# Importance of Social Interactions:

People participate in social interactions every day with friends, family, co-workers and strangers. A strong set of social skills is critical in life—for example, they help us make new friends or make good first impressions at job interviews. Sociologists believe that social interactions are the underpinnings of over modern society and good social skills begin to develop at an early age and are essential for social development and acceptance within our society [1]. Social interactions refer to all forms of interpersonal communication between the participants. This could be bilateral (between two individuals) or group interactions (between multiple people). Irrespective, all the participants are engaged in continuous exchange of social information through their behaviors, mannerisms, gaze, posture, proxemics and kinesis [2].

## Psychological Support:

Recent studies by Segrin et al. have shown that poor social skills are antecedents to psychosocial problems including depression, loneliness, social anxiety, etc. The authors conducted a battery of tests on college students to determine the effect of stress on the students when they live at away from home. Figure XXX shows Depression and Loneliness plotted against stress levels of undergraduate students. Depression was measured using the Beck Depression Inventory which is a one-dimensional instrument that has been used in various studies and has been proven to have excellent reliability and validity. Loneliness was measured on the UCLA Loneliness Scale version 3 as an index into the students experience of loneliness. For both of these tests, the participating students were categorized into high, medium and low social skilled groups based on the Social Skills Inventory which a battery of tests administered to determine the socialization ability of an individual.

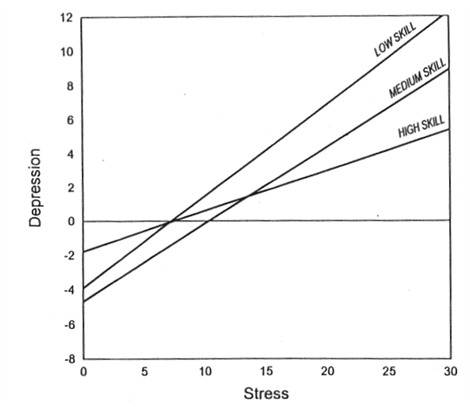
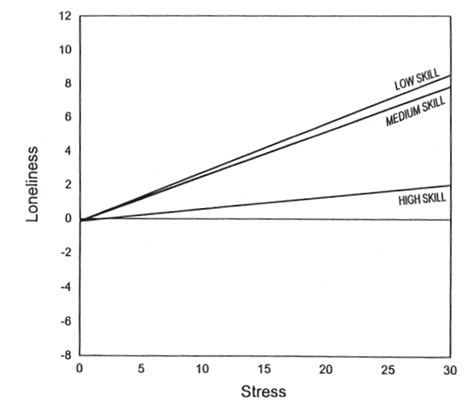


Figure XXX: Depression and Loneliness of students plotted against stress levels in high, medium and low social skilled undergraduate students. (Please see text for the scales used for the measurement.)

One can immediately identify a positive correlation between stress and an increased experience of psychosocial problems in all the students, but the ones that rank higher on social skills show higher resistance to stress and in turn higher resistance to mental breakdown. Students assessed with mild or lesser social skills were highly vulnerable to social issues as the stress increased.

Similar results were found in [7] and the authors conclude that people with high competence in communication are known to display immense capability towards adapting their social behavior based on others in their surrounding. Such competence has been acknowledged to reinforce social skills thereby creating a reinforcement feedback that allows these individuals to be successful in their social endeavors and in turn successful in their life. In a tangential study, though Magnusson was not looking for social interaction needs in people, found that social interaction is an important dimension in the cognitive organization of human behaviors. When college students were assessed individually and as a group to determine how they classified everyday activities into different situations, Magnusson discovered 5 dimensions (Principle Dimensions). These included two dimensions based on whether the students perceived a situation as being positive (*positivity*) or negative (*negativity*) influence on their behavior, two dimensions based on whether the situations were *active* or *passive,* and finally, the fifth dimension was based on *social interaction* with others. His study emphasizes how social interactions are perceived by individuals as an important scale for judgments on their activity of daily living.

It is imperative that efforts be made towards understanding development and learning of social skills in humans so that effective tools can be built to cater to people with needs.

## Social Intelligence:

Studies in Cognitive Psychology support the hypothesis that social interactions play a vital role in the overall development of intelligence in humans, especially, in the development of Social Intelligence (or Interpersonal Intelligence as defined by Howard Gardner [10]) and Emotional Intelligence [11]. *Social Intelligence (SI)* can be defined as the competence in initiating and maintaining group interactions and behaviors. First defined by Edward Thorndike, Social Intelligence is “the ability to understand and manage men and women, boys and girls, to act wisely in human relations” [12]. Recently, Karl Albrecht [13] has proposed that Social Intelligence provides for five important aspects of everyday societal inner workings, including, 1) Situational awareness, 2) Presence, 3) Authenticity (or Individuality), 4) Clarity (of action), and 5) Empathy. *Emotional Intelligence (EI)* describes the ability, capacity, skill to identify, assess and manage the emotions of one’s self, others and of groups of individuals. Many models have been proposed in the past to explain EI, such as Ability based models [14], Mixed models [15] and Trait based models [16]. All these models provide a means to measure an individual’s social and emotional skill and place him/her on a scale of abilities/disabilities. Most of these measurements are based on the person’s social interaction skills and the metrics correlate directly to one’s ability in initiating, maintaining and delivering appropriate social cues. Recently, these EI metric scales have been used to diagnose autism spectrum disorders, including autism and Asperger syndrome, semantic pragmatic disorder or SPD, schizophrenia, and Attention-deficit hyperactivity disorder (ADHD). While most of these disorders are still a mystery to the medical community, increasing the social interactions of the individual has shown to alleviate some of the symptoms.

While most SI and EI models have been theoretical in their approach to expaling the importance of social interactions, primate researcher, Humphrey [17], has demonstrated the real-world effect of social interactions to cultural transmission of knowledge and the development of intelligence. His studies with rhesus monkey 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. Humphrey argues that the interactions with other monkeys were key to Helen’s learning of spatial interactions (both with objects and other monkeys).

From a neuro-physiological perspective, advanced functional brain imaging is enabling researchers to study the workings of human brain under various functional conditions. Brothers [18] 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 [19], where the authors study autistics and controls under functional Magnetic Resonance Imaging (fMRI). 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 the 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).

## Summary:

In summary, social interactions are vital aspect of everyday living in our society. Humans learn through their social interactions and these interactions form the basis of our psychological balance. While sociologists and psychologists have been studying social interactions from the perspective of learning innate human behavioral models, social interaction models have not been studied from an

# Non-verbal Cues:

Social interactions and social skills primarily correspond to the two main channels of communication

* *Verbal communication:* Explicit communication through the use of words in the form of speech or transcript.
* *Non-verbal communication:* Implicit communication cues that use prosody, body kinesis, facial movements and spatial location to communicate information that may be unique or overlapping with verbal information.

From a communication point of view, nearly 64% of all information communication happens through non-verbal cues. Out of this large chunk, 48% of the communication is through visual encoding of face and body kinesis and posture while the rest is encoded in the prosody (intonation, pitch, pace and loudness of voice). Inability or difficulty to access any part of this non-verbal cues, seriously affects the overall understanding of the social scene and reduces the involvement of an individual in the social interactions.

From the perspective of encoding information into non-verbal cues, speech, voice, face and body form the primary channels of communication in any social interaction. Speech forms the primary channel for verbal communication, while prosody (intonation, pace and loudness of one’s voice), face and body (posture, gesture and mannerisms) form the medium for nonverbal communication. Unlike speech, which is mostly under the conscious control of the user, the non-verbal communication channels are engaged from a subconscious level. Though people can increase their control on these channels through training, innately, individuals demonstrate certain inability to control their non-verbal cues. This inability to control non-verbal channels is referred to as the leakiness and humans (evolutionarily) have learnt to pick up these leaked signals during social interactions. For example, people can read very subtle body mannerisms very easily to determine the mental state of their interaction partner. Eye Gaze is a classic example of such subtle cues where interaction partners can detect interest, focus, involvement and role play, to name a few. On this leakiness scale, it has been found that the voice is the leakiest of all channels, implying that emotions of individuals are revealed first in their voice before any of the other channels are engaged. The voice is followed by body, face and finally the verbal channel, speech. The leakiness is plotted on the abscissa of Figure XXX with the ordinate showing the amount of information encoded in these three channels. It can be seen that the face communicates the most amount of non-verbal cues, while the prosody (voice) forms the first channel to leak emotional information.

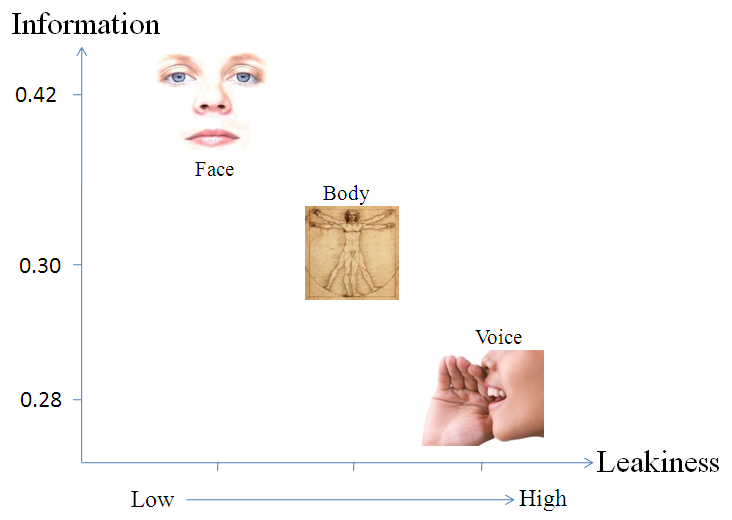


Figure XXX: Plot of communicative information encoded in the three important non-verbal channels of encoding. Speech forms the verbal channel. Face, body and voice form the non-verbal communication channels.

From the perspective of decoding non-verbal communication cues, the non-verbal channels can be analyzed under,

a) the auditory channel (includes conscious, verbal speech and unconscious, nonverbal voice),

b) the visual channel (includes nonverbal face and body mannerisms and gestures, which are distributed fuzzily between the conscious and unconscious mediums),

c) the combined Audiovisual channel (includes simultaneous verbal and nonverbal communication mediums), and

d) touch (includes the nonverbal conscious haptic sensory perceptions).

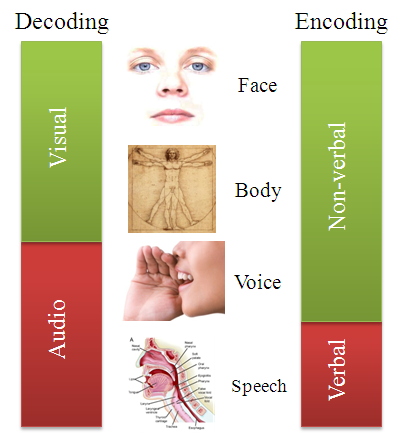


Figure XXX: Shows the encoding and decoding aspects of interpersonal communication. From an encoding perspective, humans use verbal and non-verbal cues to communicate while from a decoding perspective, face and body encoded data is received visually and verbal speech and non-verbal prosody are received through audio.

## Components of Non-verbal Communication:

In [2], Knapp and Hall describe nonverbal communication in three units, namely,

a) the communication environment,

2) the physical characteristics of the communicators, and

c) the various behaviors of the communicators.

***The Communication Environment:***

The communication environment or surroundings where the interactions are taking place make a huge difference of how humans respond or react [22] [23]. For example, lengthy periods of extreme heat [24] are known to increase discomfort, irritability, reduced work output and unfavorable evaluations of other. Along with the interaction partners, the environment either reinforces or depreciates the emotional experience of an individual. For example, wide open spaces and natural environments are known to be conducive for psychological stability [25]. Though the environmental factors just perceptual, they impose a lot of control on how humans react towards them. Some of the important environmental factors that affect interpersonal communication and non-verbal cueing are shown in the table below. These are some of the well identified factors towards which psychologists and sociologists are working towards.

|  |  |
| --- | --- |
| **The Communication Environment** |  |
| Familiarity of the environment | [26][27] |
| Colors in the environment | [28][29] |
| Other people in the environment | See next two subsections. |
| Architectural Designs | [30] |
| Objects in the environment | [31] |
| Sounds | [32][33] |
| Lighting | [34] |
| Temperature | [24] |

***The Physical Characteristics of the communicators:***

The physical appearance of a person is very important aspect of non-verbal cueing. People draw impressions of their communication partner as soon as they see them. The human body acts like means for communicating important sociological parameters like status, interest, dominance etc. Researchers have found cultural and global preferences in overall body image and any deviations from the norm affects interactions between people. For example, facial babyishness [35] has been found affect judgment of facial attractiveness, honesty, warmth and sincerity. Any deviation from the babyishness has been correlated to immediate reduction in the judgment of these traits. A similar such example is the clothing that people wear. It has been found that first impressions are positive if the interviewer and interviewee are clothed similarly [36]. The table below shows the important aspects of a person’s physical appearance that affects the interpersonal interaction. Various psychological studies have been conducted towards understanding the model of human perception of character. Very little is known on the reasons for some of the human norms, but it is an active area of research that is being explored rigorously, especially, in the context of group behaviors and personal mannerisms with work environments [37].

|  |  |
| --- | --- |
| **Physical Characteristics that affect interpersonal communication** |  |
| The human facial attractiveness | [35][38][39] |
| body shape | [40][41] |
| height of a person | [42] |
| self image | [43] |
| body color | [44] |
| body smell | [45][46][47] |
| body hair | [48] |
| clothing | [36][49] |
| personality | [50][51] |
| body decoration or artifacts | [52] |

***Behavior of the Communicator:***

The last of the three units of non-verbal communication is the behavior of the communicators. While the term behavior is used loosely in defining this unit, this encompasses both static posture and dynamic movements demonstrated by communicators. Of the three units of non-verbal communication, the behavior forms the most important aspect. Most part of the emotional information encoded by humans is delivered through the behavior of individuals during social interactions. Gestures, Posture, Touch and Voice form the basic subdivisions in behavioral non-verbal cueing. While the entire human body is important for the communication of these cues, the face and eyes play a major role.

*Gesture:*

Gestures are dynamic movement of face and limbs displayed during interpersonal communication. Together, they convey a lot of information that is sometimes redundant (with speech) while other times deliver emotional information about the enactor. Most often gestures are classified based on their occurrence with speech. Accordingly, there are

1. Speech-independent gestures, or emblems (like shrug, thumbs up, victory sign etc), that are mostly visual in nature and convey the user’s response to the situation .
2. Speech-related gestures, or illustrators (pointing to a thing, drawing a shape while describing etc) .
3. Punctuation gestures, that emphasize, organize and accent important segments of a communication, like pounding the hand, raising a fist in the air etc.

*Posture:*

Posture refers to the temporary limb and body positions assumed by individuals during interpersonal interactions. Posture is a very effective medium for communicating some of the important non-verbal cues like leadership, dominance , submissiveness and social hierarchy . For example, people who show a tendency of dominance tend to extend their limbs out while sitting thereby displaying an overall larger body size. Similarly, submissiveness seems to be correlated to reducing the overall body size by keeps the limbs together.

Both gestures and postures are influenced heavily by the cultural background of the individual and also varied with the geographical location . Though the cultural influence if true with other non-verbal and verbal cues, the perceived difference is the highest in gestures and posture displayed by individuals.

*Touch:*

Social touch has been a very important aspect of non-verbal communication in humans. Developmental biologists believe that the first set of sensory responses in a human fetus is touch . From a social context this sensory channel is very well used in conveying important interpersonal cues such as interest, intimacy, warmth, confidence, leadership and sympathy . Touch is a powerful means of unconscious interaction and it is believed that people who are very good in their social skills rely upon touch a lot .

Historically, the sense of touch (Haptics Communication ) has been studied by psychologists in the perspective of understanding the human sensory system, but recently, haptics has grown out into the technology front providing human machine interfaces that augment or replace visual and auditory interfaces .

*Face (and head):*

*Eye:*

## Summary:

# Visual Impairment - a hindrance to Social Interaction:

As explained in the section XXX, most part of the non-verbal encoding happens through visual media. While some parts of these cues are delivered along with speech, most part of the nonverbal communication is inaccessible to someone with visual impairment or blindness. This disconnect from the visual stimulations deprive the individuals of vital communicative cues that enrich the experience of social interactions. People who are blind cannot independently access this visual information, putting them at a disadvantage in daily social encounters. For example, during a group conversation it is common for a question to be directed to an individual without using his or her name—instead, the gaze of the questioner indicates to whom the question is directed. In such situations, people who are blind find it difficult to know when to speak because they cannot determine the direction of the questioner’s gaze. Consequently, individuals who are blind might be slow to respond or talk out of turn, possibly interrupting the conversation. As another example, consider that people who are blind cannot use visual cues to determine when their conversation partners change positions (e.g., pacing the floor or moving to a more comfortable chair). In this scenario, an individual who is blind might inadvertently create a socially awkward situation by speaking in the wrong direction.

To compound these problems, sighted individuals are often unaware of their non-verbal cues and often do not (or cannot) make appropriate adjustments when communicating with people who are blind. Also, people who are blind often do not feel comfortable asking others to interpret non-verbal information during social encounters because they do not want to burden friends and family. The combination of all these factors can lead people who are blind to become socially isolated [3], which is a major concern given the importance of social interaction. While people who are blind and visually impaired face a difficulty in social interactions, research in rehabilitation training for these populations recommends that the social involvement for these individuals have to substantially increase in order to enable their acceptance of the society.

National Center for Health Statistics reported in 2007 that the estimated number of visually impaired and blind people totals up to 21.2 million in the United States alone[[1]](#footnote-1). Global numbers are daunting. In 2002 more than 161 million people were visually impaired, of whom 124 million people had low vision and 37 million were blind[[2]](#footnote-2). WHO reports that more than 82% of the populations who are blind or visually impaired are of age 50 or older. With the life expectancy going up in most developing countries, the percentage of general population entering into some sort of visual impairment is going to increase in the coming years.

Recently, Jindal-Snape 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. Her seminal work in understanding social needs of children who are blind have revealed two important aspects of visual impairment that restricts seamless social interactions. These include.

1. Inability to learn social skills due to the lack of visual feedback.

Jindal-Snape 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 persons to comprehend a conversation [65] [67]and, at times, may stop conversing. Similar studies carried out by Celeste [68] 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 [69], which emphasizes that short-term feedbacks 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.

People who are sighted do not necessarily have the training to work with individuals who are blind or visually impaired. Thus, unconsciously they tend to neglect people who are blind. For example, sighted people use gaze as a primary means of keeping attention with people they communicate with. While conversing with a person who is blind or visually impaired, sighted individuals expect the same gaze feedback. The lack of such a feedback distracts the sighted individuals to turn their attention to or assume disinterest from the visually impaired individual. Research indicates that blind individuals with the ability to accommodate social requirements of their sighted counterparts have exhibited immense personal and professional growth.

1. Development of stereotypic body mannerisms, especially body rocking, as they don’t get a reinforcement feedback on their mannerisms.

Due to the lack of visual feedback, people who are blind and visually impaired do not have access to learn mannerisms from their social counterparts. Especially, people who are impaired at a very young age find it very difficult to learn appropriate social actions and mannerisms. A stereotypic body mannerism is one such scenario where positive reinforcement through visual stimulation would have prevented the individual from developing acute non-social conditions.

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 [70] issued an annoying tone in the ears of the subject while [71] 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, [72], [73] and [74] 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 [75] 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 [76] 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 [77] 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 [78]. According to [79], 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 [64][66], 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 [70]. 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.

## Summary:

# Sensing Non-verbal Cues:

## Egocentric sensing

## Exocentric sensing

## Summary:

# Processing Non-verbal Cues:

## Summary:

# Delivering Non-verbal Cues:

## Summary:

# Design of assistive technology:

## Summary:

# Research Questions:

What are the most important non-verbal cues that are important for enriching social interactions for people who are blind and visually impaired?

What assistive technology framework can be developed towards addressing the important needs identified in research question 1?

Given the above framework, how effectively can the egocentric and exocentric social interaction cues be extracted in real-time?

How effectively can the interaction partner’s non-verbal cues be delivered to individuals who are blind and visually impaired?

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