Chapter 3

ASSISTIVE MEDIATION TECHNOLOGY FOR INDIVIDUALS WHO ARE VISUALLY IMPAIRED

The overarching problem of disability-induced social signal deprivation was described in detail in Section 2.1~~ of Chapter 2~~. Further, the ~~importance~~ adverse effects of the lack of social situational awareness for people who are visually impaired ~~was~~ were highlighted as,

- the ~~I~~inability to learn social skills due to the lack of visual feedback
- the ~~L~~lack of reinforcement visual feedback on one's mannerisms

~~In this chapter, we investigate~~ This chapter discusses research ~~work~~ in the related areas of a) computer vision based non-verbal cue sensing, b) social signal processing, c) human-computer inerfaces, d) multimedia technology for computer human interactions and e) assistive technology design and development~~, towards making insightful observations that can enable us to develop the~~ ~~These~~ The results of this research inform evidence-based models for social signal enrichment. ~~Further, we also describe our efforts~~ Also presented are the results of a survey aimed at better understanding ~~to understand~~ the problems faced by people who are visually impaired ~~while engaging~~ as they engage in social interactions with their sighted counterparts, ~~through a survey which forms the~~ which provides a basis for developing ~~the mediation~~ assistive technology ~~.~~ for mediating social interactions.

3.1 Automatic Detection of Non-verbal Cues and Observations

Affective Computing research has ~~employed algorithmic framework to~~ quantitatively ~~study~~ studied both verbal and non-verbal cues displayed by the humans during social communication. Signal streams from various sensors, including visual sensors (e.g. cameras), audio sensors (e.g. microphones) and various physiological sensors (such as EEG, EMG, and galvanic skin resistance sensors) have been used to ~~evaluate~~ sense human emotional states. A good review of research work in Affective Computing can be found in [113]. This research has enabled a better understanding of human physiological signals, with respect to emotional states, and the results have been used to facilitate human-computer interaction (HCI). In theory, a system that can remotely detect non-verbal social cues could also be used as an assistive device to provide social feedback to people with disabilities. The emphasis here would not be so much on interpreting these cues as on presenting raw social cue ~~information~~ data to the user, and allowing the user to interpret them. However, very little research has been done towards finding intuitive methods for presenting raw social cue ~~information~~ data to humans. [114] developed a haptic chair for presenting facial expression information. It was equipped with vibrotactile actuators on the back of the chair that represented ~~some~~ specific facial features. Experiments conducted by the researchers showed that people seated in the chair were able to distinguish between six basic emotions. However, this solution had the obvious limitation that the user needed to be sitting in the chair to use the system.

Observation 1: Assistive technology designed ~~towards social assistance~~ to facilitate social interaction *should be portable and wearable, so that the users can ~~use them at~~* employ them in *various social circumstances without ~~any restriction to their everyday life~~.* imposing significant restrictions on their activities.

People with ~~disabilities~~ autism are not always able to perceive or interpret ~~implicit~~ OK social feedback ~~as a guide to~~ to guide them in improving their communication competence. However, they might be able to use explicit feedback provided by a technological device. Rana and Picard [115] developed a device called Self Cam, which provides explicit feedback to people with Autism Spectrum Disorder (ASD). The system employs a wearable~~, self-directed~~ camera that is supported on the user's ~~own~~ shoulders to capture the user's own facial expressions. The system attempts to categorize the facial expressions of the user during social interactions to evaluate the social interaction performance of the ASD user. Unfortunately, the technology itself plays a role in social interactions in which it is used, ~~does not take into account the social implication of assistive technologies. Since the technology is being developed to address social interactions, it is important to take into account the social artifacts of technology. A device that has unnatural extensions could become~~ becoming ~~more of~~ OK more of a social distraction for both ~~the~~ participants ~~and users~~ than ~~as~~ an aid.

Observation 2: Assistive technology designed ~~towards social assistance should allow seamless and discrete embodiment of sensors or actuators making sure the device does not~~ to facilitate social interactions should be implemented in such a way that it does not itself *become a social distraction.*

Vinciarelli et. al. [116] ~~have~~ described the use of ~~discrete~~ technologies for understanding social interactions within groups, specifically targeting professional environments where individuals ~~take~~ make decisions as a group. They analyze ~~the use of bodily~~ body mannerisms and prosody to extract nonverbal cues that ~~allow~~ they use to do group dynamics analysis. They rely on simple sensors in the form of wearable tags [117] (which detect face-to-face interaction events) along with prosody analysis to determine turn taking, ~~emotion~~ emotional state of the speaker, distances ~~to an~~ between individual ~~etc.~~ and s. Pentland describes these signals captured during group interactions as [118] honest signals. Some of his recent work [119] in the area of social monitoring ~~hopes~~ attempts to capture these signals and provide feedback to individuals about their social ~~presence~~ role within a group. The use of social feedback is illustrated elegantly in ~~their~~ his work, but ~~their findings~~ his approach required ~~relied on sensors carried by all individuals involved in~~ all members of the group to carry sensors during the study. ~~Having everyone in a group wear sensors has~~ This proved to be a viable and productive approach for studying group dynamics, ~~However, this approach~~ but it is not viable as a strategy for ~~developing~~ the implementation of an assistive technology, as it is not realistic to assume that everyone who interacts with a person ~~with~~ who has a disability will wear sensors.

Observation 3: Assistive technology designed ~~*towards social assistance should incorporate mechanisms embodied on the user to determine both self and other's social mannerism.*~~ to facilitate social interactions should be designed in such a way that it ~~[illegible]~~ can be worn exclusively by the user, and is able to monitor both sides of the interaction.

In two independent experiments [120] and [121], researchers developed ~~a~~ social feedback devices that provide~~s~~ intervention when a person with visual impairment starts to rock their body ~~displaying a stereotypy~~ in a stereotypical manner. [120] designed a device that consisted of a metal box with a mercury level switch that ~~detects any bending actions~~ is worn on the user's head. ~~The feedback was provided with a tone generator that was also located inside the metal box. The entire box was mounted on a strap that the user wears around his/her head.~~ A tone generator was activated when the user began a rocking motion. The authors tested ~~it~~ the device on a congenitally blind individual who ~~had severe case of~~ exhibited extreme body rocking and ~~they conclude that the use of any assistive technology is useful only temporarily while the device is in use. They state that the~~ found that the tone supressed body rocking only when the device was in use. The body rocking behavior returned to baseline levels as soon as the device was removed. Since the time of this experiment, behavioral psychology studies have explored the use of short term feedback for rehabilitation [73], and these studies have found ~~support the above observation~~ that short-term feedback can even be ~~is often~~ detrimental to rehabilitation, and subject's behavior ~~case~~ invariably worsens. Unfortunately, due to the prohibitively large design of the device developed by these researchers, it was impossible to have the individual wear the device over long durations.

You have presented no evidence that this will be effective!

Observation 4: Assistive technology designed to facilitate ~~*towards social assistance an*~~*d behavioral rehabilitation should be used over long durations in such a way that the feedback is slowly tapered off over a significantly longer duration of time.*

In [121] researchers used a 'Drive Alert' (i.e. a driver alerting system that ~~monitors head droop~~ audibly signals drivers when they start to fall asleep and their head droops forward) to detect body rocking, and to provide audio feedback to a congenitally blind 21 year old student. The researches found ~~research concludes~~ that they were able to control body rocking effectively, but the device could not differentiate between body rocks and some ~~from any~~ other functional body movements. ~~This device, primarily built to sense drooping in drivers provides no opportunity to differentiate between a body rock and a functional droop. Use of such devices could only be negative on the user as a~~ The resulting large number of false alarms ~~would only discourage an individual from using any assistive technology~~ discouraged the user from employing the device.

Observation 5: Assistive technology designed to facilitate ~~*towards social assistance and*~~ *behavioral rehabilitation should be* able to discriminate between socially distracting ~~*effective in discriminating social*~~ *stereotypic mannerisms* and ~~*from*~~ *other functional movement*~~*s to keep the motivation of device use high*~~.

3.1.1 Design principles for social assistive and rehabilitative devices

Based on the above observations, a device ~~that is~~ developed to facilitate ~~the~~ social interactions of people with sensory or cognitive disabilities might do so by, (a) detecting social cues during social interactions and delivering that information to the user in real time to enable empathy, or (b) detecting the user's own stereotypic behaviors during social interactions and communicating that information to the user in real time to provide social feedback. The first device would ~~might~~ be classified as an assistive technology, while the second would ~~might~~ be classified as a rehabilitative technology. Ideally, such a device would be based on the following design principles:

> *Design principle 1:* The device should be portable and wearable so that it can be used in any social situation, and without any restriction on the user's everyday life.
>
> *Design principle 2:* The device should employ sensors ~~and~~ OK personal signaling devices that are unobtrusive, and do not become a social distraction.
>
> *Design principle 3:* The device should include sensors that can detect the social mannerisms of both the user and other people with whom the user might communicate.
>
> *Design principle 4:* The device should be comfortable enough to be worn ~~repeatedly~~ for extended periods of time, to allow it to be used effectively for rehabilitation.

Design principle 5: The device should be able to reliably distinguish between the user's problematic stereotypic mannerisms and normal functional movements, to ensure that it will be worn long enough to achieve rehabilitation.

The remainder ~~Later part~~ of this chapter looks at incorporating these design principles into a social interaction assistant targeted at enriching social situational awareness for individuals who are blind ~~and~~ or visually impaired. ~~Before proceeding further, t~~The next section ~~brings the reader's attention the plethora of research that exists in~~ reviews relevant research aimed at identifying non-verbal cues ~~from the environment through~~ with computer vision ~~technologies~~ techniques. ~~While addressing any issues related to vision disability, it is prudent to explore computer vision research whose goal~~ One of the goals of computer vision is to develop pattern recognition and machine learning ~~and pattern recognition principles that covers the broad area of mimicking~~ techniques that emulate the abilities of the human visual system ~~capabilities on machines.~~

3.2 Related ~~Work in~~ Computer Vision Research ~~towards Sensing Factors that Contribute to the Overall Non-verbal Communication Picture~~ with potential application to the detection of non-verbal communication cues.

~~While the above section reviewed some of the finer details of developing an assistive mediation technology, on a coarser note,~~ C~~c~~omputer vision research has matured over the past two

Where is Table 3.1 referenced in the text?

Table 3.1: Related Work in Automatic Detection of Interaction Environment Cues

	Interaction Environment			
	Scene Change Detection	Background Modeling	Face and Object Detection	Environment Analysis
Proxemics		[122]	[123] [124]	
Objects in the scene	[125]	[126] [127]	[123]	
Natural vs manmade environment	[125]			[128]

decades to a point where ~~most~~ many ~~visual aspects~~ of the capabilities of human vision are now being ~~addressed through~~ emulated. ~~the use of cameras.~~ The rows in Table 3.2 and 3.3 ~~identifies the various~~ represent the non-verbal cues listed in Section ? 1? 2? ~~through along the rows~~, while the columns represent ~~how a certain~~ the techniques being used in state-of-the-art ~~research~~ ~~within~~ computer vision research to detect those non-verbal cues. ~~has approached the problem.~~ For example, ~~consider identifying the~~ Table 3.2 shows that ~~non-verbal cue of body posture, in Table 3.3, we identify that~~ [129] addressed posture by recognizing who the person is, and using that information to interpret the data accordingly. ~~associating posture data appropriately.~~ In contrast, [130] used body part segmentation, [131] approached it through facial feature segmentation, and [132] and [133] ~~approached~~ evaluated posture by analyzing the motion patterns of the limbs.

3.3 Requirements Analysis for a Social Assistive Technology: Evidence Aggregation

As a part of the evidence-based model for developing the social interaction assistant, after ~~addressing~~ identifying important design principles for assitive technologies (See Section 3.1), we ? focused on collecting ~~important evidences~~ data from the user community about ~~their need for~~ the kinds of information that they felt would enrich their social interactions. ~~social interaction enrichment. These evidences would not only address the functionality question~~ The goal in doing this was to focus the development of the assistive technology, ~~but would address the important~~ on human factor issues that would provide ~~of~~ perceived quality of life improvements. In order to identify ~~these~~ unmet needs of the visually impaired community, two focus groups were conducted[1]. These groups consisted ~~consisting~~ primarily of people who are blind, as well as disability specialists, and parents of students with visual impairment and blindness ~~where conducted~~ [1].

[1] In order to understand the assistive technology requirements of people who are blind, we conducted two focus group studies (one in Tempe, Arizona USA - 9 participants, and another in Tucson, Arizona USA - 11 participants) which included:

1. Students and adult professionals who are blind,
2. Parents of individuals who are blind
3. Professionals who work in the area of blindness and visual impairments.

There was unanimous agreement among participants that a technology that would help people with visual impairment to ~~recognize~~ identify people, or ~~hear them described~~ to hear a description of them would significantly enhance their social life.

Table 3.2: Related Work in Automatic Detection of 1) Physical Characteristics of the Communicator, and 2)Behavior of the Communicator

	Person Recognition	Clothing Recognition	Body Part Segmentation	Facial Feature Segmentation	Gender Race Recognition	Facial Motion Analysis	Body Motion Analysis	Eye Detection	Eye Tracking
Physical Characteristics of the Communicator									
Race and Body Color			[134] [135] [130]		[136]				
Body Shape	[129] [137]	[138] [139]	[140] [141] [134] [135] [130] [142]				[136] [137]		
Body Decoration	[143]								
Facial Hair				[133]					
Eye Glasses				[144]				[145]	
Clothing		[138] [139]							
Hair			[140] [146]						
Age	[147]								
Gender	[129]				[136]		[148]		
Identity	[149] [138] [150] [151] [152]					[153]			
Behavior of the Communicator									
Description of facial features				[131] [153]					
Body Mannerisms			[154] [155] [156]		[136]		[157] [132] [158] [159]		
Eye Gestures								[145]	[160] [161]
Gaze						[162]		[163] [164]	[162] [165]
Expressions and Emotions	[152]			[144] [131]		[113] [133] [144] [166] [167]	[168] [161] [159]	[169]	[160]
Personality	[129]		[155]		[136]		[158]		
Posture	[129]		[130]	[131]			[132] [133]		

The ~~Members~~ members of these focus groups who were blind or visually impaired were encouraged to speak freely about their challenges, in coping with daily living. During these focus groups, the participants agreed on many ~~issues as being~~ important problems. However, ~~one particular~~ the problem ~~that~~ of engaging freely with their sighted counterparts ~~-~~ was highlighted as a particularly important problem that was not being adequately addressed by ~~technology specialists~~ assistive technologies.

2.

While various other examples were cited by ~~individuals during these~~ focus group participants, ~~studies~~, the inability to access non-verbal cues were ~~considered~~ to be of highest priority. ~~Based on these discussions, a list of needs was complied that characterized social needs~~ these discussions produced the following list of 8 social needs often experienced by people with visual impairments. ~~In doing so, two important aspects~~ with regard to ~~of~~ social interactions and social situational awareness were identified. ~~These included~~

This list of 8 needs can be reduced to 2 basic categories of needs

1. The need for access ~~Access~~ to the non-verbal cues of others during social interactions, ~~and~~

2. The need for feedback about how ~~How~~ one is perceived by others during social interactions.

These two categories of needs ~~correlated with the psychology~~ were found to agree with the results of studies conducted by Jindal-Snape with children who were visually impaired. She identifie[d] these two needs as *Social* ~~*Learning*~~ Feedback and *Social* ~~*Feedback*~~ Learning, respectively. ~~While these two important categories were identified, for simplification, the non-verbal cue needs were reduced to 8 aspects of social interactions that focused primarily on the physical characteristics of the interaction partner and the behaviors of the interaction partner. These questions were developed with the help of visually impaired professionals and students:~~

move

1. Knowing how many people are standing in front you, and where each person is standing.

2. Knowing where a person is directing his/her attention.

move

[2] ~~To quote some candidate's opinion about social assistance technology in a everyday setting:~~ The following quotes are examples given by the focus group participants.

- "It would be nice to walk into a room and immediately get to know who are all in front of me before they start a conversation".
- One young man said, "It would be great to walk into a bar and identify beautiful women".

3. Knowing the identities of the people standing in front of you.

4. Knowing something about the appearance of the people standing in front of you.

5. Knowing whether the physical appearance of a person who you know has changed since the last time you encountered him/her.

6. Knowing the facial expressions of the person standing in front of you.

7. Knowing the hand gestures and body motions of the person standing in front of you.

8. Knowing whether your personal mannerisms do not fit the behavioral norms and expectations of the sighted people with whom you will be interacting.

Please check your table numberings (see previous table references) There seem to be problems

To further ~~Further, in order to~~ understand the relative importance of ~~these~~ non-verbal communication primitives, an online survey was carried out. ~~to determine a self-report importance map of the various non-verbal cues.~~ The ~~This list of~~ questions in the survey were used to infer the importance of non-verbal cues for Social Feedback, as well as Social Learning. ~~included both the importance from the perspective of allowing access to the non-verbal cues of the interaction partner (for enabling Social Learning), while also focusing on the personal body mannerism (for enabling Social Feedback) of the individual.~~ The ~~online~~ survey was anonymously completed by 28 people, of whom 16 were blind, 9 had low vision, and 3 were sighted specialists in the area of visual impairment and vocational training. The ~~online~~ survey consisted of 8 statements ~~eight questions~~ that corresponded to the previously identified list of needs. Respondents indicated the level of their agreement with the each statement ~~answered each question~~ using a Five-point Likert scale, the metrics being (1) Strongly disagree, (2) Disagree, (3) Neutral, (4) Agree, and (5) Strongly agree.

3.3.1 Results from the Online Survey

3.3.1.1 Average Response

Table 3.3 shows the 8 statements about ~~eight aspects of~~ social interactions that were evaluated ~~investigated~~ with ~~the~~ individuals who are blind or ~~and~~ visually impaired. The results are sorted by descending levels of agreement, ~~importance, as indicated by~~ based on the Likert scores of the survey respondents (the statement ~~question~~ numbers numberings correspond to the of the 8 needs ~~need~~ listed in the previous section). The mean score is the average of the scores ~~respondents~~ on

Likert scale across all respondents.

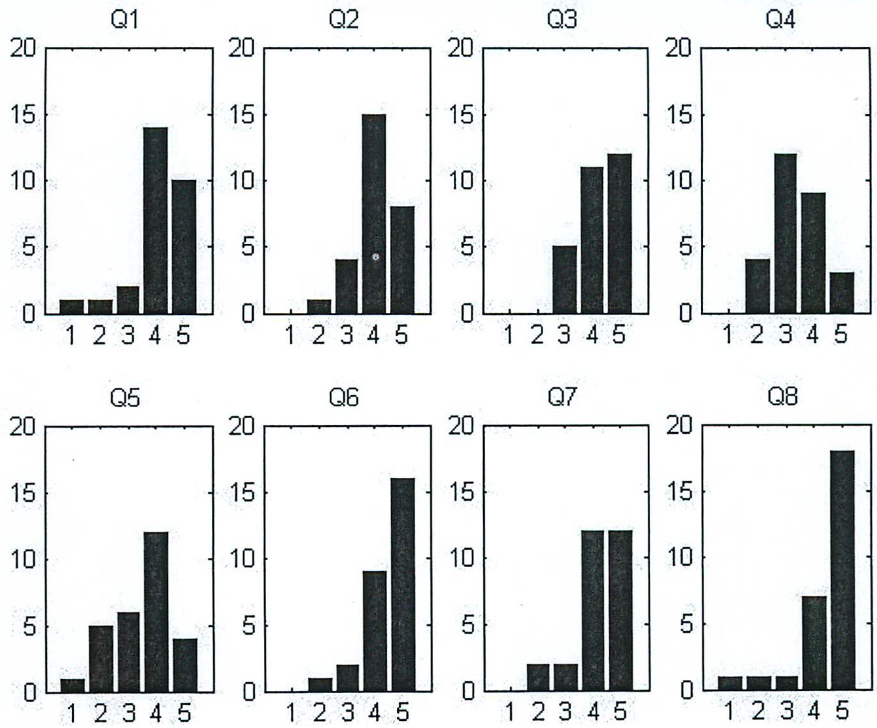
the 5 point ~~scale that was used to capture the opinions.~~ A score closer to 5 implies that the respondents strongly agree with ~~a certain question~~ that particular statement, and that they consider inaccessibility to ~~that particular~~ the corresponding non-verbal cue to be ~~important deterrent~~ particularly detrimental to their social interactions. On the other hand, a score closer to 1 ~~represents~~ indicates that the respondent did not consider ~~the~~ access to ~~a specific~~ the corresponding non-verbal cue to be very important during their social interactions.

Table 3.3: Average Likert Score ~~on the 8 Questions~~ obtained through an Online Survey, for 8 statements.

~~Question~~ Statement No.	~~Question~~ Statement	Mean Score
8.	I would like to know if any of my personal mannerisms might interfere with my social interactions with others.	4.5
6.	I would like to know what facial expressions others are displaying while I am interacting with them.	4.4
3.	When I am standing in a group of people, I would like to know the names of the people around me.	4.3
7.	I would like to know what gestures or other body motions people are using while I am interacting with them.	4.2
1.	When I am standing in a group of people, I would like to know how many people there are, and where each person is.	4.1
2.	When I am standing in a group of people, I would like to know which way each person is facing, and which way they are looking.	4.0
5.	I would like to know if the appearance of others has changed (such as the addition of glasses or a new hair-do) since I last saw them.	3.5
4.	When I am communicating with other people, I would like to know what others look like.	3.4

3.3.1.2 Response on Individual Questions

Figure 3.1 shows ~~the~~ the Likert histograms of responses for the 8 ~~Questions~~ statements that were ~~asked as part of~~ presented in the survey. Each ~~subplot~~ histogram ~~refers to~~ represents the Likert scores for a single ~~question and shows the number of times users responded to that particular question with answers from 1 to 5 on the Lickert Scale.~~ statement, ~~Each~~ The bar heights in each histogram adds up to a total of 28, ~~that~~ which corresponds to the 28 ~~participants~~ respondents ~~that~~ who took part in the online survey.



Histograms ~~of the Likert~~ showing the distribution

Figure 3.1: ~~Histogram of Responses grouped by Questions~~

of Likert score responses to each of the 8 statements

3.3.1.3 Response Ratio

percentage (77%) each of the 5 Likert scale values statements.

Figure 3.2 shows the ~~number~~ of times ~~the~~ respondents chose to answer the 8 ~~questions with their agreement or disagreement~~. ~~The y-axis has been normalized to 100 points.~~ The graph ~~shows that respondents chose to answer the most by agreeing (Likert Scale 4) with the 8 questions.~~ ~~Followed closely behind was the strong agreement (Likert Scale 5) with the questions asked in the survey.~~ ~~The respondents chose to answer the least through strong disagreement (Likert Scale 1) to what was asked in the survey.~~

Most responses indicated agreement with the statements. (40% agreed and 37% strongly agreed.) Only 2% strongly disagreed with the statements. ~~This suggests that the this should~~ This bias was not surprising since the 8 statements were derived from focus group results and

~~As described earlier, the 8 questions~~ ~~statements~~ ~~corresponding to the social needs of the individuals were identified~~ derived ~~from the focus group survey that was conducted. Thus, the questions presented in the online survey questions~~ were biased towards the needs of everyday social interactions of individuals who are blind and visually impaired. ~~Thus, the implicit assumption while preparing this survey itself is that most of these items have been identified as~~

Okay, these ~~are the facts~~ are the facts. But what do they mean? Was the survey biased? Should it have been written differently?

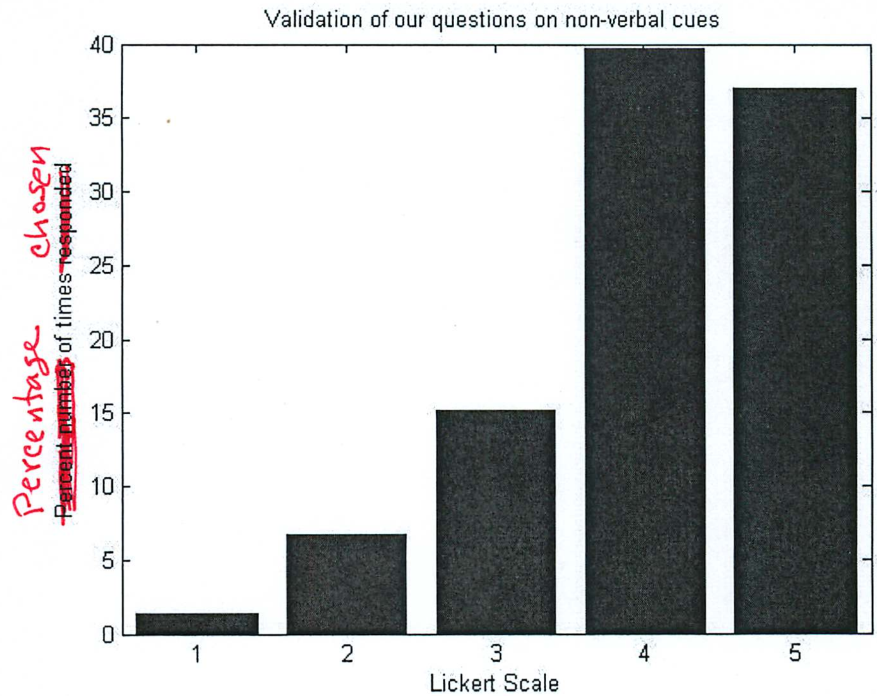


Figure 3.2: Response Ratio

The primary purpose of the survey was not to validate the 8 statements, but to determine ~~the~~ the relative importance of the 8 needs that they represent.

~~being important and that only a priority scale needs to be extracted. This implicit assumption is immediately brought out by looking at the frequency with which the respondents answer with their agreement (Likert Scale 4) and strong agreement (Likert Scale 5).~~

The relative importance of various

3.3.1.4 ~~Rank Average Importance Map for Various~~ Non-verbal Cues

survey statements

As explained earlier (and as can be seen from Figure 3.2) the ~~questionnaires~~ were biased and the frequency of the responses ~~is~~ was not Gaussian. ~~This bias implies that using sample mean~~ Since traditional statistical analysis is based on the assumption of a Gaussian distribution, it is not appropriate for analyzing this Likert data. ~~of the Lickert Scale responses will immediately show the same bias. This is due to the Gaussian iid assumption that is made while extracting the mean for the answers. In order to~~ A more appropriate method of analysis (which makes no assumption about the distribution) is the Rank Average.

overcome this non-Gaussianity, we resort to non-parametric mean for the responses. Rank ~~average of the responses is estimated instead of the typical mean of the responses for each of the question. Please see~~ (see Appendix A for the algorithm used to determine the Rank Average.) ~~Since no assumptions on the distribution of the response are made, unlike the mean,~~ The rank average ~~gives~~ provides a non-parametric method for comparing the responses of the ~~individuals~~ respondants to the 8 statements. The rank ordering

~~ranks~~ can be ~~either~~ assigned in either ascending or descending order, with respect to the Likert responses values. ~~,~~ i.e. rank 1 could mean all of the Likert responses to a particular statement ~~responses that were answered with~~ strongly disagree (numeral 1), or rank 1 could mean all Likert responses ~~that were answered with~~ strongly agree (numeral 5).

I question that ~~the~~ Figure 3.3 is any better. Plot a bar chart of the 8 means scores with the vertical axis ranging from the smallest to the largest mean score above. Then compare them visually to see if you still feel that rank average is better.

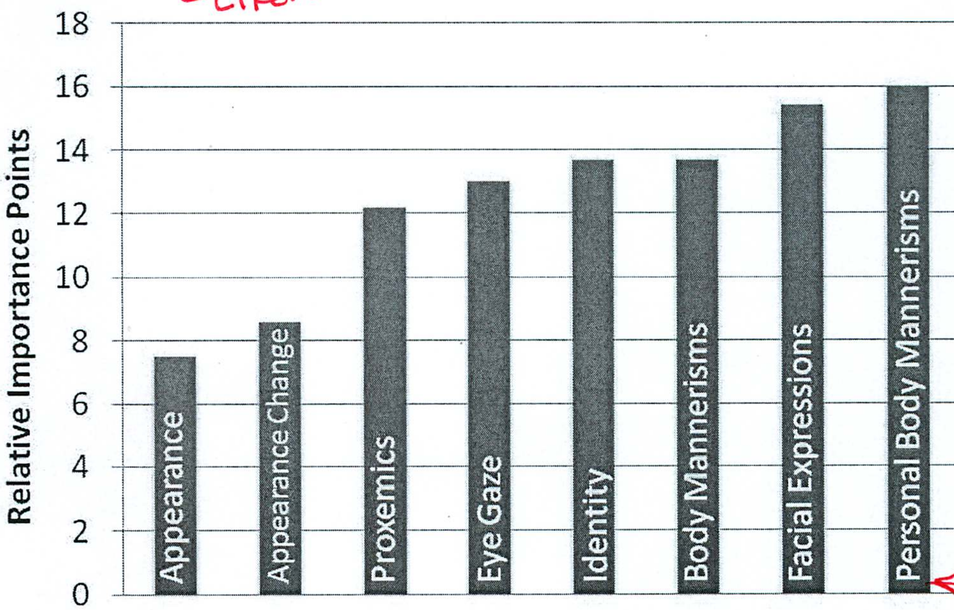


Figure 3.3: Rank average of the 8 questions

Figure 3.3 ~~shows a rank ordering~~ is based on a rank averaging that assigns ~~In the Figure 3.3, we have assigned~~ rank 1 to strongly disagree. ~~This is for the sake of visual convenience.~~ Thus, the higher the average rank, the higher is that group's overall agreement with the statement ~~response from the respondents~~. Comparing Figure 3.3 to Table 3.3 ~~??~~, it can be seen that the same ordering of priority can be seen through mean Likert score and rank average. However, ~~But~~ the mean shows little difference between the Likert responses to the 8 statements, ~~tends to show very little variation between responses~~ due to the bias that is present in the statements ~~questions~~. On the other hand the rank average provides a better ~~good~~ comparison scale.

3.4 Evidence-based Model for the Proposed Social Interaction Assistant

The important observations from the above results include,

- Respondents are highly concerned about how their body mannerisms are perceived by their sighted peers (based on the response to statement ~~Question~~ 8 on the survey).
- Facial expressions are ~~form~~ the most important visual non-verbal cue that individuals

agrees
What studies?
statement
of

who are blind or visually impaired feel they do not have access to (based on ~~Question~~ statement 6 on the survey). This ~~correlates~~ agrees with the studies ~~into~~ of non-verbal communication that highlight~~s~~ the importance of facial mannerisms and gestures~~, which are mostly visual in their decoding~~ – non-verbal cues that are perceived visually.

followed by facial expressions

- ~~Followed by facial expressions~~, body mannerisms ~~seem to be~~ are of ~~higher~~ greater importance ~~for~~ to individuals who are blind ~~and~~ or visually impaired (based on Question 3 of the survey)~~.~~,

- The responses to questions 7, 1 and 2 suggest that respondents would like to know the identities of the people with whom they are communicating, the relative location~~s~~ of these people, and whether their attentions are focused on the respondent. This corresponds to knowing the ego-centric position~~of~~s of all their interaction partners when they are involved in a bilateral or group ~~communication~~ interaction. People tend to move around~~, especially~~ when they are standing, especially in groups, ~~causing~~ and this sometimes causes people who are blind to lose ~~their bearing on~~ track of where ~~people~~ others are ~~were~~ standing. This can result in ~~individuals~~ their addressing an empty space~~, assuming~~ ~~that~~ because someone was previously standing there ~~based on their memory.~~

- The responses to questions 4 and 5 indicate that there was a wide variation in the respondents' interest in (4) knowing the physical appearance of people with whom they are communicating and (5) knowing about changes in the physical appearance of people with whom they are communicating (See Figure 3.1. Many respondents indicated moderate, little, or no interest in either of these areas.

3.5 Conclusion ~~System Architecture for a Social Interaction Assistant: An Evidence-based Assessment of Requirements~~

Based on the information collected in focus groups and with an on-line survey, a social interaction assistant device ~~From the observations made on the development of a social interaction assistant, we conclude that the device~~ should be portable, wearable and inconspicuous, and be able to provide ~~access to visual cues, while enabling~~ providing social feedback. ok ~~To this end, we propose a system that~~ The architecture of a proposed social interaction assistant is shown in Figure 3.4. It consists ~~essentially~~ of a set of body worn ~~sensor suite~~ sensors capable of extracting important social

Social Interaction Assistant

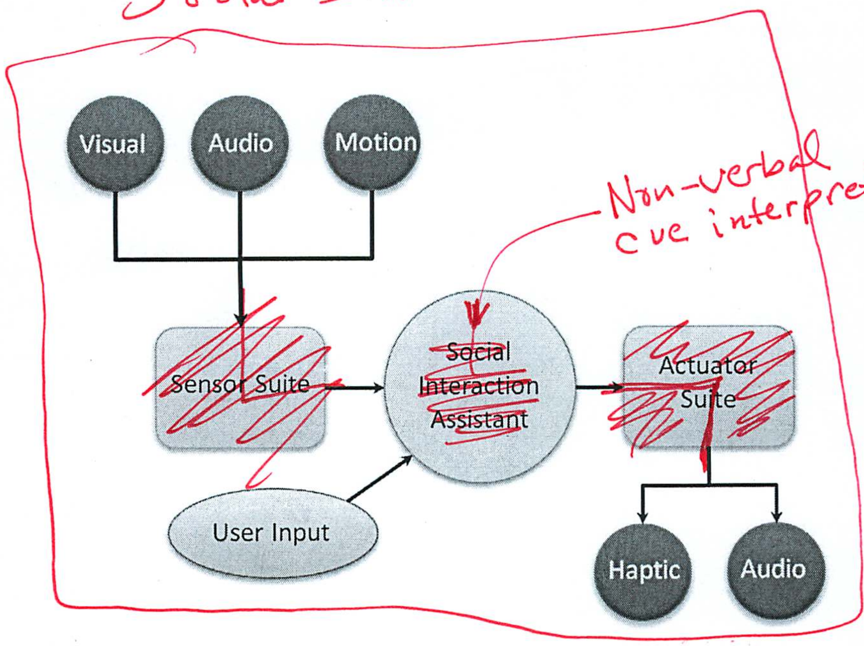


Figure 3.4: Social Interaction Assistant System Architecture.

signals from the environment, ~~while at the same time using a suite~~ and a set of actuators that are used to communicate ~~extracted data back~~ socially relevant information to the user without overloading their sensory ~~system~~ inputs. ~~Figure 3.4 shows the system architecture of the social interaction assistant, the realization of which is delayed until the components are described in the later chapters~~. Note the ~~use of specific~~ presence of a user input channel into the ~~social interaction assistant~~ non-verbal cue interpreter along with the sensor suite. This provides ~~unique~~ an opportunity for the user to configure and control some of the basic functionalities of the ~~system itself~~ Social Interaction Assistant. The details of these user ~~chosen~~ configurable functionalities will ~~become apparent~~ be detailed in ~~the~~ later chapters.

3.6 Organization of the Later Chapters

?