16 search queries) for each of the 8 ASL chapters from the article published in Deaf Studies Deaf Journal (DSDJ), "Reframing: From Hearing Loss to Deaf Gain" by Bauman and Murray (2008) in 480p.

Conditions: Each conditions uses different forms of UI.

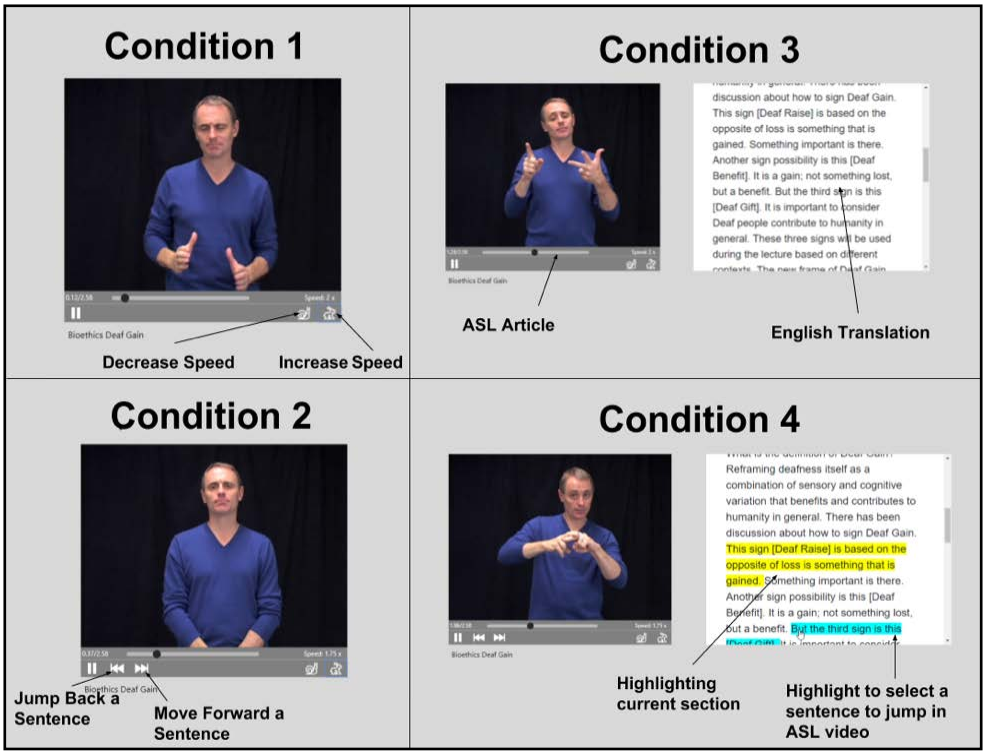

Fig. 3. The Four Conditions and the Setup of Each UI.

Design: Each participant went through 4 blocks, with each block holding 4 ASL chapters stimuli selected by Latin square. In each block, one of the stimuli were presented in each condition (Figure 4). Each stimulus were used once in first two blocks then repeated in last two blocks for total of 16 trials.

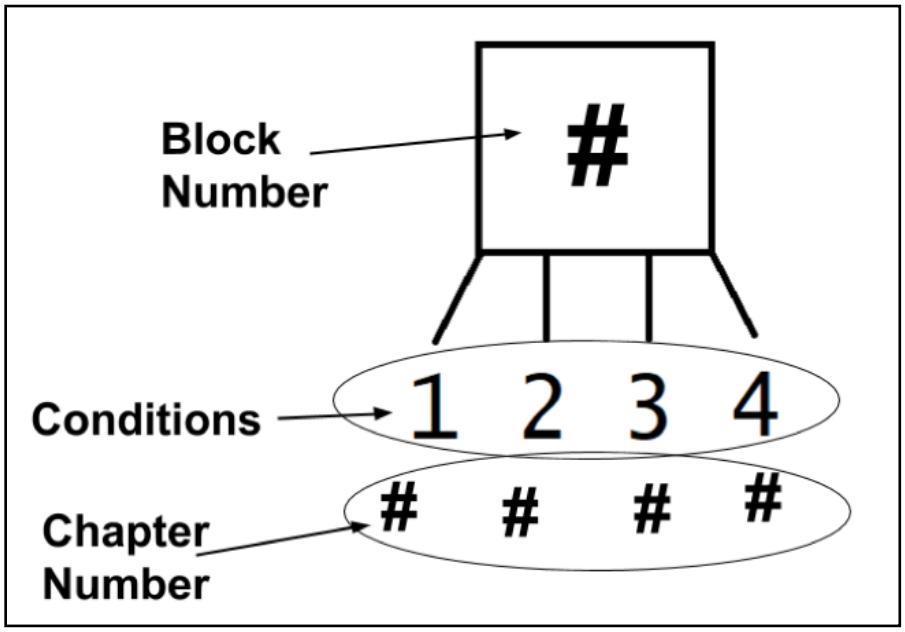

Fig. 4. Experimental Design of Each Block, Repeating for Four Blocks.

T-tests were conducted through R (R Core Team, 2012). The results of the effort judgment ratings show that M3UI is significantly easier than ASL only UI. Overall, deaf users found condition 4 to be significantly easier than condition 1 in terms of effort required to find information related to the query ($N = 21$, $t = -4.0612$, $p < 0.0002$). L1 signing deaf found condition 4 to be significantly easier than condition 1 ($N = 9$, $t = -2.2231$, $p < 0.05$). L2 signing deaf also found condition 4 to be significantly easier than condition 1 ($N = 11$, $t = -3.5681$, $p < 0.001$).

Results

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Conclusion

In terms of information seeking in different modalities, specifically signing and print, signing deaf users rated their effort differently according to the modality where the information were presented in. Their information seeking strategies differed across modalities (signed, written, and both). In general, their content comprehension and decoding was faster in their first language over than their second language. They would often double and triple check information in print due to the ephemeral nature of the signing modality.

During the construction of the multimodal interface we found that users were interacting and searching using three modalities: the first modality was the natural communication modality, which is analog such as spoken and signed modalities. For the deaf signers, their natural communication modality was signing. Next, the users interacted with the interface using a second digital modality such as English text or Sign Writing. Finally, they interacted with the interface using an emergent and new combination of both signed and written modalities so maximize both their communication and searching abilities. The mixed sign and print interface is an example of the expanded technical possibilities of this emergent modality.

However, some users of the mixed sign and print interface reported that they experienced English interference while following the content in ASL. Specifically, when they read the English text, they were unsure whether to go with ASL or English as the authoritative information. Often there is not a clear one-to-one correspondence between the signed content and printed equivalent, which contributes to the inability to determine whether to go with signed ASL or written English as the authoritative source. Finally, the spatial and affective information in ASL enhance conceptual comprehension and expression, and are often missing in the equivalent print representation.

Possible future research topics could include converting ASL to written modality, generating sign language avatars, or using digital ASL / Gestural / Embodied information input and manipulation.

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