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Music recommendation system for individuals with autism spectrum disorder

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INTRODUCTION

MOTIVATION: Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder associated with challenges in social interaction, speech and nonverbal communication, and limited/repetitive behavior ((APA), 2000). The term "spectrum" in autism spectrum disorder refers to the wide range of symptoms and severity. It also includes limited and repetitive patterns of behavior. Individuals with ASD represent a diverse group of people, each with their own abilities and challenges. Difficulties in the capacity to communicate and the limitation to socially interact adequately are generally the most noticeable aspects. These challenges may result in a poorer quality of life for those individuals who have difficulty maintaining meaningful relationships with others. There is no cure for ASD but it can be managed with intensive and early treatment. Individuals with ASD have difficulty with social interaction behaviours, including establishing and maintaining relationships, reciprocating social interaction, and communicating with others. An extensive review of the literature by (White) revealed that up to 84 % of individuals with autism meet the criteria for clinically diagnosed anxiety disorders. As they lack in communication skills, it is difficult to diagnose depressive or anxious state.As a developmental disorder, ASD impacts an individual's ability to interact socially and exhibit appropriate behaviors. Lack of social skills may have lifelong implications, affecting their family/community interactions, academic skills, self-worth, and independence. Therefore, there is a need for effective interventions targeting social outcomes in children with ASD who have differing levels of functioning and abilities. Music may also be used to address social skills in children with ASD and research evidence has indicated that music therapy interventions can facilitate to promote social skills.

MUSIC THERAPY: Music is at its core is a structured way to present information. Music therapy is defined by the American Music Therapy Association as the "clinical and evidence-based use of music interventions that facilitate sociMusic is at its core is a structured way to present information. Melodic and rhythmic patterns gives a way to organize auditory information and help memorize scripts, task sequences, and academic facts.Music can help to reduce anxiety and stress levels , it has a calming effect and can be used as a relaxation tool (Stegemann). It can help develop their communication and language skills by providing a non-verbal means of expression (Vaiouli & Georgia Andreou, 2017). Playing musical instruments can help to develop fine motor skills in individuals with autism (Fahimeh, 2018). This can be beneficial in helping them to develop the skills they need to perform daily activities.It can help make social and family connections through a mutual shared interest by encouraging group participation turn-taking and cooperative play, making repetitive learning tasks seem like fun rather than work, providing a multi-sensory approach that taps into visual, auditory, and kinesthetic learning, offering a sensory outlet through movement, interaction, and hands-on involvement helping to keep students with autism engaged , bridging the gap within inclusion settings between students with autism and neurotypical peers which can help in social interaction communicative, motor/sensory, emotional, cognitive, and music skills in individuals. Many individuals with ASD respond positively to musicexperiences, making music a safe and structured stimulus for social engagement and the practice of social skills.(PeretzIZatorreRJ, 2005). (Table 1)

MUSIC THERAPY IN THE WEST: Music therapy has been used to support individuals with autism in the West for several decades.Music therapy is recognized as a health profession and is often used as a complementary therapy alongside conventional therapies such as occupational therapy and speech therapy. Music therapy has been shown to improve communication, social skills, and sensory integration in some individuals with autism thus improving their quality of life. There are several organizations in the United States that offer music therapy programs for individuals with autism, such as the American Music Therapy Association, Music for Autism, and the Nordoff-Robbins Center for Music Therapy at New York University. These programs involve using music-based interventions to achieve specific therapeutic goals. For example, some

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programs use singing and rhythm-based activities to develop communication and socialskills, while others use listening to music to promote relaxation and reduce anxiety(Prat C, 1950). In the United Kingdom, music therapy is also a recognized health profession and is used to support individuals with autism. The British Association for Music Therapy offers a range of services for individuals with autism, including individual and group music therapy sessions. The Nordoff-Robbins Center for Music Therapy in London is also a well-known provider of music therapy services for individuals with autism.Additionally, there are several music-based initiatives that aim to support individuals with autism. For example, Music for Autism is a non-profit organization that produces concerts specifically for individuals with autism and their families. The concerts are designed to be sensory-friendly and interactive, with the aim of providing a positive musical experience for individuals with autism (Table 2).

MUSIC THERAPY IN INDIA: Music therapy in India is a growing field. There are several organizations such as the Chennai School of Music Therapy, the Music Therapy Trust, and the Music Therapy Centre in Mumbai. These programs involve using music-based interventions to achieve specific therapeutic goals. For example, some programs use singing and rhythm-based activities to develop communication and social skills, while others use listening to music to promote relaxation and reduce anxiety.Additionally, there are several music-based initiatives in India that aim to support individuals with autism. For example, the Music Therapy Trust conducts music therapy programs in schools for children with autism and other disabilities. The Humsafar Trust, a non-profit organization in Mumbai, offers a music program for children with autism that involves learning music through storytelling (Hutchinson, n.d.) Raagas are an integral part of Indian classical music and are often used in music therapy to improve physical and emotional health. Raagas are specific melodic modes in Indian classical music that are believed to have therapeutic effects on the mind and body. Each raaga is associated with a specific mood, emotion, and time of day or season.A study published in the Journal of Music Therapy (2013) (Nadig, 2013) explored the use of raagas in a music therapy program for individuals with developmental disabilities, including ASD. The study found that raaga-based interventions improved the participants' attention, relaxation, and emotional regulation, as well as reduced their anxiety levels. There have been studies conducted that show the effects of Music Therapy on individuals with ASD (ChristianGold) in the Western and Indian context (Bharathi, 2019). It has been shown that musical intervention outcomes are enhanced by listening to one's favourite music (Perham). When an individual listens to their favorite music, it can activate the brain's reward centers, releasing dopamine, a neurotransmitter associated with pleasure and motivation. This can increase the individual's motivation to engage in the therapeutic intervention and enhance their enjoyment of the music. Additionally, listening to familiar music can provide a sense of comfort and security, which can reduce anxiety and promote relaxation (Table 3).

RESEARCH GAPS: While there has been considerable research on the use of music therapy for individuals with autism, there are still several research gaps that need to be addressed. Majority of music recommendation systems are based on the concept of genres, which can limit the diversity of music recommendations for users who do not necessarily fit into a specific genre. This can be especially problematic for listeners who enjoy a wide variety of music or those who do not identify with a specific genre. A genre-less music recommendation system would provide a more personalized and diverse selection of music, based on musical attributes, rather than relying solely on genre classification.

RELATED WORK

MUSIC PREFERENCES: Autistic individuals have diverse music preferences, and the type of music they listen to can vary widely. However, some research has suggested that autistic individuals may have specific music preferences based on the sensory processing differences commonly associated with autism.For example, a study published in the journal "Frontiers in Psychology" found that autistic individuals were more likely to prefer music that had a strong beat and predictable rhythms, and that they tended to prefer music with lower levels of musical complexity. This may be because music with a strong beat and predictable

Table 1.

Test song's (Sree Ganesh Dheemahi) audio features from Spotify WEB API.

Danceability	Loudness	Speechiness	Acousticness	Liveness	Instrumental	Valence	Energy
0.609	-15.423	0.0345	0.717	0.11	0	0.524	0.285

Table 2.

Subset of related songs based on MUSIC model framework.

Danceability	Loudness	Speechiness	Acousticness	Liveness	Instrumental	Valence	Energy
0.755	-1.461	0.0297	0.654	0.0984	0.00000157	0.807	0.719
0.693	-7.392	0.0704	0.343	0.0673	0.00125	0.706	0.797
0.795	-6.031	0.0441	0.281	0.047	0.00000109	0.606	0.755
0.902	-8.29	0.0383	0.0452	0.12	0.000129	0.808	0.772
0.761	-7.048	0.357	0.122	0.0717	0.000186	0.821	0.904

rhythms can provide a sense of structure and predictability that can be comforting for individuals with autism, while music with high levels of complexity may be overwhelming or difficult to process. Other research has suggested that autistic individuals may be more likely to have a preference for music that is repetitive or that uses simple melodies. This may be because repetition and predictability can help to reduce anxiety and promote relaxation for individuals with autism.It is important to note, however, that music preferences can vary widely among individuals with autism, and that there is no one-size-fits-all approach to selecting music for music therapy or other interventions (Table 4).

GENRE BASED MUSIC PREFERENCES: Research has suggested that individuals with autism may be more likely to prefer certain genres of music. For example, research (Bonnel et al,2010) has suggested that autistic individuals may be more likely to enjoy music with repetitive or predictable patterns, which can be comforting and provide a sense of structure. This may explain why some individuals with autism enjoy listening to certain types of electronic music, which often feature repetitive beats and patterns. Here are some examples of genre-based music preferences

- **POP MUSIC** - Pop music is a popular genre among many individuals, including those with autism. Pop music is often characterized by catchy melodies, upbeat rhythms, and lyrics that are easy to follow, making it accessible and enjoyable for many listeners.**WORLD MUSIC** - World music encompasses a wide variety of musical styles and traditions from around the world, including African, Asian, and Middle Eastern music. Many individuals with autism find world music to be intriguing and fascinating due to its unique rhythms, instruments, and vocal styles.
- **ELECTRONIC MUSIC** - Electronic music is a genre that has grown in popularity in recent years, and many individuals with autism find it to be engaging and stimulating. Electronic music often features complex rhythms and textures, and can be enjoyed for its futuristic and innovative qualities.
- **ROCK MUSIC**- Rock music is a genre that has a long history of popularity among many individuals, including those with autism. Rock music is often characterized by powerful guitar riffs, driving rhythms, and lyrics that speak to themes of rebellion and individuality.

MUSIC MODEL - 5 FACTOR MODEL OF MUSIC PREFERENCES: Individuals demonstrate manifestly different tastes when it comes to self-selected music. Adolescents report that they use music for a distraction from troubles, a means of mood management, for reducing loneliness. Although music has received relatively little attention in mainstream social and personality psychology, recent investigations have begun to examine individual differences in music preferences (Rentfrow , 2006). Based on the study .It is a model of musical preferences based on listeners' affective reactions to excerpts of music from a wide variety of musical genres. The findings from three independent studies converged to suggest that there exists a latent five-factor structure underlying music preferences that is genre-free, and reflects primarily emotional/affective responses to music. A Mellow factor comprising smooth and relaxing musical styles; an Urban factor defined largely by rhythmic and percussive music; a Sophisticated factor composed of a variety of music perceived as complex, intelligent, and inspiring; an Intense factor defined by loud, forceful, and energetic music; and a Campestral factor comprising a variety of different styles of country and singer-songwriter music. Each factor has a unique pattern of attributes that differentiates it from the other factors. For instance, Sophisticated music is perceived as thoughtful, complicated, clear sounding, quiet, relaxing and inspiring, whereas Mellow music is perceived as thoughtful, clear sounding, quiet, relaxing, slow, and not complicated. It also

Table 3.

Subset of top 5 similar songs based on Cosine Similarity and Emotion of the Song.

Song Name	Artist Name	Cosine Similarity	Song's Emotion
Kaadhal kaditham	Unni Menon	0.64	Happy
My Dil Goes Mmmm	Vishal-Shekhar	0.635	Happy
Edhirthu Nill	Yuvan Shankar	0.632	Happy
	Raja		
It's the Time to Disco	Shankar-Ehsaan-	0.623	Happy
	Loy		
Hey Vetri Velaa	Mani Sharma	0.617	Happy

Table 4.

Mean Raw Total Score on the SRS scale of participants.

Participants	Test	Mean Raw Total SRS score
	Pre-test	153.8
Group 1 (n=30)	Post-test	130.9
	Pre-test	160.8
Group 2 (n=20)	Post-test	144.9

emphasizes that music preferences are influenced by social factors like demographics, age, mood and auditory features of the music (Rentfrow,2011).

SHORT TEST OF MUSIC PREFERENCES (STOMP): STOMP is a 14-item scale assessing preferences in music genres. The STOMPR is a revised version of the scale assessing preferences for 23 genres based on the MUSIC model framework (Figure 1) represents the genres and its categorization according to the MUSIC model framework.

RECOMMENDATION SYSTEM: Recommendation systems are a special type of information filtering systems. They recommend items of interest to the users based on preferences they have expressed, either explicitly or implicitly. Recommendation systems help users overcome the information overload problem by exposing them to the most interesting items, and by offering novelty, insight, and relevance in a fraction of time and without the need to search the entire dataset. They are heavily used in many commercial applications such as Netflix, Youtube, and Amazon Prime. Recommendation systems resemble search engines, however the user is not searching explicitly for an item but the engine recommends items to the user based on his previous interactions with the system, which are used to model his preferences.

CONTENT BASED RECOMMENDATION SYSTEM: This approach utilizes the properties and the metadata of a particular item to suggest other items with similar characteristics. (Stefanos)The biggest advantage of content based recommendation system is since it relies on content of each item and user's rating it can make recommendations matching to the unique taste of the user. As a result, it offers a great level of personalization. A content-based system would just use the content of every item in order to make them, therefore being more efficient. This same principle also applies in the case of newly added items. For example, a recommender can analyze a song's artist or genre to recommend additional music with similar properties. It needs little information about the user's history to provide a good recommendation. Content based recommendation system works on cosine similarity model.

MUSIC AND EMOTION: Music has the ability to elicit strong emotional responses in many people, including those with autism. Research (Bharathi,, 2014) has shown that individuals with autism may have atypical emotional responses to music, as well as differences in the way they process and perceive musical stimuli. Some individuals with autism may have a heightened sensitivity to musical stimuli, which can lead to emotional overwhelm or discomfort. On the other hand, some individuals with autism may find music to be a source of comfort and emotional regulation (LaGasse, 2019), using music as a coping mechanism to reduce anxiety and stress.The emotional response to music in individuals with autism can vary depending on their individual preferences and experiences. For example, some individuals with autism may prefer slower, more calming music, while others may prefer faster, more energetic music. Music emotion recognition (MER) is the process of automatically identifying the emotional content of music, typically by analyzing its acoustic features such as tempo, rhythm, harmony, melody, and timbre. The goal of MER is to develop algorithms and models that can accurately predict the emotional content of a piece of music. MER can be used to better understand how individuals with autism perceive and respond to different types of music, and to develop personalized music interventions based on their emotional preferences and needs (Figure 2).

VALENCE-AROUSAL MODEL - TWO DIMENSIONAL MODEL OF EMOTION: Emotions are a dominant element in music, and they are the reason people listen to music so often.Music emotion recognition, taking into account the emotion model, can be divided into categorical or dimensional. In the categorical approach, a number of emotional categories (adjectives) are used for labeling music excerpts. In the dimensional model, emotional stimuli are usually classified by considering two main dimensions: Valence, which describes the attractiveness (positive valence) or aversiveness (negative valence) of stimuli along a continuum (negative – neutral – positive), and arousal, which refers to the perceived intensity of an event from very calming to highly exciting or agitating (Russell, 1980). The two dimensional emotion plane is divided into four quadrants with five emotions.

EXISTING MUSIC RECOMMENDATION SYSTEMS LITERATURE

MUSIC RECOMMENDATION SYSTEM BASED ON ARTIST SIMILARITY: A music recommendation system based on artist similarity suggests new music based on an individual's current music preferences and the similarities between artists. This type of system works by analyzing the characteristics of the music, such as genre, rhythm, melody, and harmony, and using this information to create

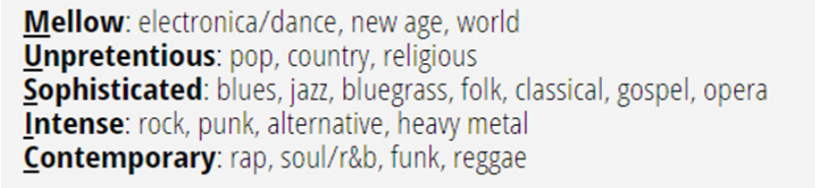

Figure 1. Rentfrow, Goldberg STOMPR based classification of genres in MUSIC model framework.

a profile of each artist. The system then compares the profile of the individual's preferred artist to the profiles of other artists in the database, looking for similarities in the music characteristics. Based on these similarities, the system suggests new artists that the individual may enjoy listening to.For example, if an individual likes the music of The Beatles, the system might recommend other classic rock bands like The Rolling Stones, The Who, or Led Zeppelin, based on their similar musical characteristics. These systems can help discover new music that matches their preferences and interests, and can also help music therapists to develop personalized music interventions based on an individual's preferred artists and genres (Vaiouli,2018).

MUSIC RECOMMENDATION SYSTEM BASED ON GENRE SIMILARITY: Music recommendation systems based on genre similarity have been widely studied and implemented in music streaming services such as Spotify and Pandora. They have proven to be effective in providing personalized music recommendations to users and enhancing their music listening experience. Below are a few examples of genres which are similar in nature.

- **ROCK AND METAL**: Both genres are characterized by heavy guitar riffs and drum beats, and often deal with similar themes of rebellion, anger, and frustration.
- **JAZZ AND BLUES**: Both genres are rooted in African American musical traditions and share similar harmonies and chord progressions. They also often feature improvisation and express emotions of sadness, longing, and melancholy.
- **ELECTRONIC AND DANCE**: Both genres prioritize beats and rhythms over melody, and are often associated with nightclubs and dance parties. They also both use synthesizers and other electronic instruments to create their unique sound.
- **COUNTRY AND FOLK**: Both genres are rooted in American folk music traditions and often feature acoustic instruments like guitar and banjo. They also often tell stories of love, heartbreak, and the struggles of rural life.
- **HIP-HOP AND RHYTHM AND BLUES**: Both genres originated in African American communities and often feature similar beats and rhythms. They also both prioritize lyrics and often deal with themes of love, relationships, and social justice issues.

The system uses a content-based filtering approach that analyzes the audio features of songs to identify similarities and dissimilarities between songs. The audio features include tempo, rhythm, melody, harmony, and other elements that define the structure and style of a song. It creates a user profile based on their listening history and preferences, and then compares this profile to the audio features of a large database of songs. The system recommends songs that are similar in genre and audio features to the user's listening history and preferences (Figure 3).

METHODOLOGY

PARTICIPANTS: Participants in each group were recruited via Reddit through r/aspergers and r/autism subreddits. Group 1 included 30 participants. Of the 30, 25 from United States of America, 2 from Finland and 3 from France. All were male. The group ranged from 16 to 22. Group 2 included 20 participants from India. All were male. The group ranged from 16 to 22.

MUSIC RECOMMENDATION SYSTEM BASED ON MUSIC MODEL FRAMEWORK

SYSTEM ARCHITECTURE: Considering the MUSIC model framework to combine multiple genres based on their musical attributes can potentially provide more accurate and diverse song recommendations for individuals with

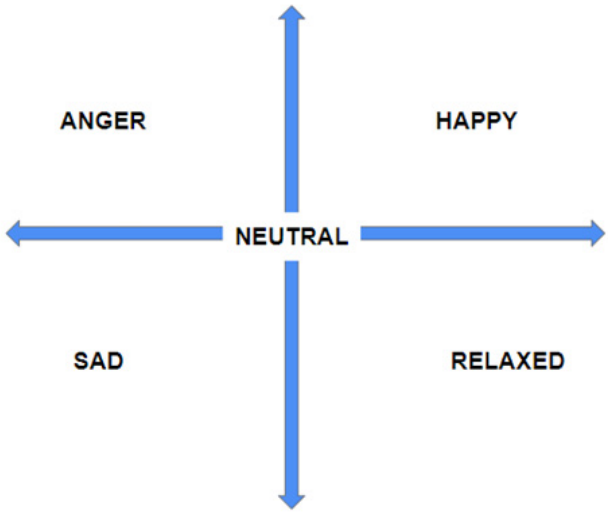

Figure 2. Valence-Arousal Model of Emotion.

autism. This approach takes into account not only the genre of the song, but also its specific musical attributes that are preferred by the listener, thus providing a more personalized recommendation. It also allows for the inclusion of a wider range of genres and styles, which can be helpful for individuals who may have eclectic music tastes or are open to exploring new genres. It can help improve the effectiveness and personalization of these systems presents a block diagram of our proposed solution to recommend songs based on combining multiple genre songs based on MUSIC model framework. Our approach comprises of the following steps:

- We collected music data from the cross cultural study participants from unstructured interviews and using Spotify Web API which lets user applications fetch data from the Spotify music catalog and manage users' playlists and saved music. Based on REST principles, the Web API endpoints return meta data in JSON format about artists, albums, and tracks along with its audio features directly from the Spotify catalog. The dataset consisted of 2000 records and 15 fields, which include categorical and numeric features. Each record in the music dataset represents a single musical piece, and each field in the record represents an audio feature.
- Data Preparation and Pre-processing is imrtnt t refine dt s tht it is suitble fr the mdels nd generte better results. In this hse we erfrmed tsks like lening, filling the missing dt, nd remving unwnted dt.The selected music genres are combined based on the Short Test on Music Preferences (STOMP) (STOMP).In the case of Indian Film Music and Devotional music, the related songs are selected based on its musical attributes.
- Feture seletin is ress f seleting neessry useful vribles in dtset t imrve the results f mhine lerning nd mke it mre urte,there re lt f lumns in the reditr vrible.Frm there, we get the t ftrs tht ffet erfrmne.The audio features fields are reduced to seven features such as acousticness, danceability, energy, instrumentalness, liveness, loudness, speechiness and valence.
- Sparse Matrices of the test song and the related songs are created and cosine similarity is calculated between these sparse matrices. The songs closest to 1 are the most similar and closest to 0 are least similar.Top ten songs are shown as recommended songs to the user.

EXPERIMENT: Based on the user's song selection, a list of top 10 songs are recommended. A video session was conducted with each participant and their expressions were captured using a camera. Ten images for each song on change of expression were taken which is given as input to an emotion reader application. It takes images as input and gives an output of the emotion which is categorized into five categories (Anger,Happiness, Neutral, Sadness and Relaxed) and the scores for each emotion detected in the image lies in the range 0 to 1. Each participant was also asked at the end of each song to point out the emotion they feel after listening to the song using emotion flash cards. This is used to verify the emotion captured as photos is same as the emotion card picked (Figure 4).

STATISTICAL ANALYSIS: The statistical analysis of a music recommendation system can include performance evaluation metrics such as precision, recall, and F1 score. These metrics can help to measure the effectiveness of the recommendation system in terms of how accurately it is able to predict users music preferences. Precision is the ratio of true positive recommendations to the total number of recommendations made by the system. It measures the proportion of relevant recommendations among the total number of recommendations. A high precision score indicates that the system is making a small number of irrelevant recommendations.Recall is the ratio of true positive recommendations to the total number of relevant items in the dataset. It measures the proportion of relevant items that were recommended by the system. A high recall score indicates that the system is able to recommend a large

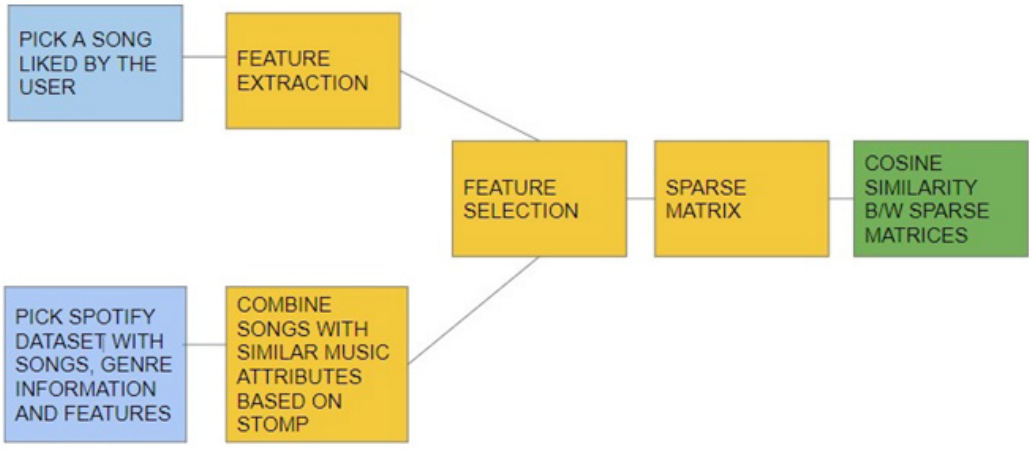

Figure 3. Proposed Recommendation System based on MUSIC model.

proportion of relevant items.F1 score is the harmonic mean of precision and recall, and is a measure of the balance between precision and recall. It provides a single score that combines both precision and recall, and is useful for comparing the performance of different recommendation systems. We evaluated the performance of our music recommendation system on a dataset of 2000 songs and compared it with the ground truth data. The system achieved a precision of 0.85, a recall of 0.78, and an F1 score of 0.81.

MUSIC AND ITS BEHAVIOURAL EFFECTS: Studies by has shown that music has the power to calm and to reduce anxiety levels. Listening to music decreases distractibility and increases the level of attention so that the individual can perform cognitive skills more easily and efficiently. The structure of music and the repetition of its words sets the stage for the capability of prediction of future activities. In the interviews, we asked our participants about behavioural effects that music they like brings in them. We asked for descriptions of these experiences, probed for their emotional reactions. In our analysis, we then mapped these responses to the music genres. Based on the interview data collected from both groups represents the distribution of music genres and its behavioural effects. Group 1 reported that rock and its sub genres has helped in decreasing their anxiety while western classical music has helped to focus. On the contrary Group 2 has reported that Indian classical music has helped in decreasing violent behaviour while instrumental music has helped in improving sleep patterns and social skills (Figure 5).

MEASURES: The Social Responsiveness Scale second edition (SRS-2)is a 65-item questionnaire, adult self reported form, assessing symptoms associated with ASD, with higher scores indicating more autistic symptoms. Higher scores represented more severe impairment There are five sub-scales such as social awareness, social cognition, social communication, social motivation and restrictive interests and repetitive behaviour.Respondents indicate their agreement with each item on a four-point likert scale. For analytic purposes, the scoring was recoded from 0 to 3 in order to compute the raw score. The sum of all items is calculated to provide a total score.In order to test our hypothesis, we designed a pre-test,and post-test for the participants who listened to their individual recommended music for 3 months. SRS scores were recorded before starting the intervention as the pre-test.The post-test social skills was measured based on SRS scores taken after the 3 months follow-up period to explore the effects of listening to recommended music based on individual's preferences shows the change in the raw score of each social attribute for the Indian participants before and after listening to the recommended music shows a significant decrease in the raw score for each social attribute, indicating an improvement in social skills. shows the change in the raw score of each social attribute for the Western participants before and after listening to the recommended music. Similarly, the shows a significant decrease in the raw score for each social attribute, indicating an improvement in social skills provides a summary of the mean difference in the SRS raw score before and after listening to the recommended music for both Indian and Western participants. The table shows a statistically significant decrease in the SRS raw score for both groups, indicating an improvement in social skills. Overall, provides a strong evidence for the effectiveness of the Music Recommendation System in improving social skills among individuals with ASD (Figure 6).

FUTURE SCOPE: One of the areas of improvement could be enhancing the personalization aspect of music recommendations. Deep learning models can be further trained on individual user listening data by extracting audio features like tempo, rhythm, melody and harmonic content to provide more personalized recommendations. This can involve the use of more advanced neural network architectures such as attention-based models or sequence modeling techniques.In an Indian population context, integrating raagas in music recommendation systems can potentially enhance the personalization and accuracy of

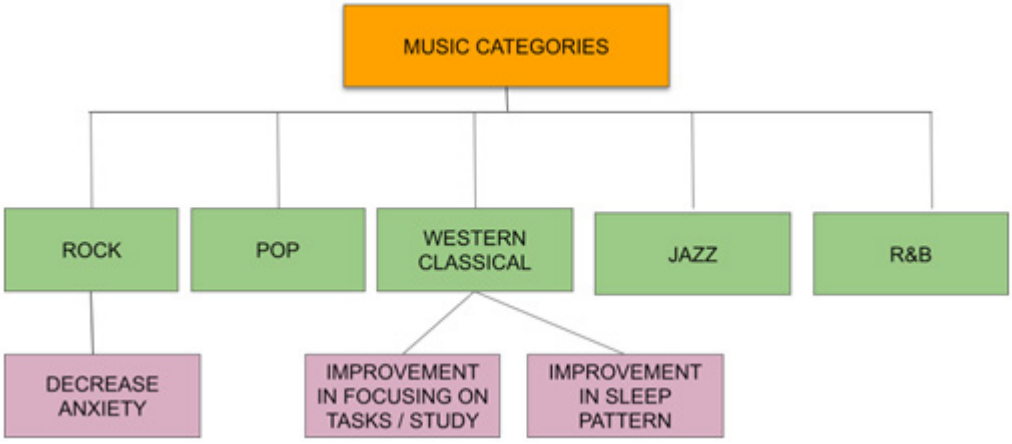

Figure 4. Music Categories and its Behavioural Effects - Group 1.

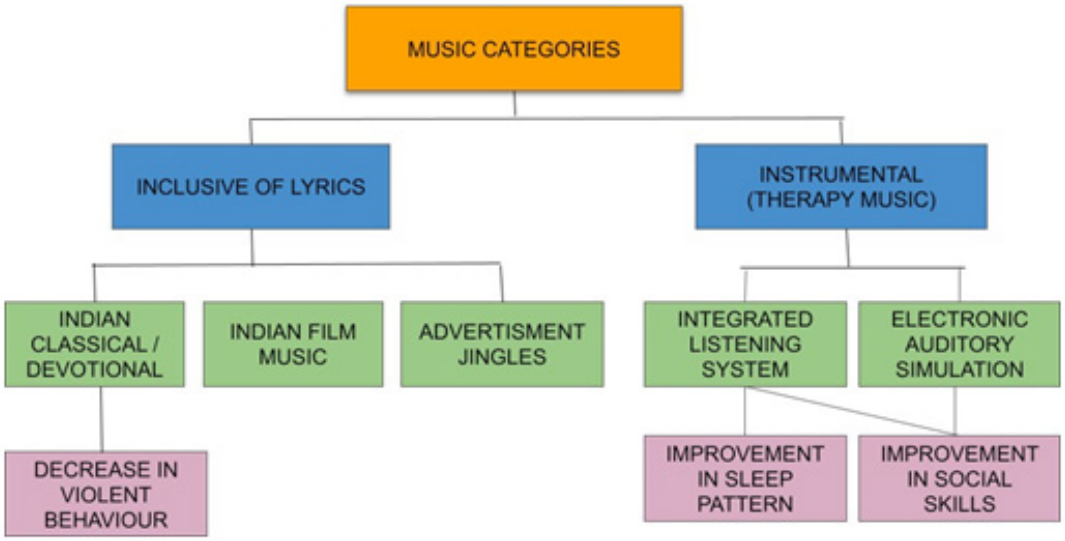

Figure 5. Music Categories and its Behavioural Effects - Group 2.

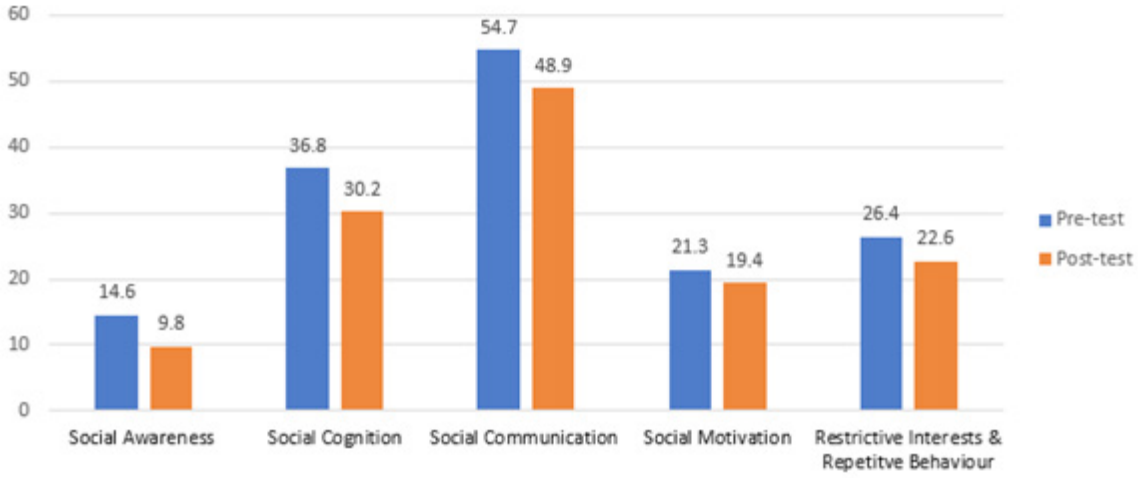

Figure 6. Mean SRS Raw Scores of Group 1 participants for each Social Attribute.

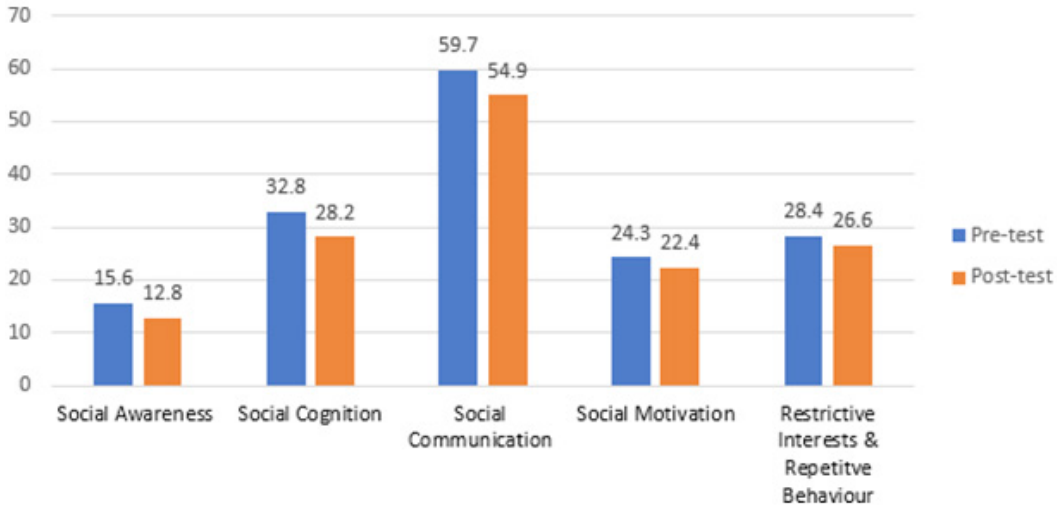

Figure 7. Mean SRS Raw Scores of Group 2 participants for each Social Attribute.

recommendations based on users' cultural preferences and emotional states. They are associated with specific emotions and moods, and their use in music therapy has shown positive effects on individuals with various psychological and neurological disorders.In a music recommendation system, raagas can be used as a feature to represent the emotional content of songs. This can be achieved by analyzing the raaga structure of songs and mapping them to the emotional states they are associated with. For example, a song that uses Raag Yaman may be associated with a romantic or soothing mood, while a song that uses Raag Bhairavi may be associated with a sad or contemplative mood. Another potential future direction for this type of recommendation system is the use of generative models, such as Generative Adversarial Networks (GANs), to generate new music that is similar in style to the user's preferred songs. This could be particularly useful for individuals with ASD who may have very specific preferences or difficulty finding new music that meets their sensory needs. Another potential direction is the integration of user feedback into the recommendation process, using reinforcement learning techniques to optimize the system's recommendations over time based on the user's responses.

DISCUSSION

The Music Recommendation System developed based on the MUSIC model framework, showed promising results in improving social skills among individuals with ASD. The system was designed to recommend music based on the individual's music preferences The study found that the recommended music led to a significant decrease in the raw scores for each social attribute under the SRS scale, indicating an improvement in social skills. This suggests that the Music Recommendation System could be a valuable tool for individuals with ASD to improve their social interactions. One of the strengths of this Music Recommendation System is its genre-less framework, which allows for a wider range of music options to be recommended, without being limited to specific genres. This is particularly useful for individuals with ASD, who may have a unique and varied range of music preferences. Another strength of the system is its adaptability to different cultural backgrounds, as evidenced by the cross-cultural study involving participants from India and the West. This highlights the potential of the system to be customized and tailored to suit the individual needs of different cultures and communities. However, there are limitations to the Music Recommendation System, as with any technology-based intervention. The system relies heavily on the accuracy of the music preference data gathered from the participants, which can be subjective and may vary over time. It was based on a relatively small sample of individuals and all the participants were male which may have led to a sampling bias. Although it provided valuable insights into the music preferences of individuals with ASD, the results cannot be generalized to the entire population of individuals as it may not be representative of the music preferences of females with ASD . To ensure the generalizability of the findings, future research should consider a larger sample size with equal number of male and female participants from different cultural and socio-economic backgrounds.

Overall, the Music Recommendation System has the potential to be a useful and effective tool for individuals with ASD to improve their social skills and interactions, and further research is needed to explore its full potential and limitations.

RESULTS

Here we detail the results of our investigation into people's experiences of music recommended by the system based on MUSIC model framework Table ?? lists the audio features of the test song "Sree Ganesh Dheemahi" obtained from the Spotify WEB API. Table 2 lists a subset of the audio features of the related songs to "Sree Ganesh Dheemahi" based on the MUSIC model framework. These features include rhythm, melody, harmony, timbre, dynamics, and lyrics. The MUSIC model framework is used to analyze the musical elements of a song and evaluate its emotional content. The related songs were obtained using the cosine similarity of the test song's audio features and the audio features of the songs in the dataset. The subset of related songs in the table represents the songs with the highest cosine similarity scores. Table 3 presented displays a list of similar songs based on the cosine similarity score and the emotion of the song. The cosine similarity score indicates the degree of similarity between the test song and the recommended song. The score ranges from 0 to 1, with a score closer to 1 indicating a higher degree of similarity between the two songs. The emotion of the song is determined based on the Valence-Arousal Model 2, which maps emotions onto a two-dimensional space of valence (pleasure-displeasure) and arousal (activation-deactivation). The valence value reflects the emotional polarity of the song, whether it is positive or negative, while the energy value reflects the energy level or intensity of the emotion conveyed by the song. Both the values lies in the range from 0 to 1. The study found that among all the participants, there was a cultural difference in music preference based on emotional valence. All 20 participants from Group 2 tended to prefer music that was high on positive emotion, while out of 30 participants from Group 1, 22 preferred music that was high on negative emotion. This suggests that culture can play a significant role in shaping individual preferences for music. This finding is consistent with previous research that has shown cultural differences in emotional expression, such as the tendency to suppress negative emotions in some cultures while expressing them in others (Figure 7).

REFRENCES

(APA), A. P. A. (2000). Diagnostic and statistical manual of mental disorders-text revision. *Amer Psych Ass.*

Bonnel, A., McAdams, S., Smith, B., Berthiaume, C., Bertone, A., et al. (2010). Enhanced pure-tone pitch discrimination among persons with autism but not Asperger syndrome. *Neuro Psychologia*.48 (9):2465-75.

Fahimeh, Imankhah, A. H., (2018). The effectiveness of combined music therapy and physical activity on motor coordination in children with autism.

Gebauer. (2014). Emotional and physiological responses to music exposure in individuals with and without specific musical anhedonia.

Bharathi, G., Venugopal, A., Vellingiri, B.(2019). Music therapy as a therapeutic tool in improving the social skills of autistic children. *Egypt J Neuro Psych Neuro Surg*.55:1-6.

LaGasse, AB., (2019). Effects of a music therapy group intervention on enhancing social skills in children with autism. *J Music Ther*. 51(3):250-75.

Nadig, A. (2013). Exploring the effects of indian classical music on cognitive and affective states of children with autism spectrum disorder.

PeretzIZatorreRJ. (2005). Brain organization for music processing.

Prat, C. (1950). Music as the language of emotion.

Rentfrow, PJ., Gosling, SD.,(2006).Message in a ballad: The role of music preferences in interpersonal perception. *Psychol Sci*.17(3):236-42.

Rentfrow, PJ., Goldberg, LR., Levitin, DJ.,(2011).The structure of musical preferences: a five-factor model. Journal of personality and social psychology.100(6):1139.

Russell. (1980). Journal of personality and social psychology.

Vaiouli, P., Andreou, G.,(2018). Communication and language development of young children with autism: A review of research in music. *Com Dis Quart*. 39(2):323-9.