## Social Interactions:

## Importance of social interaction

In popular literature, a person who interacts effectively and efficiently with others is said to possess *Social Skills* [2] or *Communication Competence* [3]. (In this paper we will use these terms interchangeably.) Social skills are critical for successful everyday living. Acquisition of these skills normally begins at an early age. They play an important role in early social development and acceptance, and ultimately help people lead normal, healthy, successful lives. Good social skills allow a person to effectively integrate themselves socially into new situations, such as making new friends, or making a good first impression at a job interview. In contrast, studies by Segrin et al. [4] have shown that poor social skills are antecedents to psychosocial problems including depression, loneliness, and social anxiety. The authors conducted a battery of tests on college students to determine the effect of stress on the students when they live at least 200 miles away from home. There was a positive correlation between stress and an increased experience of psychosocial problems in all the students. However, the students who scored higher on social skills also showed a higher resistance to stress and, in turn, a higher resistance to mental breakdown. In contrast, students who scored low on social skills were highly vulnerable to social issues as the stress increased. People with higher communication competence are known [1] to display a greater ability to adapt their social behavior based on others in their environment (i.e. show greater empathy). Such ability builds empathy in others, thus creates a reinforcement feedback loop that allows individuals to be successful in their lives.

### Social Intelligence:

Researchers in the area of cognition and intelligence strongly believe that social interactions play a vital role in the overall development of primate brain. Primate researcher, Humphrey [5], has argued strongly that social interaction is key to cultural transmission of knowledge and the development of intelligence. His studies with rhesus monkey [6] have emphasized the positive influence of social interactions on the development of general intelligence. For example, Helen (a rhesus monkey) had her visual cortex surgically removed and studies were conducted on her recovery of spatial vision. Over four years in the laboratory, Helen hardly recovered any of her spatial knowledge. However, when she was taken out of the laboratory into the real world and allowed to interact with objects and other monkeys, she regained three dimensional spatial vision within a few weeks.

Social intelligence has recently gained momentum from a neuro-physiological perspective. Advanced functional brain imaging is enabling researchers to study the workings of human brain under various functional conditions. Brothers [7] has worked extensively on the neuro-physiological patterns in primate brains that are associated with social behavior. Her work has established the presence of brain regions that are dedicated to *social cognition* (Social cognition is the processing of information that culminates in the accurate perception of dispositions and intentions of other people). She has proposed a network of neural regions that comprise the social brain: the orbito-frontal cortex (OFC), superior temporal gyrus (STG) and amygdala. Her work has been recently bolstered by studying autistics under functional Magnetic Resonance Imaging (fMRI) [8]. The subjects watched another person’s eye expressions, and guessed what that person was thinking or feeling. The fMRI images confirmed Brothers observations of STG and amygdala activations during social cognition, and showed that people with autism display a cognitive disability in the amygdala which prevents them from making appropriate mental inferences of other people’s emotions or facial expressions. Authors conclude that a social brain does exist, and that teaching children and adults social skills could offer a means of increasing activations in the social brain. This conclusion is supported by behavioral research in autism that employs social interaction training and language skill training in children, to ameliorate the social deficits characteristic of autism spectrum disorders (ASD). Thus, social interactions also provides a knowledge building loop that develops intelligence of the world around the individual.

## Disability – a hindrance to social interactions

Nearly 65% of all interpersonal communication is not explicitly expressed in words [9], but is communicated with non-verbal cues, such as prosody, facial mannerisms, and body behaviors. Generation of these cues is typically an unconscious act by the communicator, who must exercise vigilant self-monitoring to become aware of his/her own actions. It is the presence of these non-verbal cues in every social interaction that makes disability an enormous gap in effective social interactions. For example, eye gaze plays a crucial role in social interaction as humans rely heavily on social gaze in virtually every form of communication, including infant/parent interactions, turn taking in group conversations, attention seeking and even effective learning. A person who is blind or visually impaired, and is unable to follow the eye gaze of their interaction partners, does not experience the benefits of eye gaze for either social feedback or for learning, and might fail to display empathy through imitation.

Recently, Jindal-Snape [10] carried out extensive research in understanding social skill development in the blind and visually impaired. She has studied individual children (who are blind) from India where the socio-economic conditions do not provide for trained professionals to work with children with disabilities. She observed that significant others in the environment often fail to give feedback, and even when they do, it is not meaningful or understandable to an individual who is visually impaired—for example, nodding one's head in reply to a question or gesturing. Lack of meaningful feedback could make it difficult for visually impaired individuals to comprehend a conversation and, at times, may stop them from conversing altogether. Similar studies carried out by Celeste [11] indicated that social intervention by parents and teachers are very important in the formative years of a child with visual impairment. Developing on the work by [12], which emphasizes that short-term solutions are never effective, Celeste insists that professionals must identify strategies related to social skills that work, provide consistent support and follow children longitudinally to ensure effective development of social skill set. We believe that an assistive technology solution that is designed with utmost care towards understanding and interpreting human-human interpersonal communications could go far and beyond in enabling and motivating individuals with disabilities to lead a healthier life.

When deprived of the benefits of social feedback, people with disabilities may develop (or fail to extinguish) face, body and vocal mannerisms that can be distracting or detrimental in social settings. Eichel [13] describes such mannerisms as “Any repetitive or stereotyped movement that is not directed toward the attainment of any observable (obvious) goal”. Non-disabled people receive social feedback by monitoring changes in non-verbal cues (such as facial expressions) as a conversation progresses, noting signs of positive or negative emotions. Such observations might not be accessible to people with a disability, due to a sensory disability or to an inability to process the affective content of an incoming sensory stream. As a result, people who are blind sometimes develop body rocking, head weaving, head drooping, and eye poking behaviors, while people who are deaf sometimes develop repetitive vocal behaviors. Cognitive disabilities, both acquired (such as brain injury) and congenital (such as autism or mental retardation) are sometimes associated with stereotypic behaviors such body rocking, hand flapping, jumping, and marching in place.

Though harmless by itself, Stereotypy can become a hindrance to both personal and professional lives of individuals. Reference [14] introduces a 21 year old congenitally blind student who has an extreme case of body rocking (both while sitting and standing) that has become an obstruction to his career and an independent vocational evaluation states that a reduction in the student's body rocking was absolutely necessary for any form of employment. Stereotypy is a concerning problem in children, for whom peer acceptance is very important for their healthy growth and development of good social skills. Children with stereotypic behaviors become victims of teasing thereby leading to social isolation, bullying and social segregation leading to negative self esteem. Aggravating these problems, social segregation and isolation have long term psychological effects on the individual rendering an overall poor social skill set.

We believe that a carefully designed assistive technology solution could provide the much needed assistance in empathy and social feedback that are vital for an individual’s overall development. The framework that we present in this paper takes into account two most important aspects of social interactions namely, *enabling empathy* (providing opportunity for an individual at displaying vivid emotions, effective role taking, and understanding others) and *social-rehabilitation* (providing opportunity for social feedback) as the dimensions of design and suggests a novel computing platform that will allow seamless integration into the lives of individuals while also providing the much needed social intervention.

1. **Design Issues:**

## Design of an effective assistive technology to aid in social interactions

Affective Computing research has employed algorithmic framework to quantitatively study 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 human emotional states. A good review of research work in Affective Computing can be found in [15]. 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 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* social cue information to the user, and allowing the user to interpret them. However, very little research has been done towards finding intuitive methods for presenting social cue information to humans. [16] 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 feature. Experiments conducted by the researchers showed that people 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 should be portable and wearable so that the users can use them at various social circumstances without any restriction to their everyday life.

People with disabilities are not always able to perceive or interpret implicit social feedback as a guide to improving their communication competence. However, they might be able to use explicit feedback provided by a technological device. Rana and Picard [17] 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 users own shoulder to capture the user’s 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 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 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 become a social distraction.

Vinciarelli et. al. [18] have described the use of discrete technologies for understanding social interactions within groups, specifically targeting professional environments where individuals take decisions as a group. They analyze the use of bodily mannerisms and prosody to extract nonverbal cues that allow group dynamics analysis. They rely on simple sensors in the form of wearable tags [19] which detect face to face interaction events along with prosody analysis to determine turn taking, emotion of the speaker, distance to an individual etc. Pentland describes these signals captured during group interactions as [20] *honest signals*. Some of his recent works [21] in the area of social monitoring hopes to capture these signals and provide feedback to individuals about their social presence within a group. The use of social feedback is illustrated elegantly in their work but their findings relied on sensors carried by all individuals involved in the study. Having everyone in a group wear sensors has proved to be a viable and productive approach for studying group dynamics. However, this approach is not viable as a strategy for developing an assistive technology, as it is not realistic to assume that everyone who interacts with a person with 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.

In two independent experiments [22] and [14], researchers developed a social feedback device that provides intervention when a person with visual impairment starts to rock their body displaying a stereotypy. [22] designed a device that consisted of a metal box with a mercury level switch that detects any bending actions. 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. The authors tested it on a congenitally blind individual who had severe case of 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 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 short term feedback for rehabilitation [23], and these studies support the above observation that short term feedback is often detrimental to rehabilitation and subject's 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.

### Observation 4: Assistive technology designed towards social assistance and 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 [14] researchers used a 'Drive Alert' (driver alerting system that monitors head droop) to detect body rocking and provide feedback to a congenitally blind 21 year old student. The research concludes that they were able to control body rocking effectively, but the device could not differentiate between body rocks 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 large number of false alarms would only discourage an individual from using any assistive technology.

### Observation 5: Assistive technology designed towards social assistance and behavioral rehabilitation should be effective in discriminating social stereotypic mannerisms from other functional movements to keep the motivation of device use high.

1. **Stereotypic Behaviors:**

## Foundations for social rehabilitation of behavioral stereotypes

For over three decades, researchers in behavioral psychology have been publishing case studies on individuals who exhibit stereotypic body rocking. Most of these studies have targeted at reducing or controlling stereotypic body rocking. The methodologies used by these researchers, though varying in nature, can be broadly classified into two important categories.

### Intervention: Intervention relates to any form of feedback provided to an individual at the moment of exhibiting stereotype behaviors. Researchers have attempted to reduce body rocking by providing audio and/or tactual intervention whenever an individual started to rock. They have tried aversive punishment as well as less restrictive positive feedback in such situations. Felps and Devlin [8] issued an annoying tone in the ears of the subject while [12] used a recording of stone scratching on blackboard as the feedback tone whenever the individual started rocking. Both reported that the subjects responded well to the intervention. In contrast, [13], [14] and [15] have used verbal praise, physical guidance, verbal reprimands, and brief time-outs as intervention tools. Most of these researches have shown that intervention has worked in reducing and controlling body rocking without the use of aversive techniques. Aversive or not, these techniques validate a claim that it is possible to control or reduce body rocking (or any other stereotypic body mannerism) through feedback.

### Self Monitoring: In contrast to intervention, self-monitoring does not stop at intervening into the activities of the individual. It attempts to teach these individuals subtle cognitive skills to replace the current mannerism with more socially acceptable behavior, exercise, or medications. McAdam and O`Cleirigh [3] identifies that self monitoring is a very effective way of reducing the body rock behavior. They introduce the case of a congenitally blind individual who is trained (with constant monitoring and positive feedback) to count the number of body rocks he goes through. Researchers noticed that the individual slowly waned off body rocking as he came to recognize and count his body’s oscillatory movements. The research concludes that a well designed self monitoring program could benefit in reducing stereotypic body rocking. Shabani, Wilder and Flood [6] presents the case of a 12 year old child who was diagnosed with attention deficit hyperactivity disorder (ADHD) having an excessive body rocking and hand flapping stereotypy. The authors introduce an elaborate and positively rewarding self monitoring scheme that allows the child to improve on his behavior effectively. A follow-up with the child's teacher indicated that the social outlook of the child had improved over the course of rehabilitation and the case further reiterates ability to rehabilitate individuals with stereotypic behavior. Estevis and Koenig [16] introduces a cognitive approach to reducing body rocking on an 8 year old congenitally blind child through self monitoring. Teachers or family members would tap on the shoulders of the child when he started rocking, while the child was taught to recite his own monitoring script. The authors conclude that rocking can be significantly reduced through notification to the individual combined with self monitoring.

Supporting such case studies of behavioral mannerisms, psychologists have been studying intervention and feedback as an integral component of social development. Feedback can be defined as the provision of evaluative information to an individual with the aim of either maintaining present behavior or improving future behavior [17]. According to [18], feedback is critical to social development because after an individual receives information about his or her performance, he or she can make the necessary modifications to improve social skills. Most social skills develop during early years and in order for children to evaluate themselves accurately and to modify social skills, it is essential that children to be given feedback [19][20], since without clear feedback, the children are unable to identify how their social behavior differs from others or is perceived by others in the environment [21]. Based on these studies there is enough evidence that feedback that offers intervention, possibly followed by a well planned self-monitoring program could benefit in reducing or controlling body rocking behavior.

## Need for Assistive or Rehabilitative Technology

The feedback needed for intervention usually comes from people in and around these individuals who have stereotypic behavior. It has been observed that significant others in the environment often fail to give feedback, and even when they do, it is not meaningful or understandable to individuals who need rehabilitation - for example, in case of individuals who are blind or visually impaired, nodding one's head in reply to a question or gesturing [22] would be futile. Meaningful feedback is important, not only for social interaction, but for accurate self-evaluation by individuals. Most times people within the vicinity of individuals with needs fail to offer these crucial feedbacks. Many times, the individuals with needs feel guilty or obligated to ask for help from others in their environment. The ability to augment or replace this significant individual(s) in the environment with a reliable feedback mechanism is the aim and goal of all assistive technology solutions (In an independent online survey conducted by [23], the researchers found that people who are visually impaired would expressed the need for an assistive technology that would provide feedback on their own social mannerisms and offer a potential to improve their social outlook). Focusing on the development of such a technology that effectively detects body rocking and provides feedback to an individual is the goal of this paper. While we focus only on intervention through feedback, in the Future works section we highlight some ideas for extending the proposed framework into self-monitoring tools.

## Past research into building assistive technology to detect body rocking

Transon [24] developed a head mounted switching device that would trigger a tone when an individual starts to rock. The device consisted of a metal box with a mercury level switch that detects any bending actions. 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 such that the speaker aligns with the ears. The authors tested it on a congenitally blind individual who had severe case of 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 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 short term feedback for rehabilitation [22] and these studies support the above observation that short time feedback is most of the times detrimental to rehabilitation and subject's 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. Thus, any technology developed for behavioral rehabilitation should be small and researchers should target the use over long durations in such a way that the feedback is slowly tapered off over a significantly longer duration of time.

Similar to the pervious experiment, [8] used a 'Drive Alert' (driver alerting system that monitors head droop) to detect body rocking and provide feedback to a congenitally blind 21 year old student. The research concludes that they were able to control body rocking effectively, but the device could not differentiate between body rocks 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 droop. Use of such devices could only be negative on the user as a large number of false alarms would only discourage an individual from using any assistive technology.

Assessing these above technologies, we resort to two important design dimensions in every step of the building of our assistive device.

1. *Size and placement of the device*: We argue that any assistive device developed for the sake of improving social outlook of an individual should respect the appearance of a person in his/her social circle and should provide a solution that is discrete and non intrusive. We call this the *Acceptance* dimension.
2. *Ability to discriminate rocking from other functional activities*: False feedback even over a short period of time could be discouraging for an individual to continue using his/her assistive tool. It is imperative that the device be able to distinguish between the stereotypy from any other form functional activities effectively to keep the motivation of device use high. We call this the *Motivation* dimension.

The proposed methodology uses these two design dimensions while addressing the need of a new assistive technology.