Artificial Representations of Sign Language to Access Information: How affective are they?

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Abstract
There are different digital representations of sign language (DRSL) systems available, which have been widely used and adapted to accommodate a variety of different needs. Although the systems have been continuously refined and adapted, it has been noted that they receive very mixed reviews, and some receive low acceptance rates. This highlights two possible issues, either the DRSL presented to the target audience was inappropriate or the DRSL itself was unable to transmit the information correctly to a Deaf audience. The information gathered will be examining how people perceive different DRSL's and how the different systems are rated in terms of usability, likability, acceptability, sign language composition and overall preference. This study will compare different DRSLs in order to highlight and understand the different properties, problems and potential uses they have. There will be a background, hypothesis, methodology and results.

Keywords
Sign Language, Digital Representations of Sign Languages, Sign Language Technologies,

Introduction

There are different digital representations of sign language available. They have been widely used and adapted to a variety of different systems (Bangham, J. A., 2000, Hanke, T. n.d., RNIDb. (n.d.), *BSL Dictionary* (n.d.)). Although the systems have been continuously refined and adapted (RNIDa. (n.d.), Cox, S. et al, 2002) it has been noted that they all receive very mixed reviews, and some receive low acceptance rates (Abrahams, P., 2008). This highlights two possible issues, either the content of the DRSL presented to the target audience was inappropriate or the DRSL itself was unable to transmit the information correctly to a Deaf audience. This study will be comparing different DRSLs in order to highlight and understand the different properties, problems and potential uses of the three main types of DRSLs. This study will first have a background detailing what has been previously noted with DRSL systems. Then the hypothesis of this study will be stated in order to define the area of research clearly, this will then justify and lead to the methodologies used and a section explaining the participant selection for this experiment. There will be details about the pilot studies conducted, what was found, and how the experimental design was adjusted to be appropriate for the needs of the target audience.

Background

Each digital representation of sign language (DRSL) has its own benefits and drawbacks, however, as previously suggested, their comparative effectiveness against each other is a new area of research, and this analysis aims to promote a deeper understanding of the perceptions and applications of DRSLs in the real world. There are different outlooks to methods of presenting information to the Deaf and in their native sign languages. The language requirements of the Deaf are vast, they range from oralists to signers. The documentation of sign language and its movement in a digital form has led to different versions of such systems: some systems allow and permit users to transfer information in printed form (such as notation systems), while others record signing and are able to retransmit it in a two-dimensional form such as video recordings. Although less transferable these are widely used on television, video and the Internet. A third and more recent method is animation, where a virtual human signer can three-dimensionally(3D) sign information.

The difficulty is that the community feels divided about the different systems and there is no universally accepted DRSL. DRSL range from varied types of animation, notation and video systems. Each type of system has its own benefits and drawbacks such animation systems (RNIDa. (n.d.), RNIDb. (n.d.), Cox, S. et al, 2002) that use signing avatars (virtual humans) to present a 3D image of sign language. These can be used in a variety of contexts, ranging from educational environments to public information services on the Internet (Cox, S. et al, 2002). Although the software is still developing and probably will have a real-world application in the future, currently there are a number of drawbacks that do not allow overall acceptance of the system. The system has the ability to smoothly join different sequences together which gives it a unique application advantage of real-time sign language delivery (RNIDa. (n.d.)). However its poor facial expression gives the system poor feedback, and is heavily criticised for this within the Deaf community.

Video systems (Ohene-Djan, J., 2003, iCommunicator. (n.d.)) broadly consist of filmed sequences of signing. They are the most commonly accepted form of DRSL and are used in a variety of contexts, such as television, internet and educational Videos/CD-ROMS to name a few. Video gives an exact replication of sign language as it is filmed. If filmed correctly this will be of a very high quality, as facial expression and movement can be recorded very clearly. This form of DRSL is widely used in all areas of communication with the Deaf. However the major drawback of such a DRSL is that it is unable to join other video sequences together smoothly. They will appear disjointed and therefore goes against the natural flow of sign language.

Notation systems (Hanke, T. (n.d.), Sutton, V., 1996, Walker, M., 1970.) allow for the depiction of sign language movement into a series of symbols that represent, shape, movement and location. The collection of images can explain signs, and sets of sign notations can explain information in a written form of sign. This DRSL is able to cover a lot of linguistic detail in its notations and can easily join signs together. However it is written and it is not actual movement, which many Deaf/HOH people feel uncomfortable accepting as it seems like a completely different language and is difficult to grasp. Although there are members of the Deaf community that feel it is visual enough and could have a good potential use in the future, it would need to be introduced a lot earlier in the education system so that individuals familiarise themselves with it and feel comfortable with the notations.

Which Types of Information Require Translation into Sign Language?

All types of information may require sign language translation. These systems are all very different to their approaches, benefits, problems and real-world applications, however in order to investigate and understand where these systems can be used in terms of information delivery, the following categories have been used to define information; real-time information: examples are train delays, news reports and airport announcements and static information: examples are soap operas, manuals and films.

In the investigations, digital sign language presentations will be categorised into the above information categories, in order to identify any relationships of system preferences between the different information types. The presentations will be tailored to demonstrate examples of such information delivery.

If sign language is to be translated into the digital domain, then it needs to be understood in more levels than just practical application. It needs to be clearly understood, what characteristics contribute to high quality signing; flow, speed, facial expression, signing style or how the signer is dressed, its background. Once we understand this it can be clearly understood how previous systems have worked and if they have worked correctly to such standards of high quality signing. For this individuals will be interviewed and asked questions about what they expect from a human signer, and what they expect digital representations of sign language to include.

Each of these systems has a variety of benefits and drawbacks, and it may be that their application in different contexts would be more appropriate and more acceptable to users as opposed to their current application areas.

Why Choose these Systems for this Research?

The animation, video and notation information systems selected needed to have the following characteristics to be comparable:
1. Using the same version of British Sign Language(BSL)
2. Using the same dialect of BSL
3. Using the same sentence structure, vocabulary, pace and order
4. Using the same signs or representing the same sign correctly and consistently

The information systems will be visually different, as they will present signing in their programmed form. However we are examining their ability to communicate with the target audience for whom they have been designed.

The animation system selected is currently the only system of its kind (RNIDa. (n.d.)), it can create both real-time and static presentations of BSL in the London dialect, and is an appropriate avatar generation system. It fulfilled the above stated criteria and thus determined the selection of the video and notation systems. The video information system was produced for this assessment, following the exact structure, vocabulary, pace and order of the animation system. Thus it also fulfilled the above stated criteria. The animation system has the ability to produce sequences that can be organised and polished, in order to store into a database system for later retrieval. When the avatar signs it calls a preprogrammed code to generate the avatar's movements and signing sequence. This is much like the ability of video sequences, where the lighting and location can be made appropriate for filming and the filming takes place. This sequence can be stored and recalled as and when necessary within an information system. With the real-time generation of sequences within the animation system, the program had pre-recorded and stored vocabulary, which were generated on demand i.e. a request was made to the program and the program made the sequence. This does not appear disjointed but as it is generated on demand, it is not as polished as the static sequence. This was mirrored in the video sequence design, where pre-recorded vocabulary, was recorded i.e. stored. Then called on demand to generate a sequence. Therefore the presentation would show a signing sequence that had a series of vocabulary clips put together. Unlike the animation system this does not present a smooth sequence; it is a series of clips joined together and will appear more disjointed. However it provides a real-time signing alternative to animation, based on the same principles as how the animation is generated. With the notation system, there was a wide range of systems available, covering mainly two branches, pictorial or depicted. The pictorial systems (Walker, M., 1970) do not have the ability to provide detailed descriptions of a sentence as in BSL, it can provide an overall view of how this can be written, which can alter upon opinion. It was therefore more appropriate to use a notational system that depicted BSL in its actual form. There were still a range of systems available. Different systems provided different notation methods, however it was important to use a notation method such that someone who has limited to no understanding of notations could grasp the meaning of what is presented. The one notation system that was used in several educational contexts and is still actively used today to teach sign languages is the signwriting system, developed by Valerie Sutton (Sutton, V., 1996). In order to develop the correct notation for the BSL sequences in real-time and static delivery contexts, the assistance of Sutton was sought. From this it was established that signwriting is written from top to bottom, and the symbols can be depicted through different colours. This later proved to be very useful as participants could distinguish the signs easier. The real-time presentation was made similar to both the video and animation real-time presentations, where vocabulary is already established and called up to present a sentence. This was also done from top to bottom of a screen. Both the video and notation systems were a mock-up of what the real system may have looked like.

Hypothesis

The type of digital representation of sign language (i.e. avatar, video and notation systems) used in different information contexts (i.e. static and real-time) will determine higher acceptance rates of the systems and ultimately the efficiency and effectiveness of the information delivery. We aim to test the hypothesis that there is a difference in the perception of DRSL in different information delivery contexts.

Methodology: Target Population and Research Context

The participants demonstrated the London regional dialect of British Sign Language (BSL). Therefore sampling took place in and around the London (UK) area and the target population were adults. In order to understand what the deaf community thinks of the systems, BSL and SSE users were invited for participation in this research. The participants selected were deaf and hard of hearing(HOH).

Methodology: Sampling

Many organisations, schools, education centres and professionals were contacted to ask for participation in the research. People who were not contacted but were interested in the research contacted myself. There was a list formed of the participants that had come forward, and then 20 from the list were randomly selected for participation in the research. This initial sample size is considered to be large enough to give statistically significant results, however if, subsequently, there was no significant difference in results obtained then the experiment will be repeated with an increased sample size. Each participant had been offered reimbursement for travel if needed.

Methodology: Data Collection Methods
The participants were given a form to complete which gathered information such as age, gender and contact information, if they are deaf or hard of hearing and whether they regard themselves as culturally Deaf or deaf. Other questions included their primary mode of communication, and other demographic information. They then saw various presentations of static and real-time were evaluated and recorded.

Methodology: Materials
The user was presented with two information category presentations, these information categories were: Static: which is information that is standard and not often changed and Real-time: this type of information is subject to change, such as a news or weather report, bus delays and traffic updates. The presentations within these categories were: Static presentations; Avatar: Pre-recorded sequence, which will play an avatar clip, Video: Pre-recorded sequence, which will play a streaming video clip and Notation: Pre-recorded sequence, which will display pre-recorded notation graphics. Real-time presentations; Avatar: which will be played from the software spontaneously, Video: which will be a series of video clips concatenated with each other and Notation: a set of graphics that will be organised spontaneously

The users saw the presentations in their information categories, however the information categories were mixed up, and the sequences within the categories were mixed up in order to avoid primacy effects. The BSL sequences demonstrated the following sentences:

1. Real-time sentence one: "Presentation start half-hour late. Where? [Room] number 20"
2. Real-time sentence two: "Train going to London. 10 minutes late"
3. Static sentence one: "Technology department where? Third floor"
4. Static sentence two: "Train going to London, [platform] number two"

As it can be noted the English structure is different, but this is done so that the sentences reflect the correct structure of BSL. Testing the various combinations of DRSLs was not the main focus of this study, so this was tested on some participants in order check for some preferential differences.

Methodology: Procedure
The following steps were implemented:

1. Introduction: The participants were called in one at a time and given general information
2. Familiarization: The experiment was explained to the participants.
3. Information gathering: Each participant was asked questions regarding the presentations they saw.
4. Question and Answers: At the end of the session, participants were given the opportunity to ask questions.

Results
This section provides the analysis of the results that were found in the study. It will compare the effectiveness and perception of different digital representations of sign language (DRSL) in

order to recognise and understand the benefits and drawbacks of these systems, and also to establish a deeper understanding of the target audience, what they prefer and why.

Static vs Real-time

Digital representations for sign language can be developed and used for different information delivery contexts. For clarity purposes these information delivery contexts have been divided into two groups static (pre-recorded and edited sequences) and real-time (sequences made on demand). These two modes are available in all three digital representations of sign language. It was investigated that if each digital representation of sign language could be used to represent real-time or static presentations, which of the two would rate better and why? Also what is the significance in the difference in their ratings.

Static and real-time presentations were tested against each other and questions were asked about how the presentations were perceived. The categories of assessment were established in the previous study (Naqvi, S., 2005), which was further confirmed with wider reading about BSL linguistics. The linguistic criteria have been slightly modified to cater for this study. Another element of systems that needed to be understood for the research is the overall acceptance of a system. It could be that a system may be very usable but is disliked, and a system may be comprehensible but simply not accepted because of another reason. Therefore questions were designed to assess the acceptability, usability, likeability and comprehension of the systems. Having only one question per criterion would not suffice as it does not give an overall understanding. Therefore a series of questions were asked, for which ratings could be given. These ratings could then be averaged to provide a score for each criterion outlined. The linguistic criteria have been verified with BSL practitioners, teachers and linguists within the BSL using community

Descriptive Statistics for Static Presentations

All 20 participants were involved in the experiment; they all had the opportunity to view the different digital representations of British Sign Language and rate them according to the above stated criteria. The tables below show the average scores of each system in terms of it's usability, likeability, acceptability, comprehension and linguistics. NOTE: Min represents minimum values, Max represents maximum values and SD represents Standard Deviations. The above scale is 1 for Excellent to 5 for Poor ratings. The total sample was of 20 participants.

Category	**N**	**Min**	**Max**	**Mean**	**SD**
Notation Likeability	20	2.20	5.00	4.21	.92
Notation Usability	20	1.75	5.00	4.03	.94
Notation Acceptability	20	2.00	5.00	4.10	.95
Notation Comprehension	19	1.75	5.00	4.30	.89
Notation Linguistics	19	2.25	5.00	4.17	.93
Valid N (listwise)	19				

Table One: Descriptive Statistics of Notation systems static presentation in the categories of Usability, Likeability, Acceptability, Comprehension and Linguistic ability. The above table presents descriptive statistics for the notation system in static presentation mode. Data summarised here provides the basic features of the data in this study. We are able to establish from the data there was a strong dislike of the system that was presented.

Category	N	Min	Max	Mean	SD
Animation Likeability	20	1.60	5.00	3.8	1.12951
Animation Usability	20	1.75	5.00	3.6625	1.09807
Animation Acceptability	20	1.75	5.00	3.8125	1.00615
Animation Comprehension	20	1.50	5.00	3.9500	.95834
Animation Linguistics	20	1.75	5.00	3.5563	.91180
Valid N (listwise)	20				

Table Two: Descriptive Statistics of Animation systems in static presentation in the categories of Usability, Likeability, Acceptability, Comprehension and Linguistic ability. This table also presents descriptive statistics, but for the animation system in static presentation mode. Data summarised here provides the basic features of the data in this study. We are able to establish from the data there was a dislike of the system that was presented, but it was rated better than the notation system.

Category	N	Min	Max	Mean	SD
Video Likeability	20	1.00	4.60	2.0600	1.02618
Video Usability	20	1.00	4.75	2.0500	1.02618
Video Acceptability	20	1.00	4.00	2.0375	.95033
Video Comprehension	20	1.00	4.00	2.1375	.96816
Video Linguistics	20	1.00	3.00	2.0313	.69995
Valid N (listwise)	20				

Table Three: Descriptive Statistics of Video systems in static presentation in the categories of Usability, Likeability, Acceptability, Comprehension and Linguistic ability. This final table, presents descriptive statistics, but for the video system in static presentation mode. Data summarised here provides the basic features of the data in this study. We are able to establish from the data that participants liked this presentation the best out of the three systems in static mode.

From the descriptive statistics of static presentations we can clearly see that Video averaged better in terms of digital sign language representations overall. The second best system was animation and the third was notation. In real-time mode we had the following results.

Category	N	Min	Max	Mean	SD
Notation Likeability	20	1.60	5.00	4.3000	1.03110
Notation Usability	20	1.75	5.00	4.0750	1.08852
Notation Acceptability	20	1.75	5.00	4.2625	. 95226
Notation Comprehension	20	1.75	5.00	4.2625	.88286
Notation Linguistics	19	2.00	5.00	4.2500	1.00347
Valid N (listwise)	19				

Table Four: Descriptive Statistics of Notation systems in real-time presentation in the categories of Usability, Likeability, Acceptability, Comprehension and Linguistic ability. The above table presents descriptive statistics for the notation system in real-time presentation mode. Data summarised here provides the basic features of the data in this study. We are able to establish from the data there was a dislike of the system, similar to the results found in the static presentation in table one.

Category	N	Min	Max	Mean	SD
Animation Likeability	20	1.40	5.00	3.3900	1.12479
Animation Usability	20	1.75	5.00	3.2375	1.10166
Animation Acceptability	20	1.00	5.00	3.5000	1.07911
Animation Comprehension	20	1.00	5.00	3.4125	1.15643
Animation Linguistics	20	1.50	5.00	3.3875	1.01137
Valid N (listwise)	20				

Table Five: Descriptive Statistics of Animation systems in real-time presentation in the categories of Usability, Likeability, Acceptability, Comprehension and Linguistic ability. NOTE: Min represents minimum values, Max represents maximum values and SD represents Standard Deviations. The above scale is 1 for Excellent to 5 for Poor ratings. The above table presents descriptive statistics for the animation system in real-time presentation mode. Data summarised here provides the basic features of the data in this study. The sample group was a total of 20 participants, and we are able to establish from the data there was a strong dislike of the system that was presented and the results were not much different from the static data set presented in table two.

Category	N	Min	Max	Mean	SD
Video Likeability	20	1.00	4.20	2.4500	1.10477
Video Usability	20	1.00	5.00	2.3625	1.17394
Video Acceptability	20	1.00	4.00	2.0875	.94338
Video Comprehension	20	1.00	4.25	2.3000	.90902
Video Linguistics	20	1.38	4.38	2.3250	. 78995
Valid N (listwise)	20				

Table Six: Descriptive Statistics of Video systems in real-time presentation in the categories of Usability, Likeability, Acceptability, Comprehension and Linguistic ability. The above table presents descriptive statistics for the video system in real-time presentation mode. Data summarised here provides the basic features of the data in this study. We are able to establish from the data there was a liking of the system, similar to the results found in the static presentation in table three. As noted from the three above tables they are very similar to the descriptive statistics shown in the three tables for static presentation.

From the descriptive statistics of real-time presentations we can see that Video averaged better in terms of digital sign language representations overall the same as the static results. The second best system was animation and the third was notation.

Inferential Statistics

Further inferential analysis were conducted in terms of *t* -tests. We noted that the only result that showed statistical significance was in the animation digital representation of sign language, under the linguistic category of hand shape. It was noted that the overall means were statistically significant; the mean for the static presentation of animation was 3.2 and the mean for the real-time presentation was 3.8, $t\ (19) = 2.11$, $p < 0.05$. This was on a scale where 1 was rated excellent and 5 was rated as poor. It can be suggested by the means that the static presentation was rated better than the real-time presentation.

It was observed that although the digital representations of sign language were different in static or real-time mode, they had significantly high correlations. In the digital representation of animation, when static and real-time presentations were shown, the following categories had significant correlations, likeability r = .75, usability r = .67, linguistics r = .60, under linguistics the following were observed; morphology r = .61, lip movement r = .59, facial expression r = .39, correct sentence BSL structure r = .44. In the digital representation of Notation the following correlations were noted, likeability r = .75, acceptability r = .72, comprehension r = .817, linguistics r = .70, under linguistics the following were observed hand shape r = .61, morphology r = .73, distance of the body from the arm r = .43, lip movement r = .70, facial expression r = .70, correct sentence BSL structure r = .47.

There were a lot of high correlations between the variables used in the paired sample t-tests between static and real-time presentations of each digital representation of sign language, these results have been listed in the table below, as you can see from the average means the systems were rated quite poorly on the scale, where 1 was excellent and 5 was poor. In other words for animation and notation: not only were the static and real-time means similar for a given category (as manifest within the rows of table seven) but also the participants who gave higher (or lower) ratings for static presentations also tended to give higher (or lower) ratings to real-time presentations, as manifest in the generally high correlations.

Presentation Mode	**Category**	***r***	**Sig**	**Average Mean**
Animation	Morphology	.611	0.004	3.5
Animation	Lip Movement	.583	0.007	4.25
Animation	Facial Expression	.384	0.095	4.2
Animation	Correct sentence BSL structure	.436	0.054	3.05
Animation	Likeability	.747	0.000	3.6
Animation	Usability	.668	0.001	3.45
Animation	Linguistics	.601	0.005	3.5
Notation	Handshapes	.606	0.006	4.2
Notation	Morphology	.732	0.000	4.05
Notation	Distance of the arm from the body	.430	0.066	4.3
Notation	Lip movement	.692	0.004	4.4
Notation	Facial Expression	.704	0.001	4.35
Notation	Correct sentence BSL structure	.466	0.002	4.15
Notation	Likeability	.747	0.000	4.25
Notation	Acceptability	.717	0.001	4.1
Notation	Comprehension	.817	0.000	4.25
Notation	Linguistics	.699	0.001	4.25

Table Seven: Correlations between Static and Real-time Presentations of Digital Representations of Sign Languages for the Respective Variables. NOTE: Sig represents Significance. A statistical relationship between two variables (static and real-time) identified a few correlations of a high positive correlation. Means are shown in order to indicate that - the high correlations are not withstanding the variables were generally high (poor understanding). The main significant differences and correlations were found only in animation and notation, video did not show any statistical significance in terms of difference or correlation. This was data found again on the same 20 participant sample group.

The following table will examine inferential statistics from the data found in the study. A one-way ANOVA was conducted to test the differences between the three systems (Video, Animation and Notation) in respect of their usability, acceptability, likeability and linguistics. Linguistics will be broken down into its respective components which are hand shape, morphology, distance of the arm from the body, lip movement, facial expression, correct sentence BSL structure, correct placement and correct signing context. Further t-tests were conducted between the systems to test if there was a difference between the groups. This was conducted on the data found on the same sample group of 20 participants within this study. NOTE: *p* -values denote the results from varied *t* -tests. V represents video, A represents Animation and N represents Notation

Test Criteria	**ANOVA**	***p* – value V and A**	***p* – value V and N**	***p* – value A and N**
Acceptability	0.000	0.000	0.000	
Usability	0.000	0.000	0.009	0.006
Likeability	0.000	0.000	0.000	0.085
Comprehension	0.000	0.000	0.000	
Linguistics	0.000	0.000	0.000	
Linguistics - handshapes	0.000	0.000	0.000	
Linguistics - morphology	0.000	0.000	0.000	
Linguistics – distance of the arm from the body	0.000	0.000	0.000	
Linguistics – lip movement	0.000	0.000	0.000	
Linguistics – facial expression	0.000	0.000	0.000	
Linguistics – correct sentence BSL structure	0.000	0.001	0.000	0.007
Linguistics – correct placement	0.000	0.000	0.000	0.006
Linguistics – correct signing context	0.000	0.000	0.000	0.002

Table Eight: Summary of significance levels of ANOVA's testing for the differences between the three systems (Animation, Notation and Video) in static presentation modes in respect of varied categories. Further post hoc analysis was conducted in the form of t-tests between the groups, and significantly relevant results are shown.

Test Criteria	**ANOVA**	***p*–value V & A**	***p*–value V & N**	***p*–value A & N**
Acceptability	0.000	0.000	0.000	
Usability	0.000	0.000	0.009	
Likeability	0.000	0.004	0.000	0.003
Comprehension	0.000	0.001	0.000	0.003
Linguistics	0.000	0.001	0.000	0.003
Linguistics - handshapes	0.000	0.000	0.000	
Linguistics - morphology	0.000	0.000	0.000	
Linguistics – distance of the arm from the body	0.000	0.000	0.002	
Linguistics – lip movement	0.000	0.000	0.000	
Linguistics – facial expression	0.000	0.000	0.000	

Linguistics – correct sentence BSL structure	0.000	0.000		0.002
Linguistics – correct placement	0.000	0.079	0.000	0.001
Linguistics – correct signing context	0.000		0.000	0.002

Table Nine: Summary of significance levels of ANOVA's testing for the differences between the three systems (Animation, Notation and Video) in real-time presentation modes in respect of varied categories. Further post hoc analysis was conducted in the form of t-tests between the groups, and significantly relevant results are shown.

It was notable that irrespective of real-time or static presentations, the systems acceptability in terms of Usability, Acceptability, Comprehension and Likeability was greatly influenced by its ability to linguistically represent British Sign Language in an artificial form, and how the Deaf community views these systems' ability.

Discussion

For the *t*-test a null hypothesis and the alternative hypothesis were stated, the null hypothesis states that participants shown the real-time and static information system, will show no difference in the perception of the digital representation of sign language. Thus the acceptability of the system is reliant on it's ability to function, in the most technologically optimal solution for that given information delivery context. However the alternative hypothesis states that there is a difference in perception of the system when presented in different information delivery contexts. For example avatars are promoted on their ability to present real-time sign language generation for any type of information. Video has limitations, in that it needs to have the vocabulary/sentences prerecorded. Therefore joining various video clips together can appear awkward in its delivery as the signs do not connect like natural sign language. Avatars are able to connect vocabulary together without the awkwardness. It can therefore be assumed by practitioners in the field that avatars pose a more appropriate solution for real-time generation of information in sign language. In this research we tested if we made an alternative with video, presenting the "awkward" connection of vocabulary, for a real-time information delivery, how does this compare to avatars? This was also done with notation systems. In the static presentation, video was prerecorded and had what would be seen as the most popular solution as it is most widely used. However avatars provided static presentations as well, but they have ability to be moved three-dimensionally and; therefore, they can be viewed closer, further away, at another angle and any which way you moved the avatar, giving this technology a seeming advantage. So it can be asked how would this compare in the same information delivery context? Notations provided an alternative solution as they were like a written language, and can be manipulated much like subtitles, either recorded in advance and presented in demand, or presented in real-time.

Initially the hypothesis was testing whether the acceptance of a system was dependent on the information delivery context, (i.e. a real-time or static information delivery context). It was found from the data analysis (ANOVAs plus a series of t-tests checking for the difference of perception on the systems from both real-time and static delivery modes) that this was not in fact the case. We identified that there was a strong difference in scores between the three systems, but that difference was not a manifestation of the information delivery context. Irrespective of the information delivery context, the linguistic criteria determined the system's level of acceptance. It was noted that all participants commented about the systems that had weaker scores as to the systems "linguistic ability", that they lacked "emotion". Thus while the null hypothesis was supported, we also established that the linguistic criteria rather than the information delivery context formed the basis of the systems' acceptance. The user-led approach to investigating this problem, has assisted in understanding the difference in how technologists may identify the potential of a system, and how they are actually received. Most essentially this has highlighted the "finite" criteria that are often missed by technologists in the thinking through of a system design, and has also highlighted the importance of the same "finite" criteria in terms of clear and effective communication for the Deaf.

Conclusion

The hypothesis tested specifying that the type of information delivered in different DRSLs would affect the system's level of acceptance, was not supported from the findings. Instead it was found that if the system demonstrated particular linguistics of BSL appropriately it would then receive higher acceptance from the Deaf community, irrespective of being in static or real-time mode. The main theme continuously mentioned by participants was 'emotion'. The results show that regardless of technology the level of Emotional Representation is the key determinator to the systems' level of success.

Sign Language technology has been fast developing into a popular area of research with many advances, tools, technology, hardware and software continuously being generated. It has spurred discussion amongst the d/Deaf and hearing community about the potential and real-world application of many of the systems that have been used and introduced. There have been many claims about the real-world application of various systems and their potential has and is being researched. However there has been skepticism among the d/Deaf and Hard of Hearing (HOH) as to whether DRSLs other than video have any potential to work within the Deaf community, and in many cases their criticism has been well justified.

This research's aim was to understand more about DRSLs and whether particular DRSLs are more suited to particular information delivery contexts. However from the findings it was identified that irrespective of the information delivery context the DRSL itself held more importance, the central theme being, can the DRSL communicate effectively? What was found was that it is not necessarily the system but more so the "emotional characteristics" also known as the “linguistic criteria” of a system that are needed for effective communication. It could be said that irrespective of the information system presented, if it holds true to the characteristics of sign language, such that it has particular linguistic elements present, it will receive a positive end-user response.

This research has provided an indepth understanding of the user perspective of the end-products that have been proposed for language support for Deaf people.

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