

# Eye-Contact and Facial Expression Tracking for Assertiveness Training in VR-Based Anti-Bullying Education

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## Abstract

This paper described the use of eye-contact and facial expression tracking as part of a comprehensive approach to assertiveness training in a VR-based anti-bullying simulation environment. We briefly discuss the psychological foundations of assertiveness and then focus on our approach to tracking the facial expressions and eye-contact that a user maintains while communicating with the virtual bully in the simulation. We also outline additional non-verbal indicators tracked by the software and discuss the dialog system, which drives the simulation. Finally, we outline some ethical considerations, discuss the limitations of our current software prototype, and list future directions for enhancing assertiveness training in anti-bullying education.

**Keywords:** eye-contact, emotion tracking, personal space, voice level, AI dialog, assertiveness, anti-bullying, VR

## 1. Introduction

Bullying is a pervasive societal problem impacting people of all ages, genders, and ethnicities. It is characterized by a pattern of repeated intentional physical or psychological assault or abuse of another individual or a group of individuals. At its core, bullying is based on a real or perceived imbalance of power between the bully and the victim(s). Bullies “desire power and dominance over their peers” (Olweus, 1997). Victims tend to be sensitive, introverted, and lack assertiveness, which “leaves them lonely and increases their insecurities” (Olweus, 1997). Many studies have demonstrated that one of the most effective ways of addressing bullying is at a young age, before the harmful traits of bullies (cruelty, aggressiveness, domineering, lack of empathy, etc.) and victims (insecurity, anxiety, low self-esteem, etc.) become engrained into children’s personalities (Bijttebier & Vertommen, 2017; Cornell & Limber, 2015; Cornell & Mehta, 2011; Eslea & Smith, 1998; Gaffney, Farrington, & Ttofi, 2019; Gaffney, Ttofi, Farrington, 2019; Griffin & Gross, 2004; Olweus, 1997; Olweus & Limber, 2010). Unfortunately, decades of traditional psychological approaches have yielded very limited results. In recent years, software-based approaches to anti-bullying prevention and education have proliferated (BRIM; GoSpeakUp; HIBster; Stavroulia et al, 2016). Among those, virtual reality (VR) based anti-bullying projects have taken a lead role by providing an immersive educational experience (Barreda-Ángeles, 2021; Ingram et al, 2019; Ivanov & Ramos, 2020; Ivanov 2022; Stavroulia et al, 2016; ClassVR; VR Action Lab; Upstander). VR-based anti-bullying education has been demonstrated to be at least as effective as traditional methods and much more engaging for the participating students.

The most important aspect of anti-bullying education is training users to maintain confidence and assertiveness during a bullying confrontation. Assertive behavior is exhibited through a combination of behavioral traits such as keeping a firm posture at an acceptable social distance, using appropriate responses, delivered in a level tone of voice, and maintaining proper eye-contact.

This paper describes our approach to VR-based assertiveness training for anti-bullying education focusing on eye-contact- and facial expression tracking and their interaction with other assertiveness traits. We begin by briefly discussing the psychological underpinnings of assertiveness and explaining the architecture of our anti-bullying environment. We then describe the implementation of user eye-contact- and facial expression tracking and their relation to the NLP dialog system, which drives the simulation scenarios. The integration of eye-contact and facial expression tracking with other non-verbal traits tracking is briefly discussed. Finally, we outline directions for further research.

## 2. Psychological Aspects of Assertiveness

Assertiveness is an essential element of interpersonal interaction, the foundation of healthy relationships, successful careers, and the ability to stand up for oneself in the face of adversity. In the context of bullying, projecting self-confidence and assertiveness is a vital skill for resolving a bullying incident (Boket et al, 2016)

Assertiveness is a communication style, which allows a person to express their opinions or feelings or to stand up for their rights while respecting the rights, feelings, and opinions of others. In contrast, an aggressive person puts their own feelings, opinions, and rights exclusively above those of others, while a passive/submissive

person puts the rights, opinions, and feelings of others above their own.

Assertive communication has several traits:

- Maintaining proper eye-contact with the other person while communicating
- Preserving a calm, neutral facial expression
- Respecting the personal space of the other communicator
- Speaking in a calm, level tone of voice
- Using appropriate vocabulary and avoiding the use of words and phrases that can be construed as aggressive or passive

A well-structure assertiveness training program should emphasize the combined use of these traits in interpersonal communication to help individuals learn to express their thoughts and ideas with a high degree of self-confidence (Eslami et al, 2014, Gündoğdu, 2012)

### 3. Software Architecture

Our project implements a complex, first-person, VR environment for anti-bullying education of pre-teens (ages 8 through 12). The software is implemented using the (Unity) game engine and consists of several modules, which present the user with different types of bullying challenges involving one- or multiple bullies (Figures 1 & 2).



Figure 1: One-on-one bullying scenario.

In some scenarios, bystanders may be present, who can be either sympathetic to the victim or side with the bully. The dynamics of the interaction and the strategies for a successful resolution depend on the number of bullies and the presence/absence and type of bystanders. Additional factors that the user must consider are the presence/absence of adults, who the user can ask for help, and the environment in which the bullying incident occurs. For example, the optimal strategies are different depending on whether the user is backed into a corner or standing in the open, where escape is a viable option.



Figure 2: Multiple bullies bystander scenario.

In addition to teaching children strategies for resolving bullying incidents, our software provides modules for training bystanders: These modules provide the user with the opportunity to experience bullying from a different perspective and learn essential techniques to assist a victim in diffusing a bullying situation.

The initial prototype of our software is specifically designed for the training of pre-teen girls, who are subject primarily to verbal bullying. Physical bullying, which is much more common among young boys, is not modeled, though the user has the option to “punch” the bully. Doing so, however, leads to an unsatisfactory resolution of the bullying incident with both the victim and the bully being reprimanded by a virtual adult.

### 4. Tracking Assertiveness

Tracking the user’s assertiveness during a bullying incident requires the integrated, continual monitoring of all five assertiveness traits – proper eye-contact, calm facial expression, respect for personal space, use of positive, non-aggressive language, and an even tone of voice.

#### 4.1 Eye-contact

Eye-contact is one of the most important aspects of assertive communication. It is a key indicator of the power dynamic between the individuals in real-life communication. Psychological studies have demonstrated that normal interpersonal communication is commonly bound by the “50-70 rule”: A communicator should maintain eye-contact 50% of the time while speaking and 70% of the time while listening. Moreover, normal eye-contact should be maintained for 3 to 5 seconds at a time, and then the communicator should look away before resuming eye-contact. Looking away too quickly and not maintain steady eye-contact while communicating can be perceived as a lack

of self-confidence or even dishonesty, while maintaining uninterrupted eye-contact for more than 5 seconds at a time while speaking can be perceived as aggression. In the context of bullying, the rules of normal communication need to be altered in order to project strength and assertiveness in the face of aggression. Thus, it is necessary to maintain eye-contact more than 50% of the time while speaking: 3 to 5 seconds of eye-contact followed by only a brief (0.5s to 2s) look-away period before eye-contact is resumed.

Our implementation of the tracking of the user's eye-contact with the virtual bully uses VR raycasting: An invisible ray (i.e., an unrestricted-length Vector3 object) is projected forward from the center point between the user's virtual eyes. The ray moves relative to the position and rotation of the parent object (i.e., the user's VR headset). A trigger collider component is added around the eyes of the bully character. When the ray intersects the collider, a 5 second timer is initiated. If the user's eyes do not shift away before the timer fires, a small yellow eye icon (Figure 3) is displayed to remind the user to look away. If the user's gaze does not shift away from the bully for another second, a red icon is displayed as a final warning. If the user's gaze still does not shift away from the bully's "eyes", the simulation scenario is terminated.



Figure 3: Yellow eye-contact reminder icon.

If the user's gaze shifts away from the bully's "eyes" before the 5 seconds timer expires, then the current timer value is compared to a predefined minimum (e.g., 3 seconds). If the timer value is smaller than the minimum, the yellow eye icon is displayed and blinks to remind the user he/she has not maintained their gaze on the bully long enough. If the timer value is within the specified range (3s to 5s), then the timer is reset with a 2 second value - the user must return their gaze back to the bully's "eyes" before the timer runs out or risk being perceived as passive/submissive by the bully. If the user does

not look up, then after 2 seconds, the yellow icon reminder is displayed again, followed by the red icon (Figure 4) reminder one second later. If the user still does not look up, the simulation is terminated with an appropriate explanation.



Figure 4: Eye-contact icons.

When looking away, the user must not look straight down, which can be perceived by the bully as a sign of weakness or submissiveness. To track this feature of eye-contact, a different trigger collider is placed directly in front and below the eye level of the user. If the user looks straight down, the raycast intersects this collider, triggering the display of a different attention icon – one with two arrows pointing sideways (Figure 5). This is a reminder to the user to look to either side instead of straight down.



Figure 5: "Look to the side" icon.

The eye-contact interaction timers are active only while the user or the bully are speaking. If no verbal communication is occurring, the user is free to look around.

## 4.2 Emotive Facial Expressions

Facial expressions are a form of nonverbal communication using the movement of facial muscles. Along with eye-contact, facial expressions constitute a crucial aspect of communication since they often accurately reflect an individual's emotional state (American Psychological Association). We focused on seven universal emotions - anger, happiness, sadness, fear, contentment, disgust, and surprise (Stichter et al, 2011). Each of those emotions is expressed by facial expressions, which result from the movement of specific facial muscle groups – lowering or raising of the eyebrows, squinting or opening of the eyelids, curving the mouth corners up or down, etc.

Conveying emotion through facial expressions not only serves the purpose of expressing feelings but also influences the behaviors of others (Frontiers). For instance, if the facial expression of one communicator displays anger, then the

other communicator may react with fear. Moreover, different facial expressions and gaze patterns can alter the interpretation of a person's speech. For example, if an individual verbally expresses something positive but their facial expression indicates disgust or anger, then the overall message may be perceived as sarcasm. Speakers often produce visual cues that demonstrate their confidence level. Speakers with lower confidence are more prone to exhibit a distressed facial expression often accompanied by an averted gaze. Understanding the interplay between verbal and nonverbal cues is essential to the accurate modeling of natural communication.

Children are especially sensitive to non-verbal emotional communication. In (Fox et al, 2017), the correlation between facial emotion recognition skills and the behavior of young adolescents in bullying situations was investigated. It was revealed that fear was highly recognized and could potentially aid aggressive individuals in identifying vulnerable victims. In situations where no bystanders are present, fear, anger, sadness, and disgust might empower the bully by signaling weakness in a victim. Conversely, if bystanders are present, the detection of fear and sadness may elicit empathetic concern for the victim and increase the likelihood of bystander intervention.

Our VR anti-bullying environment employs the eye-tracking and facial expression tracking features of the Meta Quest Pro headset and Meta's (Movement SDK) to process in real-time the user's emotional reactions to the bullying conversation and notify the user if the displayed emotion is counterproductive to resolving the bullying incident.

For each of the universal emotions from (Stichter et al, 2011), we developed numerical range representations. To do this, we used the Meta's avatar "Aura" (Figures 6) to approximate the facial expressions corresponding to the basic emotions by adjusting the avatar's blendshapes including eyebrow raising/lowering, jaw dropping, and lip-, cheek- and eye movements. For each facial expression, we recorded the weight ranges of every adjustable blend-shape connected to the skin meshed renderer on the avatar's face. Establishing these weight ranges involved careful considerations: Each facial expression is a combination of facial movements occurring simultaneously. Thus, we had to ensure that in each case the weights were strong enough to avoid interference with other expressions sharing similar facial movements. Additionally, we grouped expressions in a manner that prevents activation through speech or subtle facial movements. Additional finetuning was required

once we started testing against actual human expressions during the simulation.

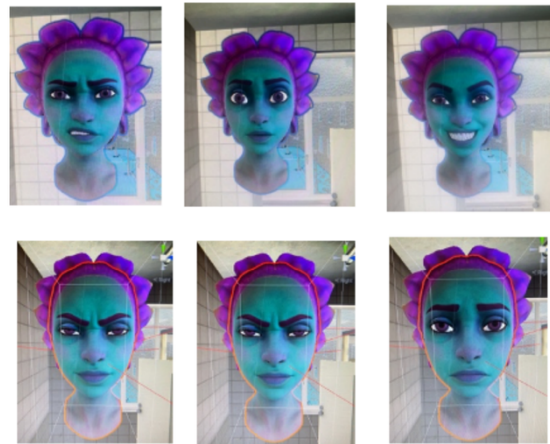


Figure 6: Facial expressions expressing different emotions

At run time, we use the Meta Quest Pro's five inward-facing infrared cameras and Meta's Movement SDK to track the actual facial expressions of the user, comparing the recorded values to predefined emotional range sets. When a facial expression, which is counterproductive to the anti-bullying effort is detected, a small icon is displayed to remind the user to control their emotions as best as possible (Figure 7).



Figure 7: Emotion icon displayed to the user

## 4.3 Other Non-Verbal Features

### 4.3.1 Personal Space

Maintaining an appropriate distance and respecting the personal space of others is an essential aspect of communication. In the 1960s, the anthropologist Edward Hall conducted extensive research on the relationship between communication distance and the type of communication (Hall, 1963). He defined four types of separation during communication:

- *Intimate distance*: from less than an inch to about 18 inches
- *Personal distance*: approximately 2 to 4 feet
- *Social distance*: approximately 4 to 12 feet
- *Public distance*: 12 to 25 feet or more

The distances between the bully and the victim during a bullying incident are usually dictated by the bully: Typically, the initial confrontation begins at a social distance of 8-12 feet, but if the confrontation escalates, the distance can quickly decrease to less than a foot.

It is crucial that the victim attempts to preserve a social- or at least a personal distance during the confrontation. This is a delicate balance: If the victim steps too far back, the move can be perceived by the bully as a sign of weakness. On the other hand, the victim's stepping forward or refusal to step back can be perceived as aggressive and lead to a further escalation of the conflict. The victim must attempt to preserve the distance established at the beginning of the conflict, taking a step back or sideways only if the distance shrinks rapidly and stepping forward only after the incident has been resolved.

Our implementation of personal space tracking involves the use of trigger colliders. A minimum distance collider is placed around the victim. The radius of the collider is based on the bullying scenario: In one-on-one bullying, the minimal distances are usually 2ft to 4ft. In many-on-one bullying, the minimal distance is somewhat larger (3ft to 6ft) and depends on the number of bullies and bystanders. Each bully is programmed to move based on the state of the bullying dialog: If the exchange escalates, the bully is programmed to take one or more steps towards the user. If the dialog moves towards an acceptable resolution, the bully is programmed to take a step back. The user is expected to attempt to keep the bully outside the minimum distance. If a bully crosses into the minimum distance collider, a small red icon is displayed (Figure 8) prompting the user take a step back until the bully is outside the minimum distance collider. A second, larger trigger collider around the player displays a yellow icon if the player backs off too far from the bully or attempts to flee (Figure 9). The radius of that collider is usually set to 8ft. The maximum distance collider is disabled in certain training scenarios when escape is a viable alternative. In general, however, the player must keep the bully between the larger (max-distance) collider and the smaller (min-distance) collider until the conflict has been resolved.



Figure 8: Red icon prompts the user to step back



Figure 9: Yellow icon prompts the user to stop backing up and take a step forward

#### 4.3.2 Tone of Voice

Assertive communication requires an even, sufficiently loud tone of voice. A quiet voice can be construed as a sign of weakness, whereas too loud a voice can be perceived as aggressive. Additionally, excessive fluctuations in the vocal pitch and loudness can be a sign of emotional distress. A confident voice exhibits relatively small, smooth fluctuations in pitch and loudness.

We use a script to capture live feed from the headset's microphone and measure the loudness and frequency spectrum of the user's voice: When the user approaches the bully, the script begins capturing sets of microphone input samples. The microphone signal is passed through a low pass filter to cut out background noise and frequencies that do not correspond to human speech (80Hz to 255Hz for adults and 250Hz to 400Hz for children). We use the `GetSpectrumData()` and `GetData()` methods of Unity's `AudioSource` and `AudioClip` classes to obtain the loudness and frequency data from the microphone samples. The loudness data is used to control a small volume bar icon, which changes color from green

(appropriate volume) to yellow (slightly low/high) to red (very low/high). The scale of the sound bar shows if the user is talking too quietly (partially-filled red or yellow bar) or too loudly (completely full red or yellow bar) (Figure 10).



Figure 10: The user is too far, speaking quietly and looking at the bully too long.

#### 4.4 The Verbal Communication System

The most important aspect of any anti-bullying training environment is the dialog system. While impactful, non-verbal cues usually cannot, by themselves, resolve a bullying situation. Therefore, it is imperative to implement a verbal communication system, which teaches the user how to successfully deal with bullying incidents.

Most anti-bullying education has traditionally revolved around scripted dialogs, where the user is taught how to respond to specific bullying taunts. Our approach is to let the user try, and fail, and eventually succeed in resolving the situation on their own. After each session, we provide guidance as to how the situation could have been handled better. But the goal is to let the user determine for themselves what works.

To implement the verbal communication system we use the Microsoft (Speech SDK) to provide real-time text-to-speech (tts) and speech-to-text (stt) functionality and OpenAI's (ChatGPT) to act as a "bully" as well as to evaluate the user's responses. The conversation is initiated by the "bully" when the user crosses the bully character's proximity collider. We prompt ChatGPT to generate a child-like taunt, which is then passed to the tts system to play the taunt to the user. The system waits for the user to respond and, once the response is received, it is converted to text and passed to ChatGPT along with a prompt "In one word, is this sentence positive, negative, or neutral". Depending on the estimated polarity of the user's response, ChatGPT is instructed further to act either in a more adversarial- or a more friendly manner. The dialog is usually short – no more than 5-6 bully-user exchanges.

The user's success or failure is judged by a point system which combines the weighted scores from the verbal exchange as well as from the various non-verbal cues displayed during the simulation. The point system takes into account the interaction between the verbal and non-verbal communication: For example, if the user responds positively to a bully taunt while exhibiting a positive or neutral facial expression, an additional positive point is awarded. Conversely, if the positive response is accompanied by a negative facial expression, an extra point is subtracted.

## 5. Conclusion

This paper describes the methodologies used for tracking of user assertiveness and teaching assertive communication skills in a complex VR-based anti-bullying training environment. The software integrates verbal and non-verbal interaction tracking including eye-contact, facial expressions, personal space, tone of voice, as well as appropriate verbal communication. Each of these topics is very complex and requires a significant amount of future adjustments.

Much work remains to be done on refining our tone-of-voice algorithms. Notably, frequency spectrum inconsistencies and loudness fluctuations can be due to overlapping background noise frequencies as well as vocalization artifacts such as exclamations and prosodic pauses.

Refinements will be added to the eye-contact tracking methodology as well: When facing multiple bullies, it is important that the victim keeps shifting their gaze from one bully to the next rather than focusing on a specific bully. Doing so is even more important in the presence of bystanders since engaging bystanders through eye-contact is likely to establish a more personal connection and help bring the bystander to the victim's side. Implementing an eye-contact tracking methodology which encourages gaze shifting is one of the next goals of our project.

Eye-contact and facial expressions tracking are not the only aspects of body-posture assertiveness. Gestures such as crossing one's arms, leaning forward, or slumping are implicit expressions of assertiveness, aggression, or submissiveness. The limited availability and high cost of full-body VR suits makes integrating the tracking of such gestures infeasible for the moment. However, one of our immediate next steps will be adding the tracking of hand-gestures, such as raising one's fists.

Finally, we hope to expand the use of our assertiveness tracking methodology beyond anti-bullying training. Assertiveness is a valuable trait in any human interaction and creating a stand-alone software environment to teach assertiveness in different social settings (e.g., negotiating for a salary raise, asking someone on a date, or debating a topic with friends) will be a beneficial endeavor for society as a whole.

## 6. Ethical Considerations and Limitations

Bullying is a highly complex and sensitive topic. Any anti-bullying methodology needs to be carefully vetted by one or more qualified institutional review boards (IRB) and undergo a thorough testing by qualified professionals. Large-scale deployment should only be attempted after a series of smallest test studies involving limited groups of testers, beginning with psychology experts and eventually moving towards target audience participants. Our software is still in its prototype phase and a review by our IRB is still pending.

There are many areas of concern: Foremost among them is the reliability of Generative AI acting as a simulated bully. While the ChatGPT prompts that drive the simulation are carefully vetted, there are no assurances as to what responses ChatGPT (or any other LLM) will generate. It is, therefore, virtually impossible to guarantee that a particular response will not be inappropriate or harmful, especially to a child participant.

Any bullying situation – even a simulated one – can be very stressful to some individuals and even more so to children. Part of the reason we opted for VR instead of an augmented/mixed reality simulation was because some of the stress can be mitigated by using characters and environments that are intentionally designed to look somewhat cartoonish and not hyper-realistic. Adopting this design approach provides the simulation with a more game-play atmosphere that alleviates some of the stress of participating in the training. Regardless, it is highly recommended that a qualified professional – either a psychologist or a school counselor – observe the training session and be ready to intervene if the participant exhibits signs of strong emotional distress.

It is well known that VR causes vertigo in some individuals due tovection - the (often subconscious) illusion of motion while seated. Our simulation

software has been designed with the aim of minimizing VR discomfort for the user. We provide smooth motion, avoiding sudden/jerky camera movements, and do not use teleportation. We do our best to avoid bringing up peripheral visual stimuli, though this is occasionally difficult or impossible to do given the complex nature of the simulation environment, involving numerous virtual characters and moving objects. Once again, the vigilance of a school psychologist or counselor is necessary to ensure that the participants do not suffer from the effects of VR-induced motion sickness.

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