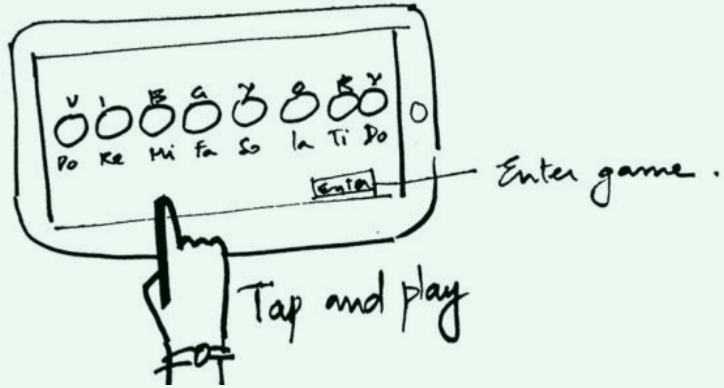
Musical Auditory Habilitation for Children with cochlear implants

M. Des . Project 3



RAMPRASAD S
126330011 . Interaction Design

Guide: Prof. Ravi Poovaiah

IDC 2014

Declaration

The research work embodied in the written submission titled "Musical Auditory Habilitation for Children with cochlear implants" has been carried out by the undersigned as part of the post graduate program in the Industrial Design Centre, IIT Bombay, India under the supervision of Prof. Ravi Poovaiah.

The undersigned hereby declares that this is his original work and has not been plagiarized in part or full from any source. Furthermore, this work has not been submitted for any degree in this or any other University.

I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action if need arises.

Ramprasad S
126330011

Approval Sheet

This interaction design project entitled "Musical Auditory Habilitation for Children with cochlear implants" by Ramprasad S, 126330011, is approved in partial fulfilment of the requirements for Master of Design Degree in Interaction Design.

Project Guide:

Chair Person:

Internal Examiner: R. Venkatesh

External Examiner:

Date: 29/05/2014
Place: Mumbai

Acknowledgement

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Special thanks to all those who took time out and participated in the interview and testing sessions. During my time in National University Singapore, interactions with Prof. Wang Ye, Dr. Graham Percival, Liangjun, Sam Fang, helped greatly in the design process.

I would like to thank my best friends Anusree and Glen for all the support and encouragement and also for all the honest reviews they have been giving about my designs since my under-graduation days. Last but not the least, I would like to thank my parents for all the love, support and freedom they have been giving me right from school days.

"....even had Newton or Leibniz never lived,
the world would have the calculus.
But if Beethoven had not lived,
we would never have had the C-minor Symphony"

– Albert Einstein

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Abstract

Cochlear ear implants have vastly improved the lives of deaf or severely hearing impaired people by allowing them to understand speech in a quiet environment. However, understanding speech in an environment with background noise (e.g., a hawker center, a shopping mall) is challenging and music perception is quite poor. In particular, people with cochlear implants have difficulty detecting pitch and timbre, which are crucial components in being able to understand music and speech with background noise (by separating the sound of one person's spoken voice away from the other noise).

This project presents a learning environment to support children with cochlear implants understand the fundamentals of music like pitch and timbre and also learn to sing the musical notes with the help of an interactive platform. More specifically, mobile games were designed to help children improve their pitch and timbre perception through a combination of listening and singing exercises.

Though the game is intended to serve users with hearing impairment, it can also benefit other users(like users with Amusia/tone-deafness) as it encourages them to practise with more constraints as one progresses.
In addition, the solution aims to be suitable for communicating the individual’s progress to speech therapists, teachers and parents by making it easier for them to participate in the whole process.

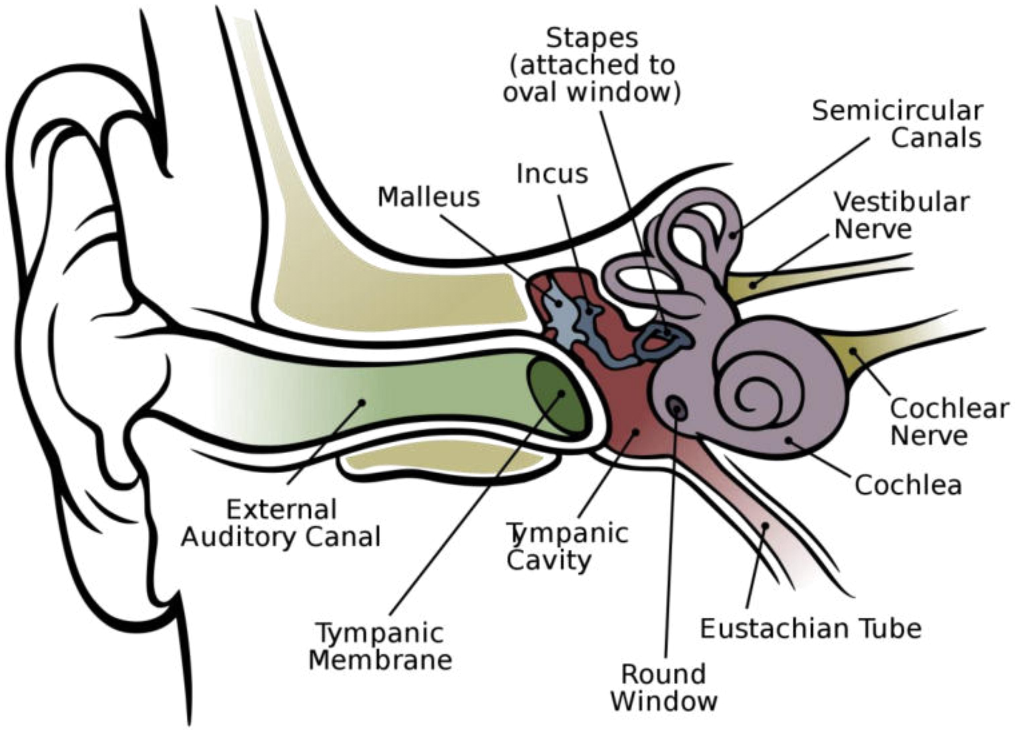
Need for this Project

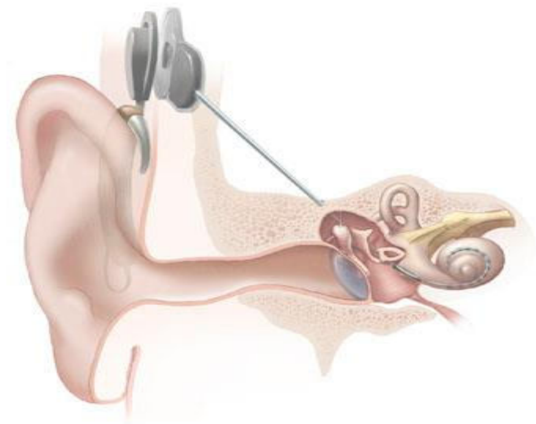
Music has become one of the fundamental components in our life. Whether musically trained or not, most people sing or hum to themselves during their day-to-day activities. Many of the world's legendary composers and musicians have been self-taught. However, for users with hearing impairment and cochlear implantation, formal training in music often helps to grasp better and perform progressively with the needed hard work and practice each individual may require.

Why music for hearing impaired?

Auditory habilitation is an important part of the implant process to boost recipients' adaption for the devices post cochlear implantation. Natural speaking involves variations in pitch, volume, modulation etc., and music habilitation helps them in understanding these concepts so that they might later be self-motivated to improve their listening and speaking skills.

Musical habilitation can enhance recipients' self-esteem and increase their motivation for practicing more.
The main obstructions for musical habilitation is lack of appropriate one-to-one teaching resources, time and money.





Source : http://en.wikipedia.org/wiki/Ear
http://en.wikipedia.org/wiki/Cochlear_implant

Human Ear and Hearing

Sound waves from the environment are funnelled by the outer ear(the ear lobe/pinna), are modulated by the middle ear, and are transmitted to a nerve in the inner ear, the vestibulo cochlear nerve. This nerve transmits information to the temporal lobe of the brain, where it is registered as sound.

Sound that travels through the outer ear impacts on the tympanic membrane(ear drum), and causes it to vibrate. These vibrations are then carried to the three ossicles(malleus, incus and stapes) and they transmit the vibrations to the inner ear which, via the cochlea, is sent to the brain to be processed as the sound as is.

Deafness

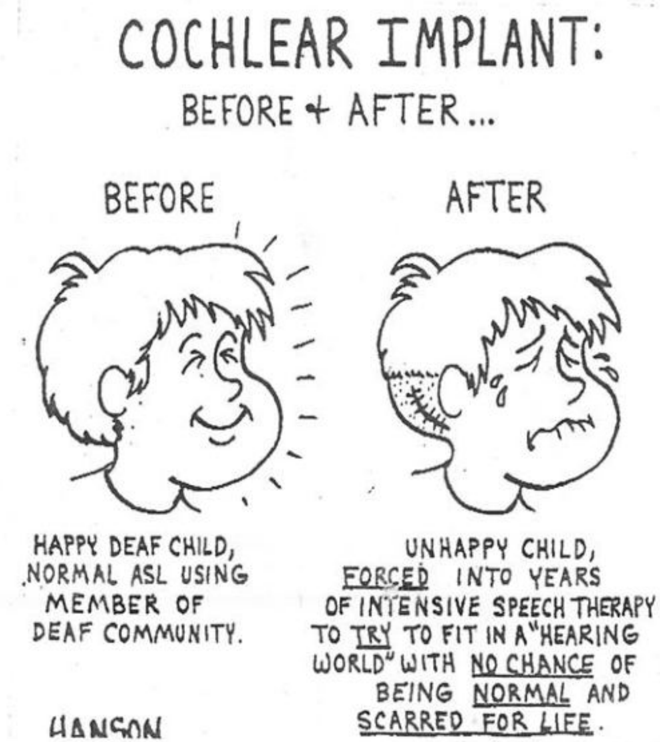
Deafness refers to a partial or total loss of the ability to hear. This may be a result of injury or damage, congenital disease, or physiological. When deafness is a result of injury or damage to the inner ear, vestibulochoclear nerve, or brain, it is known as sensorineural deafness. Cochlear implants serve patients with severe sensorineural deafness.

Why Cochlear implant?

A cochlear implant (CI) is a surgically implanted electronic device that provides a sense of sound to a person who is profoundly deaf or severely hard of hearing.

Cochlear implants may help provide hearing in patients who are deaf because of damage to sensory hair cells in their cochleas.

The implants often can enable sufficient hearing for better understanding of speech in such patients.
The quality of sound is different from natural hearing, with less sound information being received and processed by the brain. However many patients are able to hear and understand speech and environmental sounds. Patients cannot perceive music the way a healthy individual would. They have difficulties in detecting details in the sound if the environment is noisy.



Bruce Hanson/Silent News

A cartoon from Silent News, a newspaper for the deaf based in Rochester, showing one attitude towards the hearing world.

User Group

Cochlear implant users can be classified into 3 types[1].

- Persons with prelingual deafness
- Persons with post-lingual deafness
- Persons with congenital deafness

The first and third groups are mostly children who have not been exposed to music because of their disability to perceive the same. Also these groups struggle to learn speech and language more than post -lingually deafened persons.

Children with severe sensorineural deafness are recommended to get implanted with cochlear implants from 10 months age. Children who have implants before 4 years age have shown to exhibit improved development than children with implants after 5 years age.

Age Group

Around the age 2 to 3, children finish learning at least 50 words and start doubling words to form sentences. Hence age group between 3 to 12 is chosen to facilitate learning the fundamentals of music along with language.

Difficulties faced?

Children with cochlear implants have great difficulty perceiving music[2]. Poor music perception impacts

- Their ability to understand music, especially melody.

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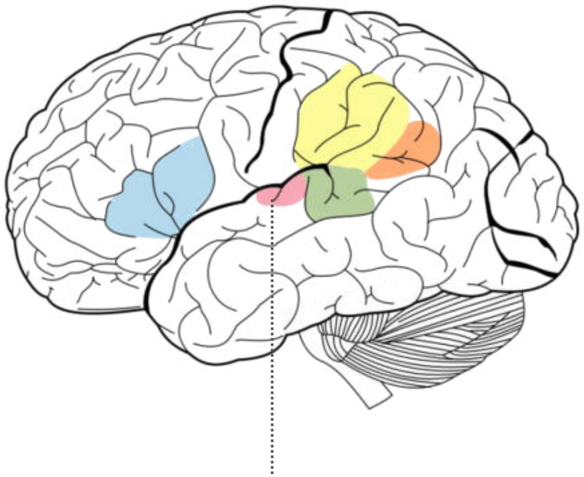
- Their ability to differentiate between two different voices, musical instruments.

- Their ability to use pitch to indicate emotion and intonation while speaking.



Primary Auditory Cortex

Permanent underdevelopment
of a human quality ?

Scope and Objective

Scope of the Project

The project tries to identify a way to make children with Cochlear implants understand the fundamental concepts in music and learn to listen and sing.
The solution should make it easier for children, parents, speech therapists and teachers by evaluating the children's performance and communicating them on how much they have progressed and also helping them in sharing the improvements gained, accomplishments, etc.,.

Objectives

The general objective of this project is to make users understand the basic concepts in music and learn to improve their listening and singing skills.

i. To design an interactive tool for learning the fundamentals in music.

ii. To design audio-visual, task based interactions that help in understanding concepts that are difficult to comprehend otherwise.

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Source : http://cosmic.nus.edu.sg/index.php/projects/mogat

Design Process followed

December

- Finalising of topic
- Defining the need of the problem
- Secondary Research

January

- User studies with hearing impaired Children
- Secondary Research
- Understand the current learning process
- Analysis

February

- Redefine the brief
- Initial Concepts
- Connecting the dots

March

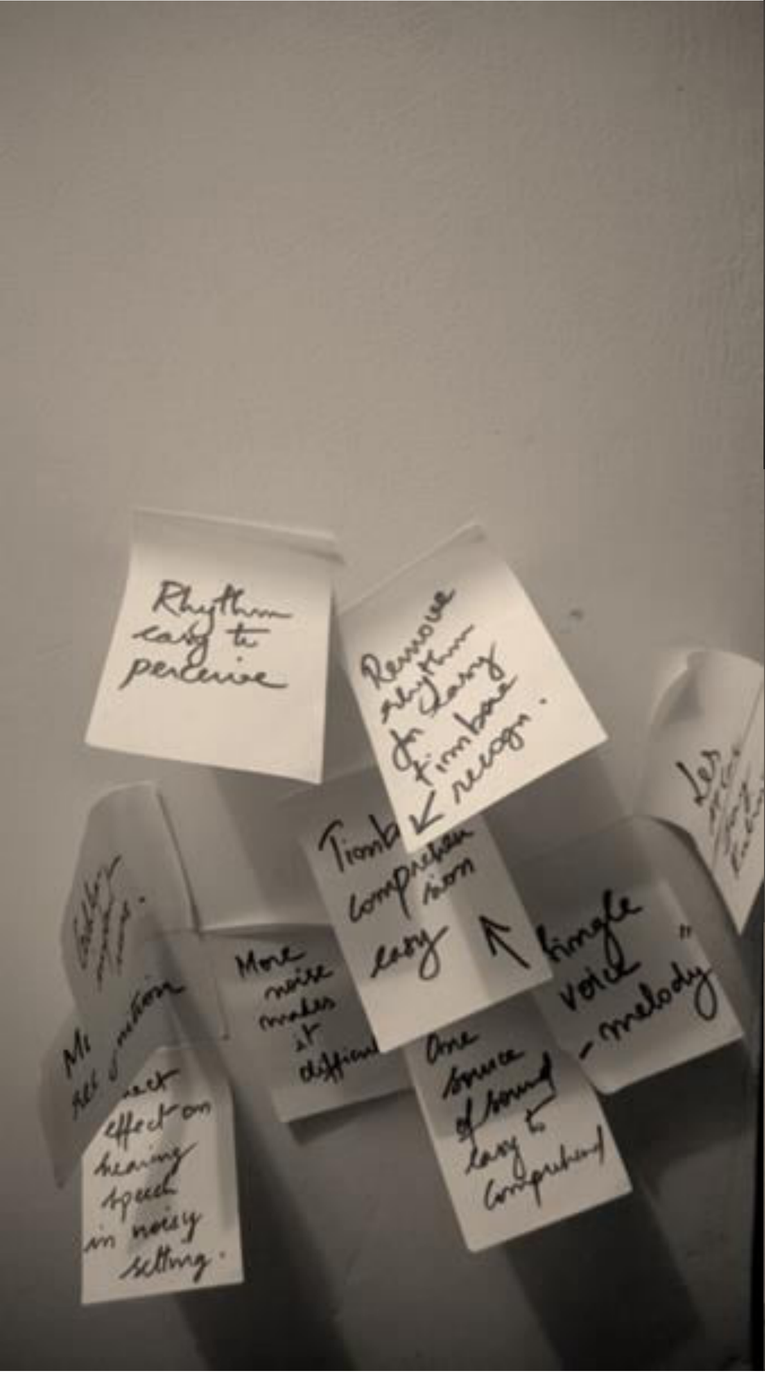
- Final Concept
- Design
- Iterations and Implementation

April

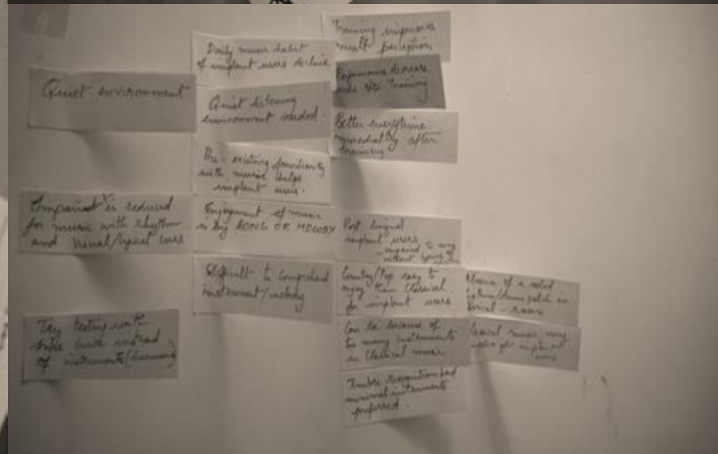
- Prototyping
- Usability tests and redesign

May

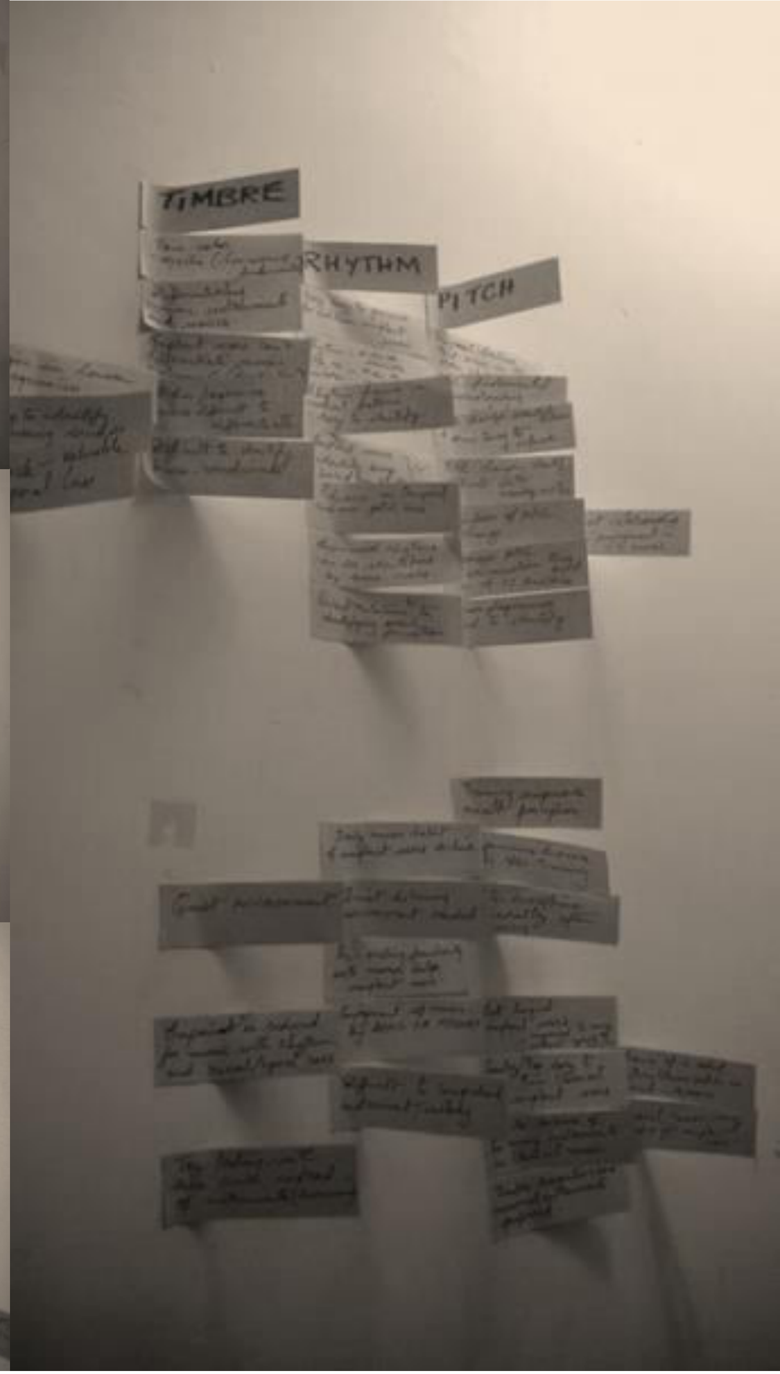
- Report Writing
- Explorations on timbre and Refinement


Rhythm easy to perceive
Remove rhythm for easy timbre recogn.
Single voice - melody
More noise makes it difficult
One source of sound easy to comprehend
effect on hearing speech in noisy setting.


MUSIC
PERCEPTIO
TIMBRE
PITCH
LYRICS


Quiet environment


TIMBRE
RHYTHM
PITCH


TIMBRE
RHYTHM
PITCH

Secondary Research

Perceiving Music with Implants

The way children with implants perceive music is very different from normal. Each of them is found to be having varying levels of perception for each of the following fundamentals in music.

- Rhythm
- Pitch
- Timbre

Research insights from studies, papers, articles and the internet were compiled and grouped to analyze and set design guidelines.

Definitions

Rhythm

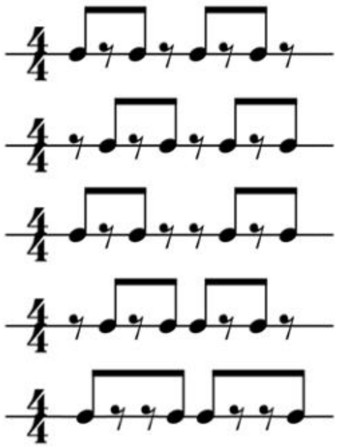
Rhythm generally describes the temporal features of music that typically occur on the order of seconds (as opposed to the fine scale temporal features that occur on the order of milliseconds that are crucial in the perception of pitch and timbre).

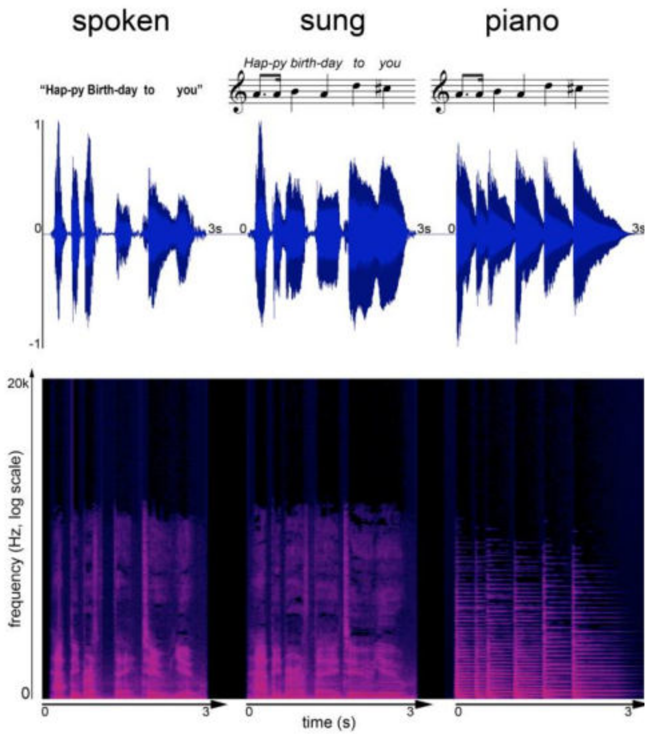
Pitch

Pitch describes the absolute frequency of a musical note framed within the context of a musical scale. Pitch processing is fundamental to the perception, identification, and enjoyment of music.

Timbre

Timbre, or tone-color is derived from the acoustic properties of spectra (the ratios of the harmonics to the fundamental frequency) and timing (envelope) of each harmonic constituent. The psychoacoustic property of timbre permits us to differentiate between two musical instruments playing at the same pitch and volume level.





Source :H. J. McDermott. Music perception with cochlear implants:
[Galvin JJ, Fu QJ, Nogaki G. Melodic contour identification by cochlear implant listeners.Ear and Hearing 2007; 28: 302–319.

Secondary Research

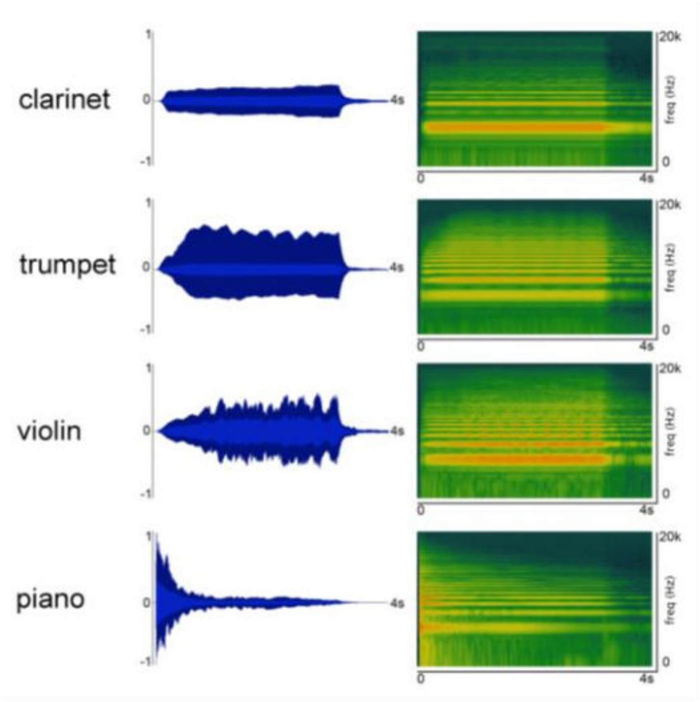
Perceiving Rhythm

- Rhythm is easier to perceive for Users(than the other two parameters).
- Song identification is therefore done based on rhythm identification.
- Reliance on temporal cues better with cochlear implants than pitch cues.
- Improvised rhythm patterns easy to differentiate.
- Direct relation to speech perception (rhythm of words pronounced).

Insights

- Rhythmic patterns can often frame a musical passage yielding basic perception in spite of poor or erroneous perception of pitch, timbre, or other music aspects.

- To make Users understand the other aspects of music, it is important for us to remove rhythmic qualities in the music sample given for testing.



Source :H. J. McDermott. Music perception with cochlear implants:
[Galvin JJ, Fu QJ, Nogaki G. Melodic contour identification by cochlear implant listeners.Ear and Hearing 2007; 28: 302-319.

Secondary Research

Perceiving Timbre

- Difficult to identify voice/music instrument in noisy setting.
- Single melody sans the rhythm is easier for identifying timbre.
- In some users, differentiating instruments from different families also is difficult*.
- High-pitched notes – Difficult to identify timbre*.
- Easier to identify percussive instruments like the piano/xylophone than violin*.

Insights

- Two or more melodic instruments at a time make timbre perception cumbersome.

- Silence and single sound source, the best to train in the beginning.

- To make beginner Users understand pitch , it is important for us to remove timbre qualities in the music sample(raw frequency sans harmonics) given for testing.

- The raw frequency given can preferably be percussive(like piano sound).

Source : H. J. McDermott. Music perception with cochlear implants:
[Galvin JJ, Fu QJ, Nogaki G. Melodic contour identification by cochlear implant listeners.Ear and Hearing 2007; 28: 302-319.

Secondary Research

Perceiving Pitch

A musical phrase, or melody, is created when a series of pitches are sequentially and temporally organized into patterns of varying musical contour and interval.
The perception of melody requires the fine discrimination of changes in pitch, including both the direction of change (up or down) and the degree of change (interval size).

Pitch with respect to users with cochlear implants:

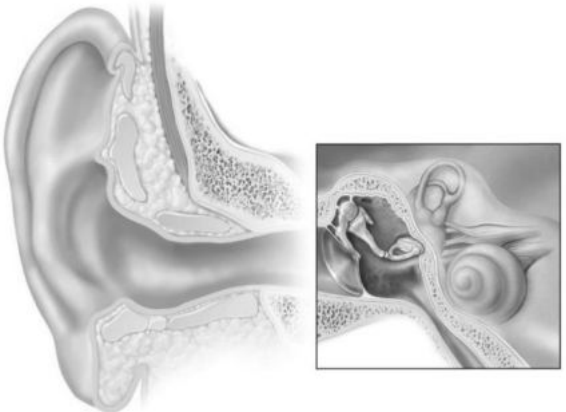
- Difficult to identify Pitch in noisy setting.
- Range identifiable in most of the users (not less than 4 semitones).
- In severe cases, the next octave pitch is also not identifiable.
- Difficult to identify direction of pitch change and contour.
- Low-pitched Notes are difficult to identify.
- Melody enjoyment not possible because of bad pitch perception.

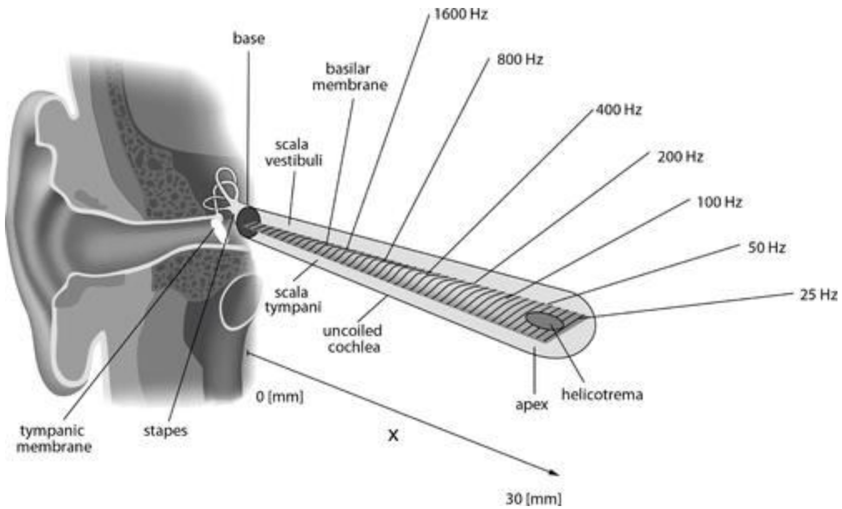
Insights

- By designing a level-based approach in pitch perception training, one can slowly reduce the semitone-differentiation-range from over an octave to just one semitone.

- The low pitched notes can be taught much later in increasing order of diffculty.

- While designing for pitch perception: rhythm, timbre and more than one instrument/music source can be avoided.





Source: http://upload.wikimedia.org/wikipedia/commons/thumb/6/65/Uncoiled_cochlea_with_basilar_membrane.png/500px-Uncoiled_cochlea_with_basilar_membrane.png

Secondary Research

General Insights

- Children with Cochlear implants often prefer silent environments and listen to one sound source at a time.
- Music Perception impairment is reduced for music with rhythm and visual/lyrical cues.
- Post-lingually deafened children exhibit better music perception as they were familiar to music prior to deafening.
- Providing continuous training to children with implants has found to give profound improvement in their music perception.
- Enjoyment of music is because of the rhythmic lyrics in a song and they don't prefer instrumental or melody.
- Children find Country and Pop music easier to enjoy than Classical Compositions that sound "complex" to them.

Primary Research

User studies

For user research, shadowing and observation I visited Shri Patcheappane School For The Hearing Impaired, Thengaithittu , near Pondicherry.

To collect data about how sound/music is perceived and understood by hearing impaired users, shadowing and observations were done on both cochlear implant users and non-cochlear implant users.

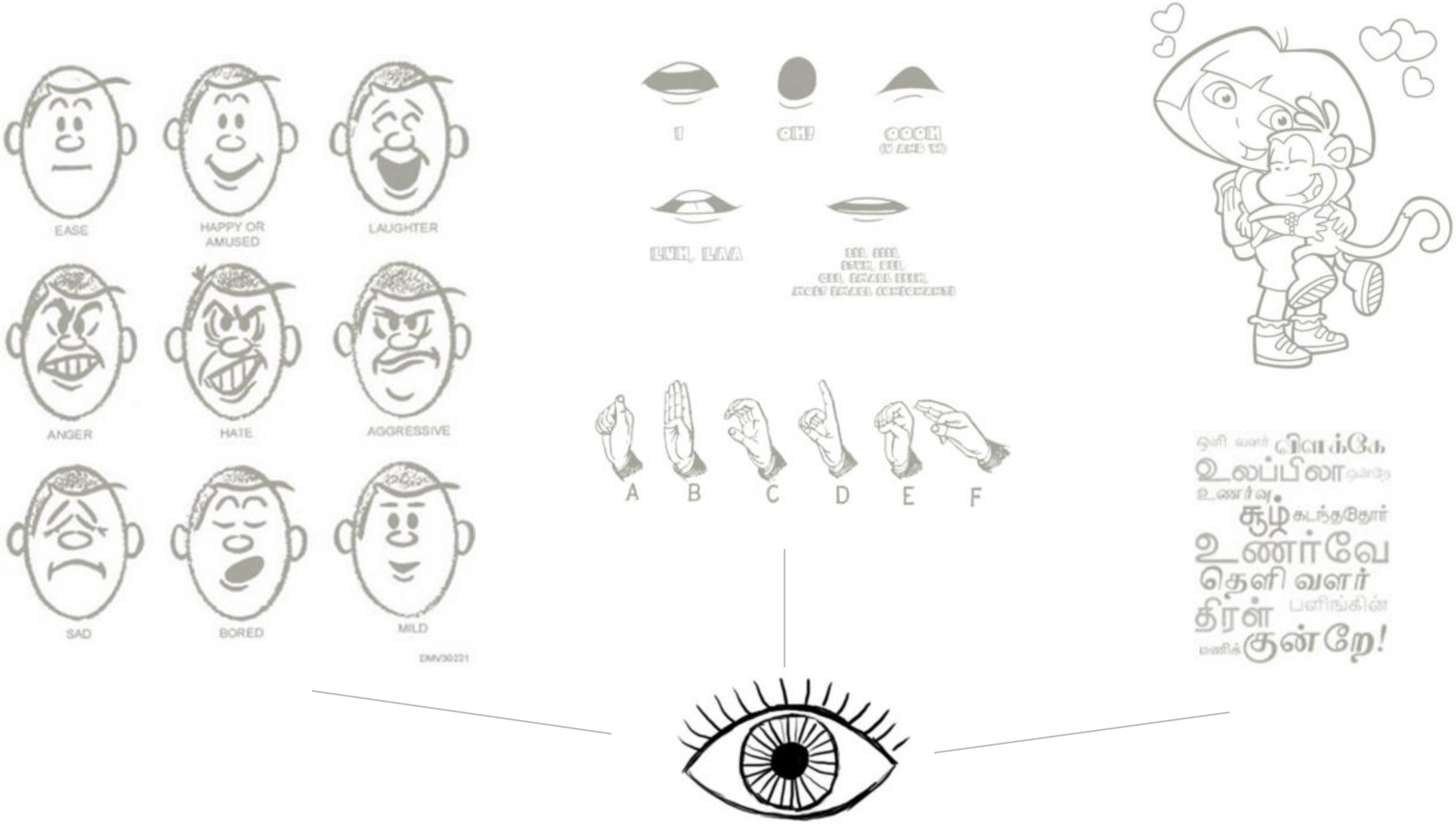
The school focuses on the training of the residual hearing of each student by administering an aural-oral program. The school had students from the age of 2.5 years to 15 (X Std). Special language and speech training is given for Children in pre-primary level (2.5 to 5.5 years age) after which students are recommended Tamil Nadu State Board Syllabus.

Shadowing

Shadowing is a technique wherein the user is shadowed throughout the course of the activity[7]. The observer and the observant may or may not converse with each other. This method helps in uncovering detailed insights into a specific task, activity which in this context is about perceiving sound. This involved observing the children of the school during their classes as well as in outdoor environmet – playground, lunch time.

Effect of training

- Training helps greatly in sharpening the residual hearing. Continuous training brings remarkable improvement.
- Training required for each individual will vary depending on the degrees of hearing impairment.



Feeling Sound : Visual + Residual Hearing

Primary Research

Feeling sound

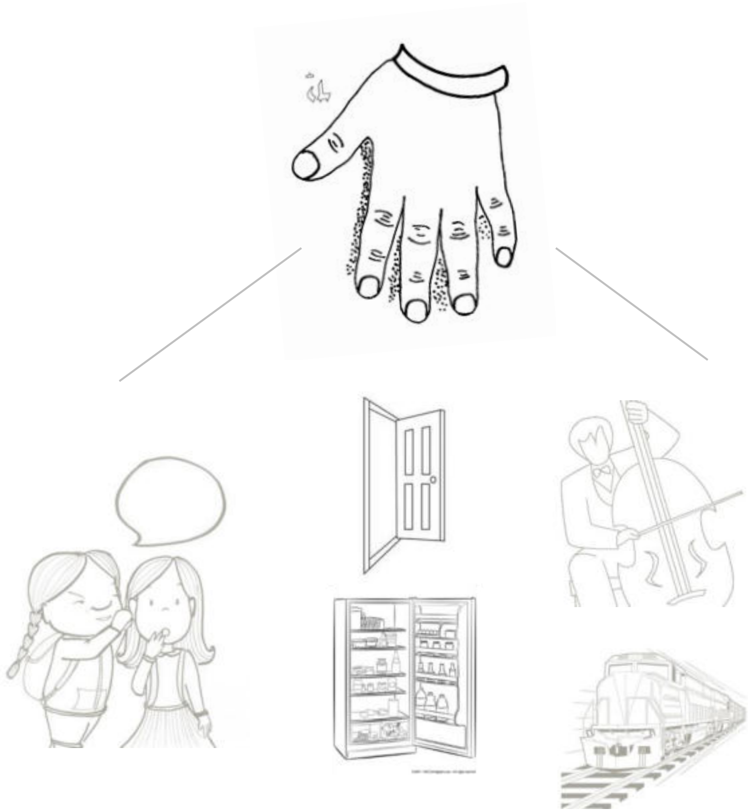
Along with residual hearing, hearing impaired children used visual cues, tactile means and rhythm based cues to feel sound.

Visual + Residual Hearing

- Gestures- body gestures and facial expressions
- Sign Language
- Lip reading
- Images
- Videos

Tactile + Residual Hearing

- Approaching Train, bus, other vehicles
- Whispering close to ears
- Environment sounds, doors, thunder etc.
- Acoustic Music Instruments



Feeling Sound : Tactile + Residual Hearing

The project

Known Assumptions

The system assumes that establishing the back end operations like the following will be possible.

1. Live Detection of the musical note the voice produces and visually representing it on a live display.

2. Programming the interactions so that they react based on voice, touch and gestures.

Project Design Brief

Objective

Designing Interactive means to allow children, with cochlear implants, learn and practice pitch perception and production, timbre perception and melody perception and production.

- Listening to pitch and Timbre and finer differences within them.
- Learning to sing single note as well as a whole melody[5].

Scope

The solution should make it easier for pre-lingually deafened children with cochlear Implants to learn and practise perceiving, understanding and producing pitch, timbre and melody by evaluating their performance and communicating them their progress[9].

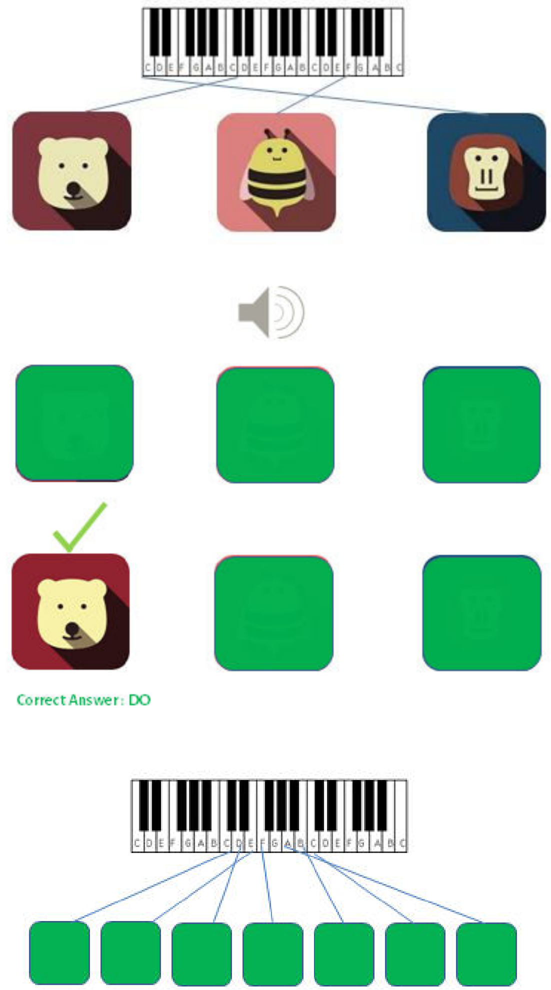
SWARA	SANSKRIT EXPANSION	MEANING	ANIMAL	CHAKRA	GOD
SA	SHADJA (षड्ज)	SIX-BORN	PEACOCK	*MŪLĀDHĀRA* मूलाधार (BASE OF SPINE)	GANAPATI
RE	RISHABHA (ऋषभ)	BULL	SKYLARK	*SVĀDHIṢṬHĀNA* स्वाधिष्ठान (GENITALS)	AGNI
GA	GANDHARA (गान्धार)	SKY	GOAT	*MAṆIPŪRA* मणिपूर (SOLAR PLEXUS AND NAVEL)	RUDRA (SHIVA)
MA	MADHYAMA (मध्यम)	MIDDLE	DOVE/HERON	*ANĀHATA* अनाहत (HEART)	VISHNU
PA	PANCHAMA (पञ्चम)	FIFTH	CUCKOO/NIGHTINGALE	*VIŚUDDHA* विशुद्ध (THROAT)	NAARADA
DHA	DHAIVATA (धैवत)	EARTH	HORSE	*ĀJÑĀ* आज्ञा (THIRD EYE)	SADASIVA
NI	NISHADAM (निषाद)	HUNTER	ELEPHANT	*SAHASRĀRA* सहस्रार (CROWN OF THE HEAD)	SURYA(SUN)

Source : http://en.wikipedia.org/wiki/Swara

Initial Concepts

Concept 1: Visualizing music notes

The idea is to map images of animals to pitch values/music notes. The idea inspired from studies during primary research with Indian musicians. Musical notes = (i.e., Sa, Re/Ri, Ga, Ma, Pa, Dha/Da, and Ni) are traditionally believed to have originated from the sound of different animals and some have additional meanings of their own. This can help children identify music notes by visualising them easily in the early stages. As they progress the semitone difference is gradually decreased so that the users learn to differentiate between finer variations in pitch.



Why it wont work?

- The mapping of pitches to animals might make children misunderstand the relationship between the way animals make sound and pitches of the musical notes.

- Also, there are mobile applications that already exist teaching them to pronounce sounds of diifferent animals like “bow bow” for a dog and “meow” for a cat.(OUTLOUD 6 – Sounds Test for Windows)[10].

Initial Concepts

Concept 2: Mapping Vibrations

The idea was to make use of tactile Sound – vibrations from the device – tablet/phone (like the bowing of a cello), and encourage participatory listening cum pitch production by touching. This idea will combine touch and vision in addition to the user's residual hearing for pitch perception.

Why it wont work?

The vibration frequency range* in today's phone/tablet doesn't allow the difference between semitones to be clearly communicated to the user by vibrating appropriately (vibration range of phones~150 Hz)[6].

Source : http://en.wikipedia.org/singing,
Screenshots from the iStore Music app - BEBOT

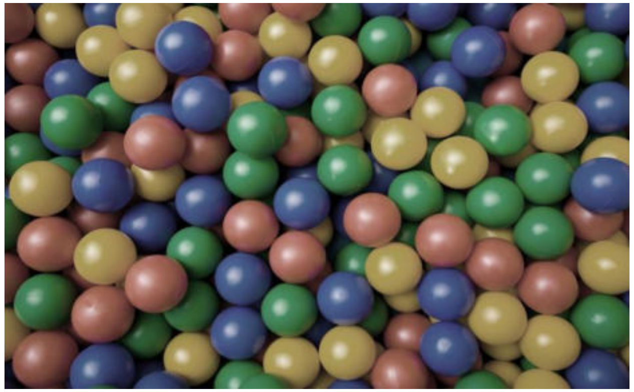
Initial Concepts

Concept 3: Facial Expressions

The idea was to map pitches to facial gestures like the bebot app in iphone that helps children to understand not only pitch in music but also its role in speech modulation and intonation and people's facial gestures while producing it. This idea combines visual cues along with residual hearing. This might contribute a lot to their expressive speech ability as well.

Why it wont work?

Following a cartoon character for learning/imitating movements, gestures and lip movements is not better than imitating a human, because the details in gestures that a real human would do, are lost in the cartoon which is often made very abstract and minimal.
Since this is the only a trivial disadvantage, this idea was later incorporated with the final concept.



Source : Screenshots from TED talk video by Neil Harbisson

Connecting the Dots

Game-Based learning

The idea was to connect many of the ideas into one platform and to gamify the musical auditory habilitation programme.

The main reason for gamifying the design solution was to ensure the following

- Increase the User's engagement level ,
- Give him/her a sense of progression
- Make the whole process more social by sharing
- Encourage cultivation of a habit and self-motivation

Concept Inspiration

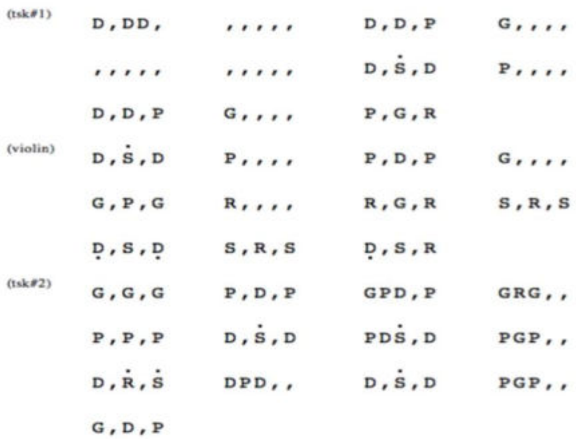
Colour and Music Notes

There have been many Hypotheses from scientists like Newton and Pythagoras about the relationship between colours and individual music notes in an octave.
If we take note A = 440 Hz and keep doubling until you get into the range of light we will find ROYGBIV = F, G, A, Bb, B, C, D, E, F.

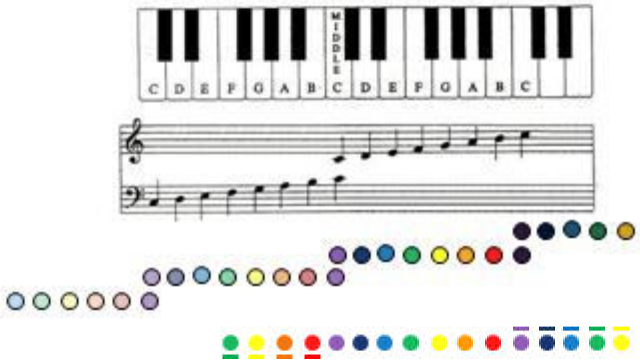
Neil Harbisson

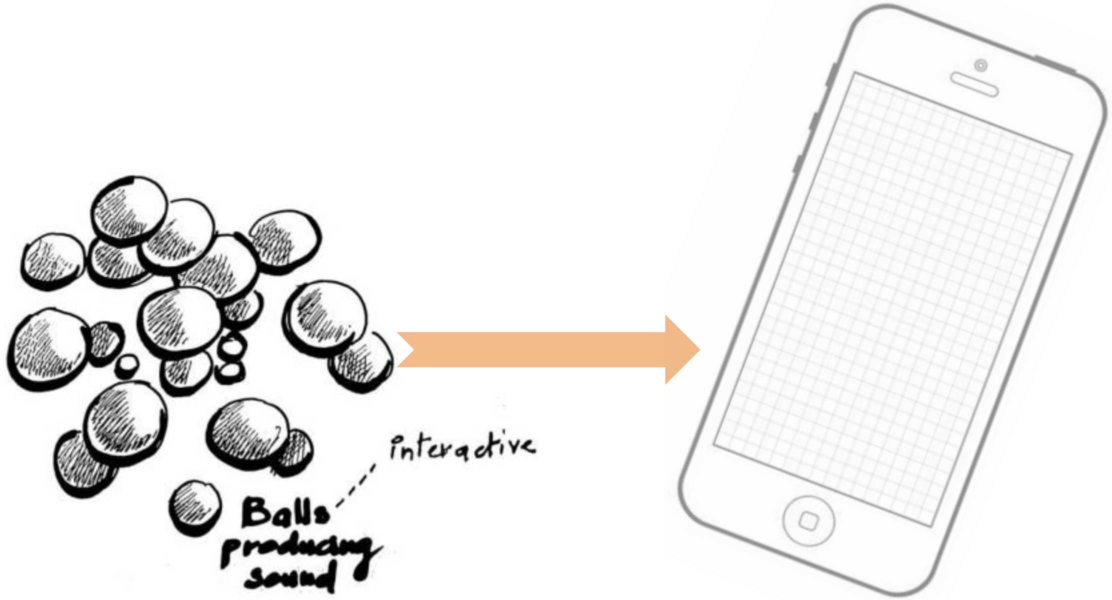
Neil Harbisson is a contemporary artist, musician, and cyborg activist best known for his self-extended ability to hear colours and to perceive colours outside the ability of human vision. He uses the musical note his device produces when exposed to a colour, to recognize that particular colour.

These ideas contributed greatly to the evolution of the final concept.


(tsk#1) D,DD, ,,,,, D,D,P G,,,,
,,,,, ,,,,, D,Ṡ,D P,,,,
D,D,P G,,,, P,G,R
(violin) D,Ṡ,D P,,,, P,D,P G,,,,
G,P,G R,,,, R,G,R S,R,S
D,S,D S,R,S D,S,R
(tsk#2) G,G,G P,D,P GPD,P GRG,,
P,P,P D,Ṡ,D PDṠ,D PGP,,
D,Ṙ,Ṡ DPD,, D,Ṡ,D PGP,,
G,D,P


1 = C 2/4
· 15 ·


C D E F G A B C D E F G A B C
MIDDLE


interactive
Balls producing sound

96

Final Concept

Mapping Colours to Notes

For convenience Sake, the mapping is done from violet to red (the same order as in a Rainbow), along the ascending music scale in an octave. By this way, the seven notes in an octave(major scale) shall correspond to the seven colours in the rainbow thereby facilitating easy learning and remembrance.

Musical Spheres

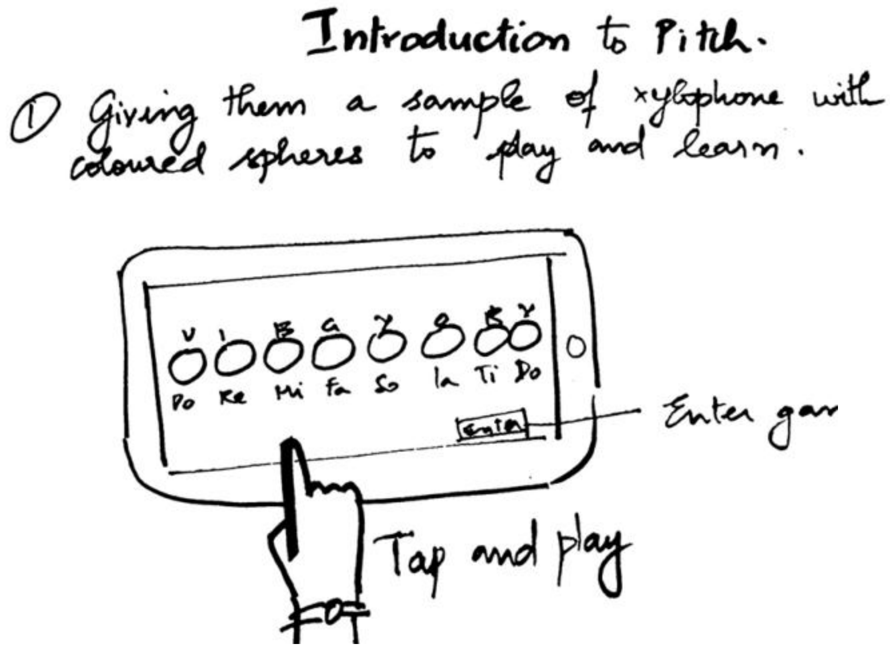
The tonic in the diagram shown below is taken as C, where the colours from Violet to Red are assigned along the scale. The idea was to have coloured balls to represent corresponding notes.
Initially, luminance(brightness) of the colours was assumed to display the octave, the ball belongs to.
The octave values were later denoted by bars above and below the balls(inspired from Chinese and Indian music notation system) to avoid confusion.

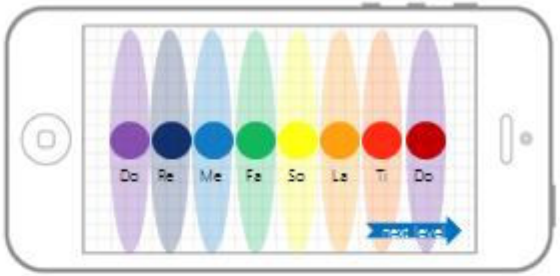
Fitting it all in a display

Mobile game?

The idea was to have a solution that is cost-effective and portable so that it can be used anywhere, anytime by the users.

The solution should ideally be a cross-over of the different ideas discussed prior. It should be a holistic, all-in-one solution to all the problems in one platform addressing them one by one in increasing order of difficulty.


Introduction to Pitch.
① Giving them a sample of xylophone with coloured spheres to play and learn.
Do Re Mi Fa So la Ti Do
Enter gam
Tap and play


Do Re Me Fa So La Ti Do
next level


Do Re Me Fa So La Ti Do
next level

Final Concept

Overall Scheme

The following is the order of objectives, which the user has to ideally go through in the game levels.

- Pitch Perception,
- Timbre perception
- Single Pitch production and
- Melody production with lyrics.

In simple terms, the user kid has to

1. learn to listen to the differences in pitches and the differences in timbre.

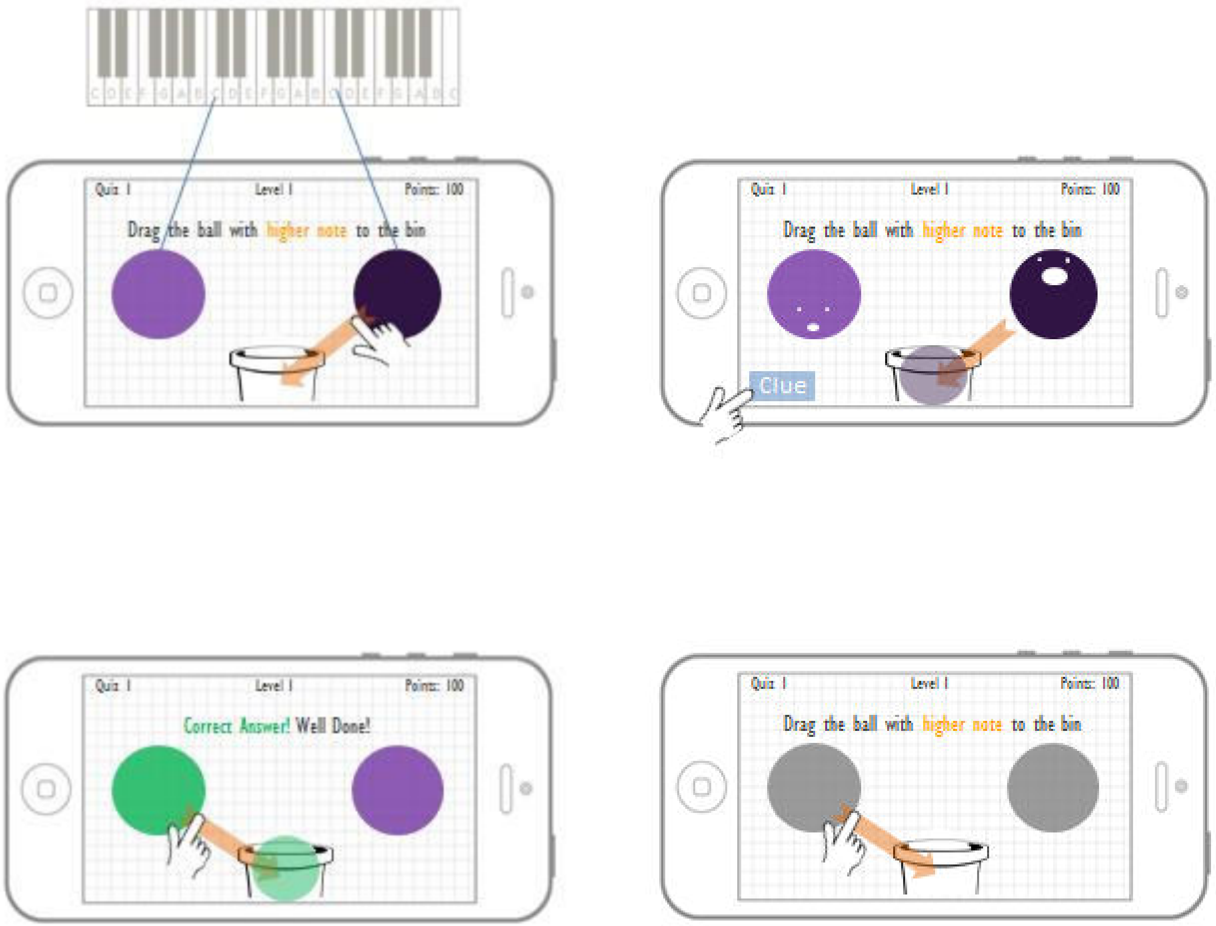
2. learn to sing in one particular pitch and then sing a melody.

Pre-Pitch perception - Level 0

Prior to learning Pitch Perception, the user has to get a hold of colours being mapped to every musical note. As an introduction, the user is given a xylophone interface with colourful spheres which sound when the display is touched.

The mapping of notes will be from violet to red with the 7 coloured spheres forming the notes of the major scale.

During the first time play, the user cannot go to the next step unless the user spends at least 30 seconds playing the xylophone to get an idea of the various pitches.


Quiz 1
Level 1
Points: 100
Drag the ball with higher note to the bin
Quiz 1
Level 1
Points: 100
Drag the ball with higher note to the bin
Clue
Quiz 1
Level 1
Points: 100
Correct Answer! Well Done!
Quiz 1
Level 1
Points: 100
Drag the ball with higher note to the bin

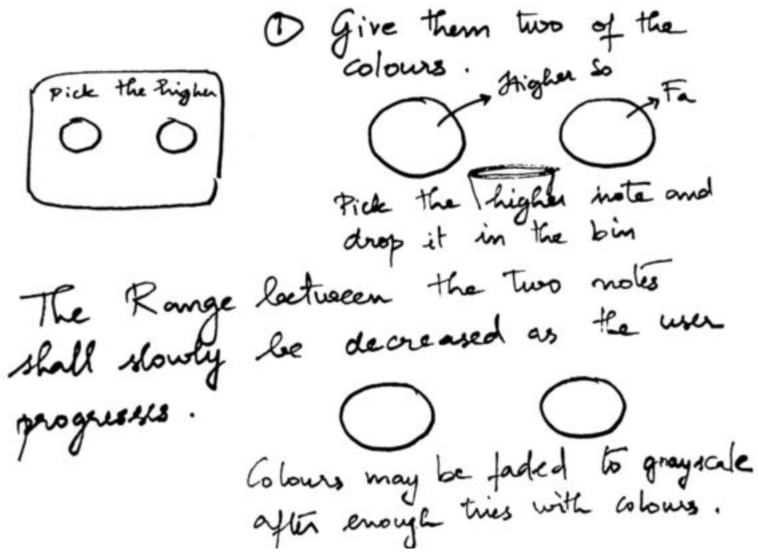
Final Concept

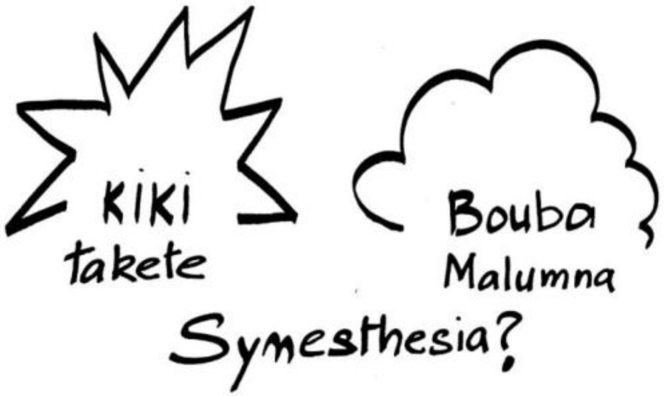
Pitch Perception - Level 1

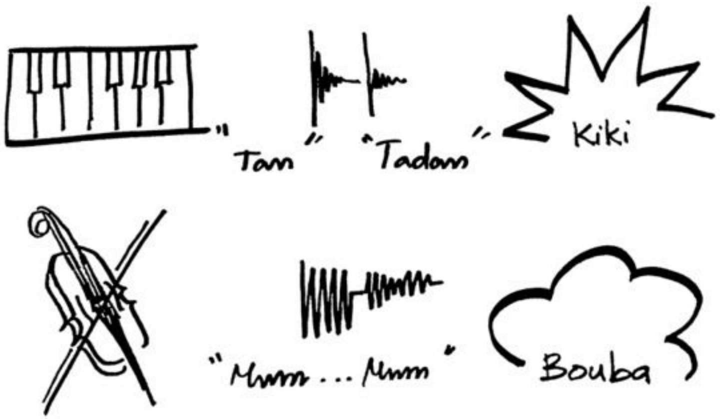
For Pitch Perception, the user is given two of the musical coloured spheres and asked to choose the one with the higher note.

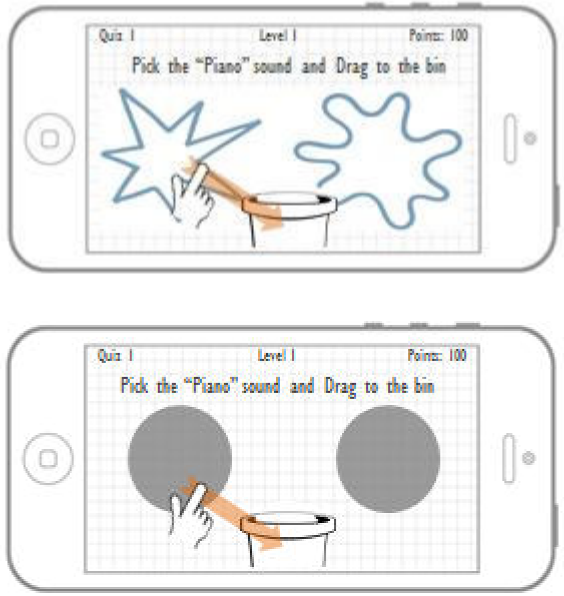
The difference in semitone range is first given as really high for easy differentiation between high and low pitches and then gradually decreased in subsequent try's so that the user identifies finer differences in pitches.

As the user slowly starts finding the pitches the colours are made grey so that the user doesn't depend on the colours to identify and starts listening to the pitch keenly.




KIKI
takete
Bouba
Malumna
Synesthesia?


"Tam"
"Tadam"
Kiki
"Mmm... Mmm"
Bouba


Quiz 1
Level 1
Points: 100
Pick the "Piano" sound and Drag to the bin
Quiz 1
Level 1
Points: 100
Pick the "Piano" sound and Drag to the bin

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Final Concept

KIKI – BOUBA Design

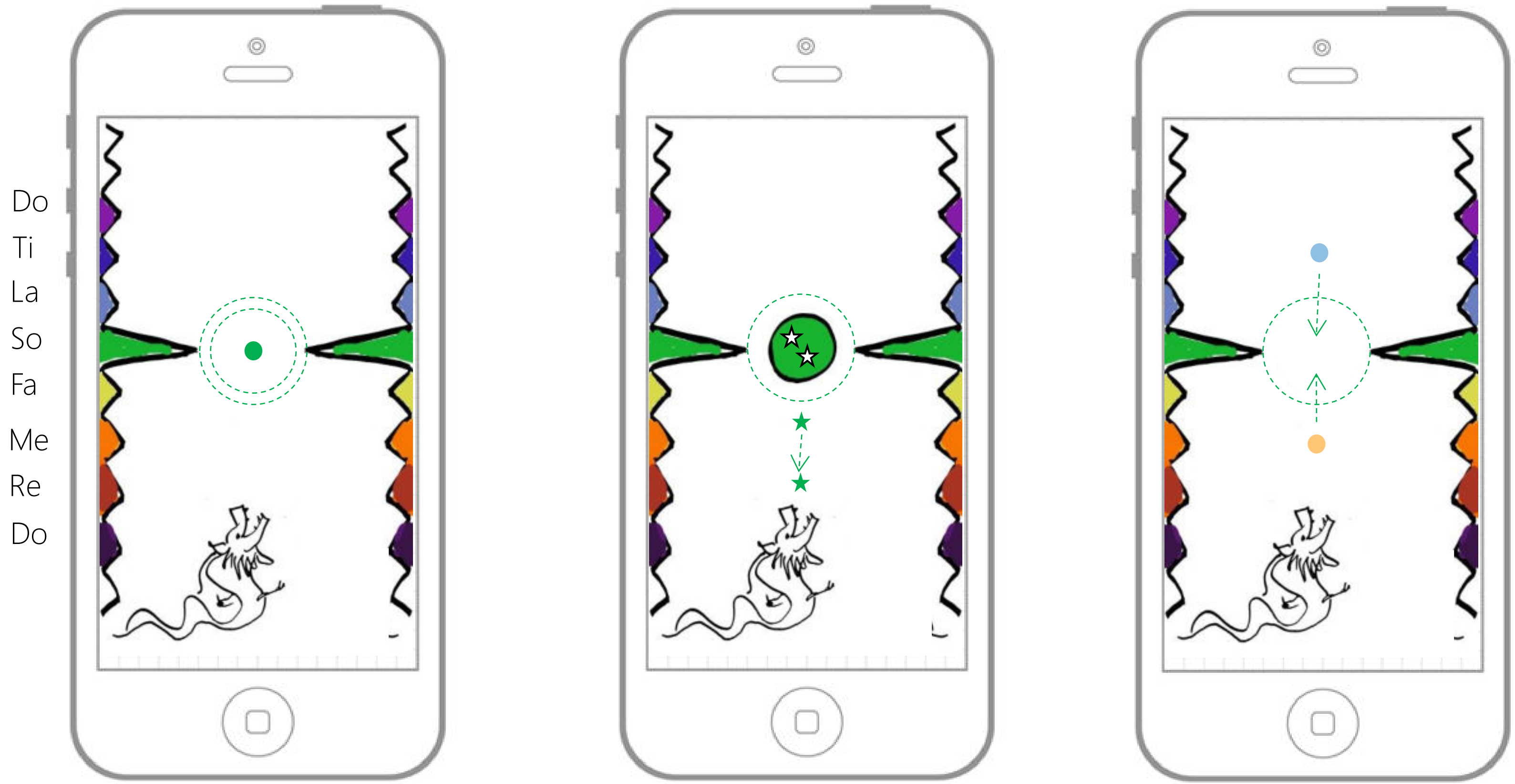
More than 95 percent of Americans and Indians tested identified the "spiky" shape to be "Kiki" and globular shape to be "bouba"(experiments by Scientist Viliyanur Ramachandran)[11]. The idea was to use these shapes to map different musical instruments. Musical instruments that are percussive(piano, xylophone) have greater attack in their waveform than a violin or oboe. Thus spikier the shape, the more percussive the music instrument.

Timbre Perception - Level 2

For Timbre Perception, the users need to differentiate between two different music instruments.

The two shapes (inspired from Kiki-Bouba concept) are displayed and once touched, they produce each of the assigned music instruments' sounds.

The user has to choose one of them as the instructions require and drop them to the basket below.
As the difficulty levels increase, the user has to just listen to the sound and choose from the two similar spheres. This makes them more keen on the sound than the visuals.


Do
Ti
La
So
Fa
Me
Re
Do

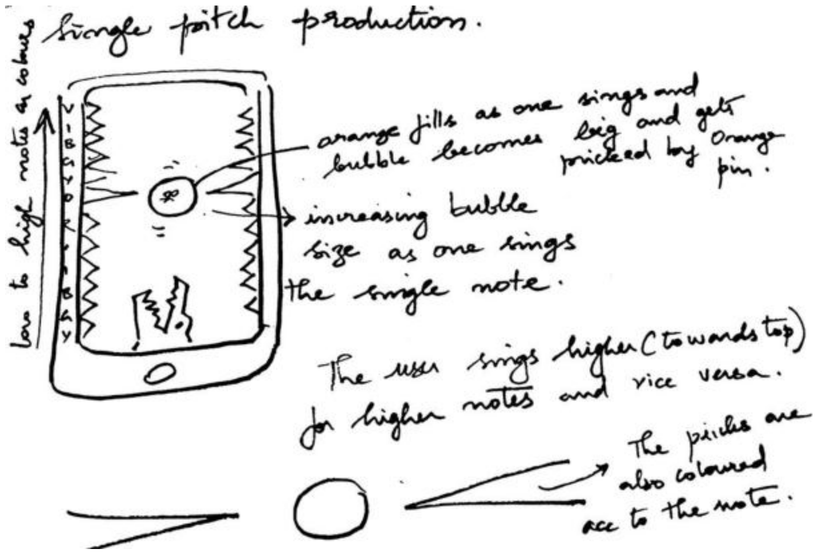
Final Concept

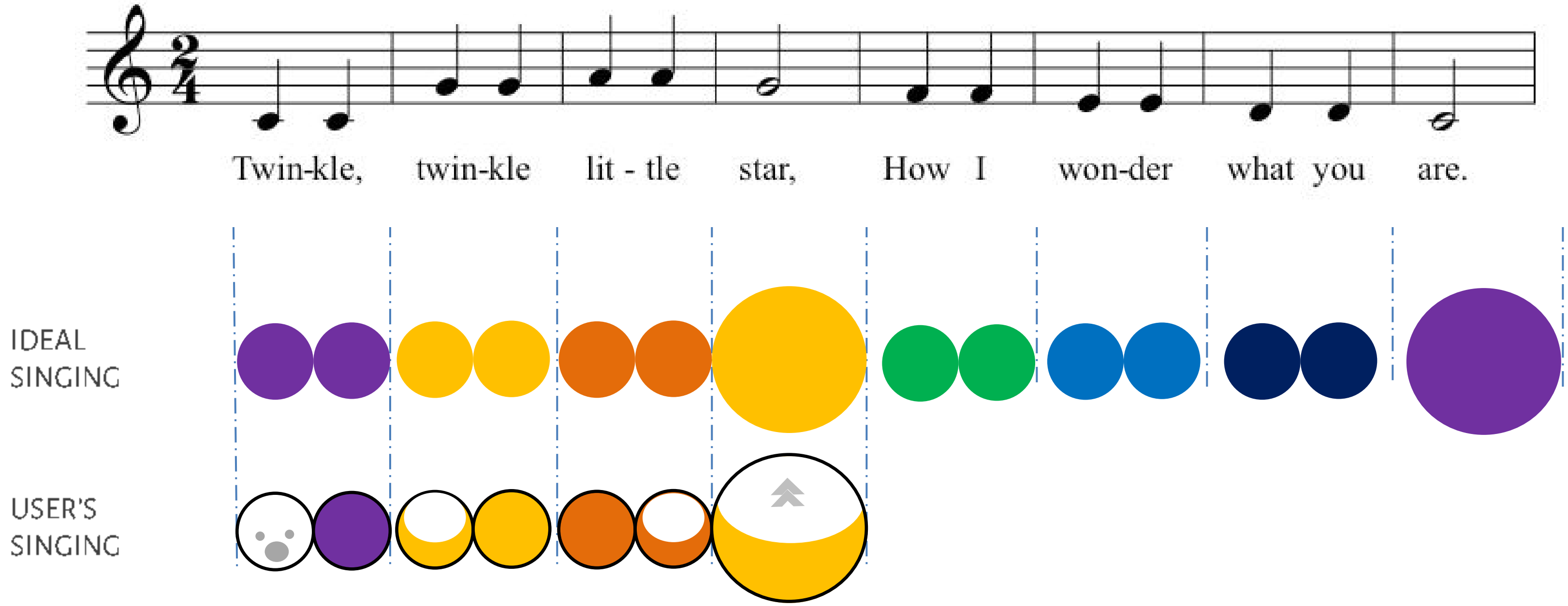
Pitch Production - Level 3

For Pitch Production, the users need to sing one particular note and prolong it.

The reference pitch/note is played from the pre-recorded files in the game and the corresponding colour in the interface is highlighted. The user is prompted to sing along.

As the user sings and prolongs the note, the bubble in the centre gets bloated with the note's colour and bursts by awarding points to the user. If the user doesn't sing the note, then the bubble remains small and wavers according to the wrong notes sung.





The circles get filled with appropriate colours only if the user sings correctly. The amount of colour filled in corresponds to the correctness of the note he/she has sung.

Final Concept

Melody Production - Level 4

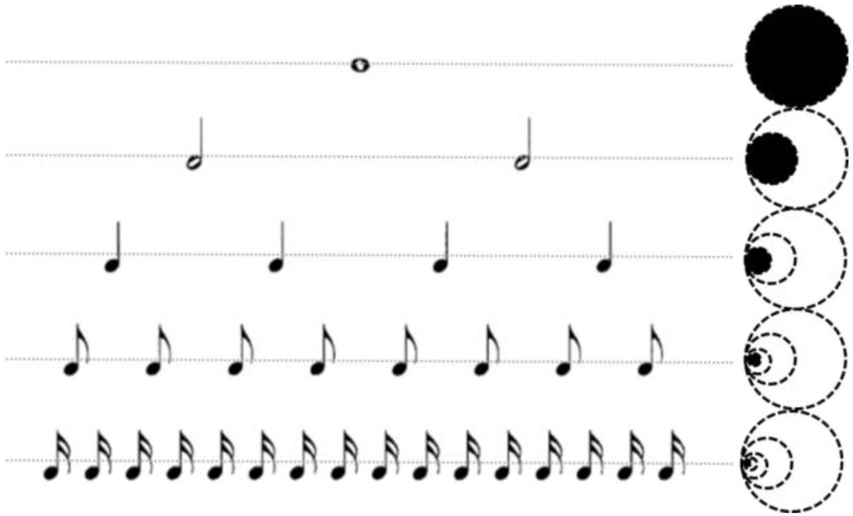
For Melody Production, the users need to sing along with the melody played back by the device.

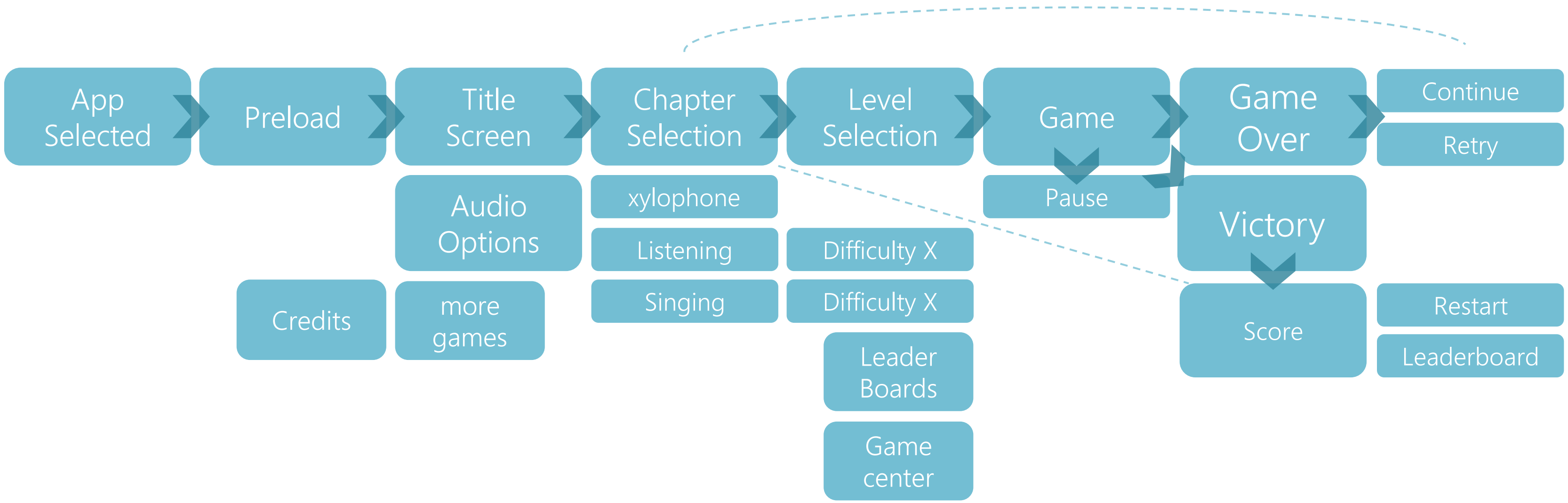
This melody is also expected to be sung along with lyrics. Since these melodies are designed for children, most of these are simple songs and rhymes(in english).

The interface is designed so that the user gets awarded with points only if he/she sings the exact pitches in the melody. The same is also visualised in terms of percentage of perfection in the tuning.

English names for notes and rest values

Sign	Name	Relative Length	In 4/4 Time	Rest
𝅝	Semibreve	Whole note	4 beats	𝄻
𝅗𝅥	Minim	Half note	2 beats	𝄼
♩	Crotchet	Quarter note	1 beat	𝄽
♪	Quaver	Eighth note	1/2 beat	𝄾
𝅘𝅥𝅯	Semiquaver	Sixteenth note	1/4 beat	𝄿

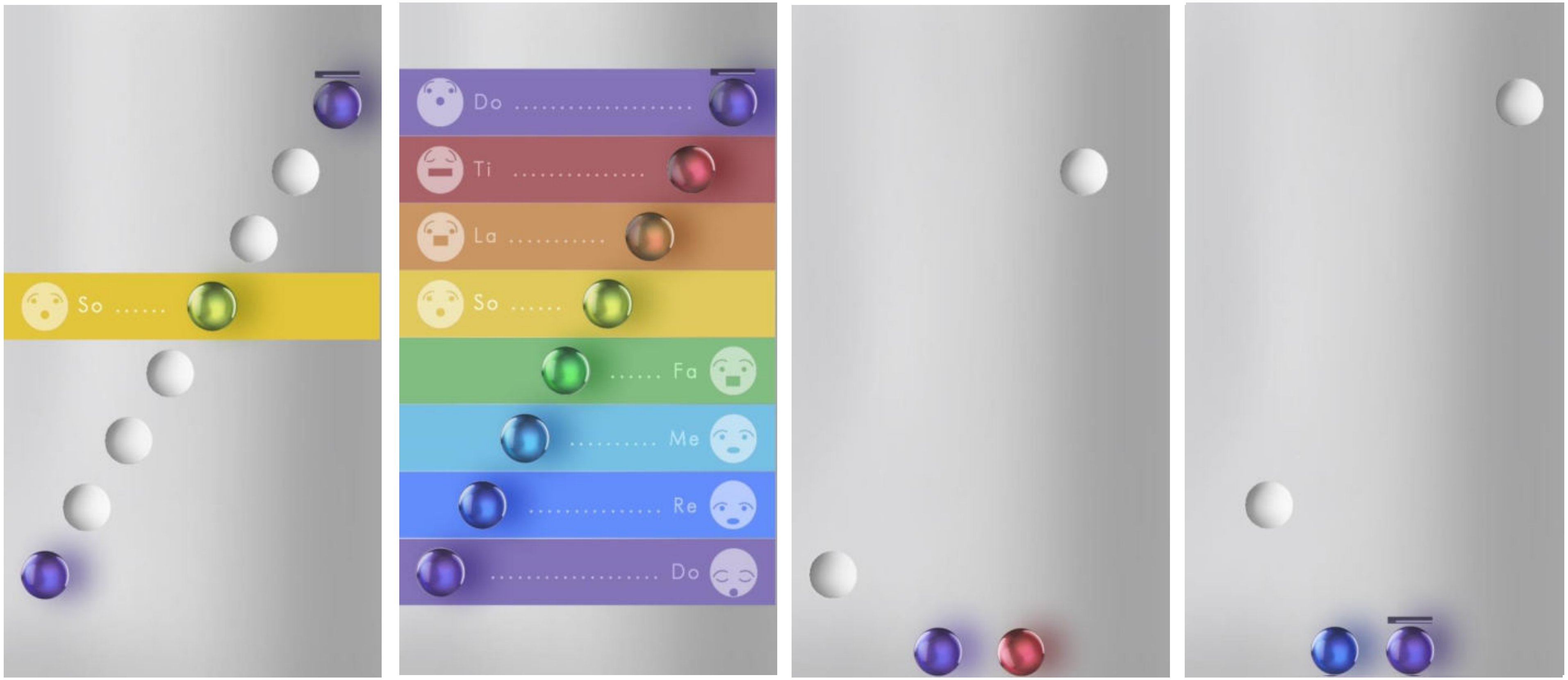



App Selected
Preload
Title Screen
Chapter Selection
Level Selection
Game
Game Over
Continue
Retry
Audio Options
xylophone
Pause
Victory
Listening
Difficulty X
Credits
more games
Singing
Difficulty X
Score
Restart
Leaderboard
Leader Boards
Game center

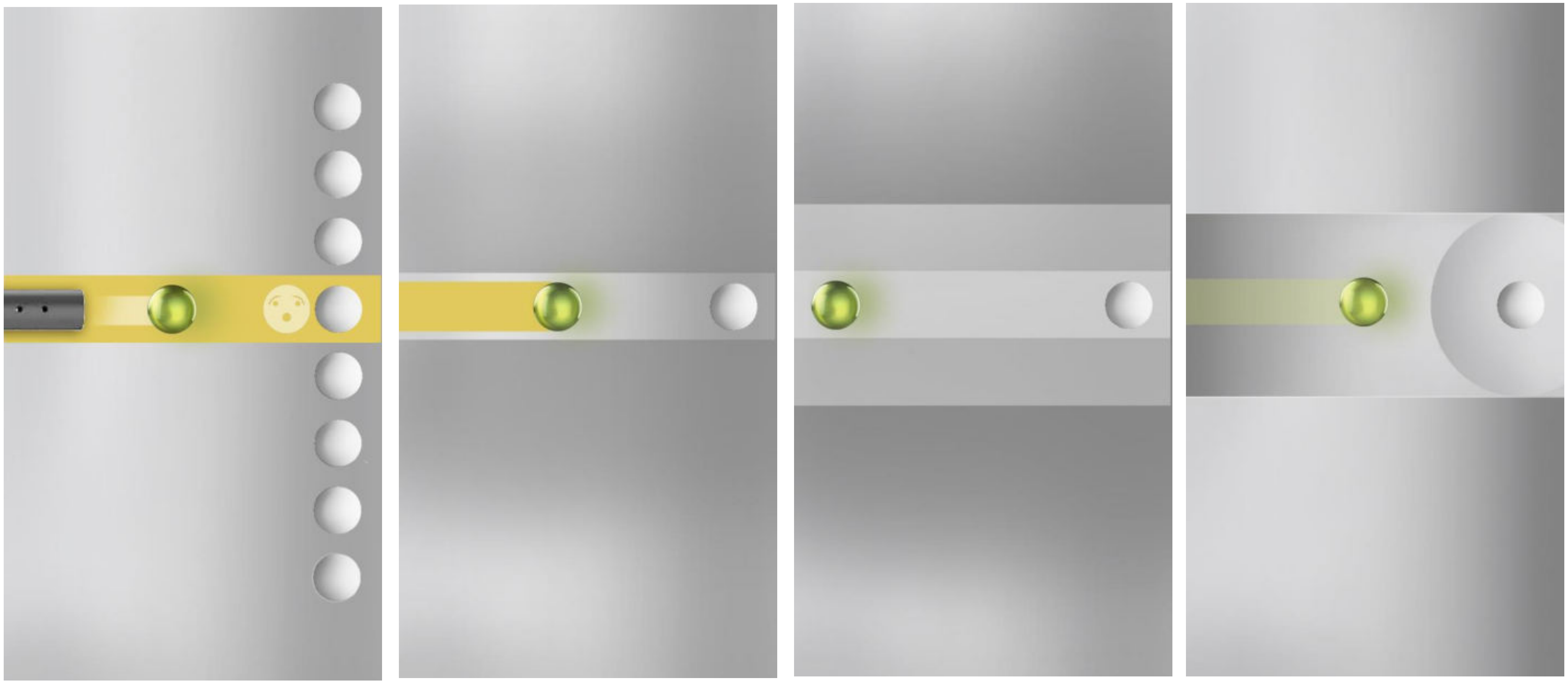
Final Concept

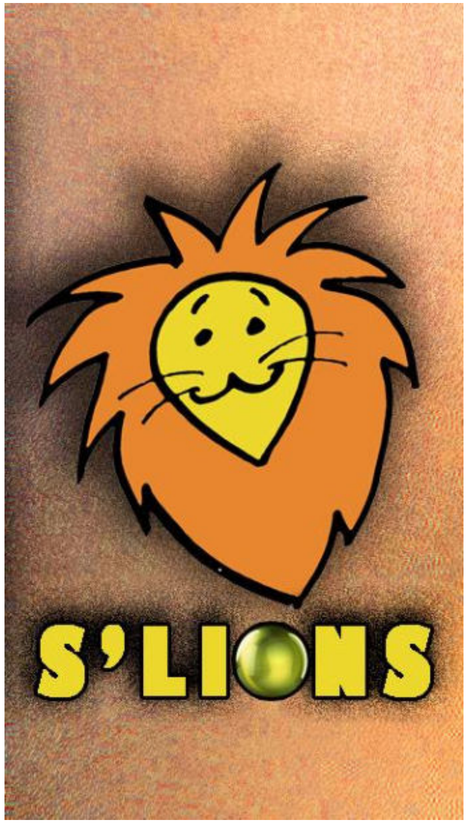
Holistic Design Solution

Although these games would solve the problems as individual entities, they were detached from each other in the ways they were presented. After many explorations, I narrowed down on directly taking inspiration from the recesses and marbles of the brainvita game. The whole concept seemed apt for denoting notes, dragging and dropping them in the right recesses and also moving them around by singing. Also this idea was kept simple, keeping in mind that children of age group 3- 12 are the users.


So ......
Do ....
Ti ....
La ....
So ......
...... Fa
.... Me
.... Re
.... Do

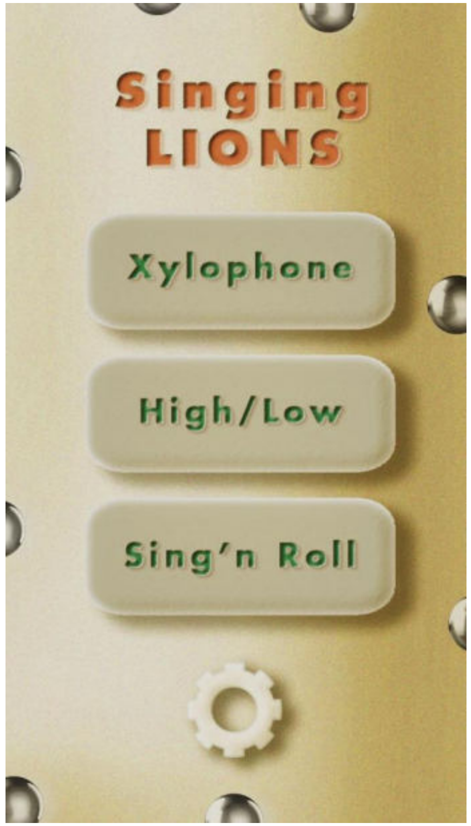
Explorations




S'LIONS


ROARRR!
You scored 15 Points...


Singing
LIONS

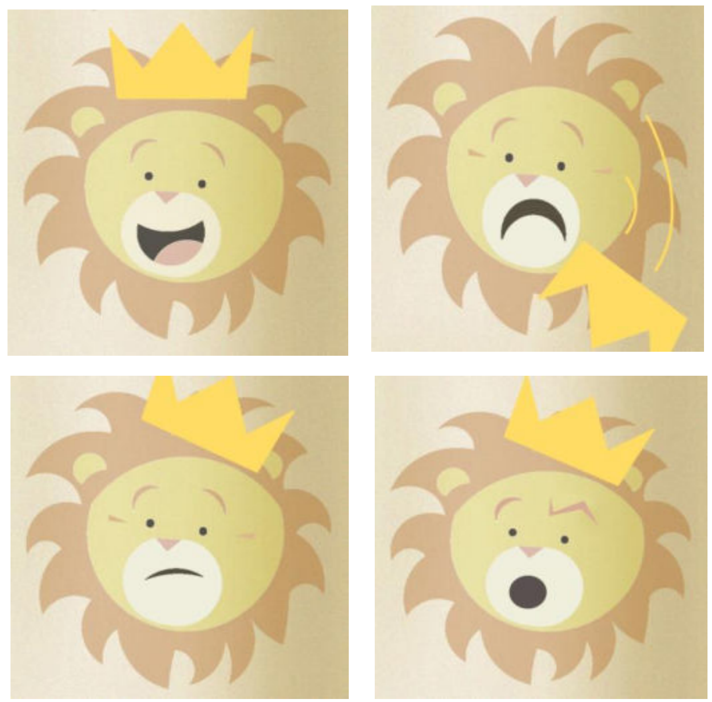

Singing
LIONS
Xylophone
High/Low
Sing'n Roll

Explorations

Singing Lions

We included a mascot as a friendly element to the game. The mascot was designed to express different expressions to denote the user's win and loss in the game. We made the mascot looks like a lion as it would be coherent with the acronym of the project @COSMIC, NUS Singapore – Singing and Listening to Improve Our Natural Speaking – S'LIONS.

The idea was to make the marbles seat in the Lion King's crown every time the user answers correctly and wins the game. Sad expressions come on the Lion's face and his crown falls down sans marbles, when the user gives a wrong answer.



Evaluation

In order to evaluate the ease of use and the user's satisfaction while using Singing Lions, a Usability Evaluation was planned. The mobile app was prototyped to help children (age 4-12) with implants improve their pitch and timbre perception through a combination of listening and singing exercises(Xylophone, high low and Sing n Roll).
We planned to test the app with normal adult users; fix any issues arising from those tests, then repeat the process with the actual users.

Goals of the evaluation

1.Evaluate the ease of use of "Singing Lions" android game for mobile devices.

2.Identify interaction design and interface design flaws in the app.

3.Evaluate the User's Satisfaction while using the game/app.

Methodology

We used questionnaires and observations for our study, as interviews may not serve as the primary source of information with children between 4-12 age group. During the visit to the school, notes were taken and these notes were aggregated after the visit. Each test was recorded with a phone camera. After the test, the users were given a short questionnaire to fill in. Qualitative analysis was performed on the primary observations recorded in the notebook and from the recorded videos.

The questionnaires used during the test are attached in the subsequent pages.

Users

Pilot tested with 5 adults with the same methodology prior to testing with 5 children with cochlear implants of age group 4 – 7.

Questionnaire for Child

Pre-Session

Participant No : ___________ (to be filled by evaluators)
Observer will ask these questions to the child
and complete the form.
Name:________________________
Tick in the appropriate blank
How often do you use the smartphone?
___ Every day
___ Once a week
___ Once a month
___ Only when I need something
Where do you use the smartphone the most?
___ School
___ Library
___ Home
___ Others ______________
Who usually uses the smartphone with you?
___ Parent
___ Only me
___ Sitter
___ Teacher
___ Others _______________
What language does your smartphone work in?
___ English
___ Mandarin
___ Malay
___ Tamil
___ Others _______________

Questionnaire for Child

Post-Session

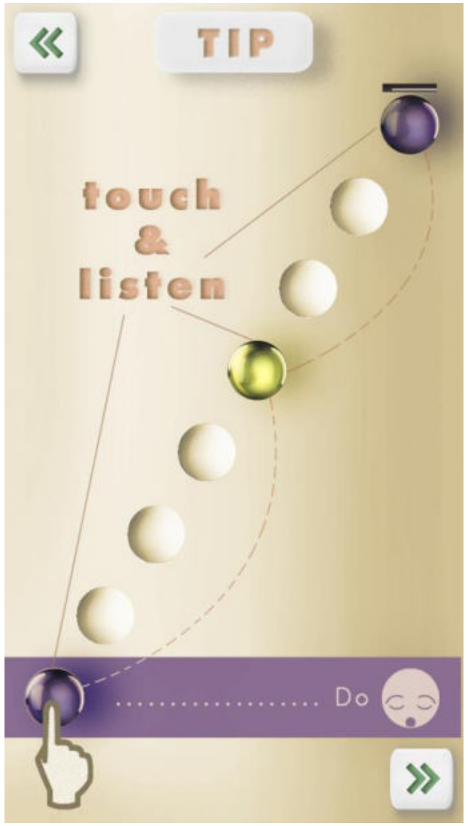
Child - User Satisfaction Survey

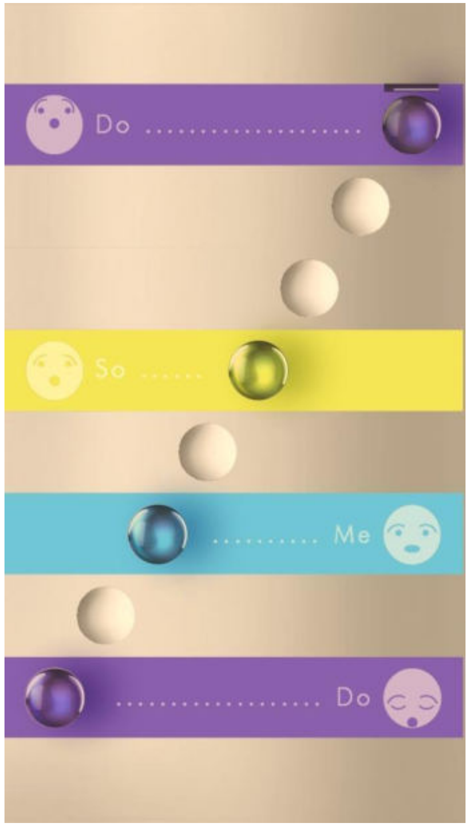
Participant No : ______(to be filled by evaluators)
Please fill out the following questions about the game (tick the appropriate box)

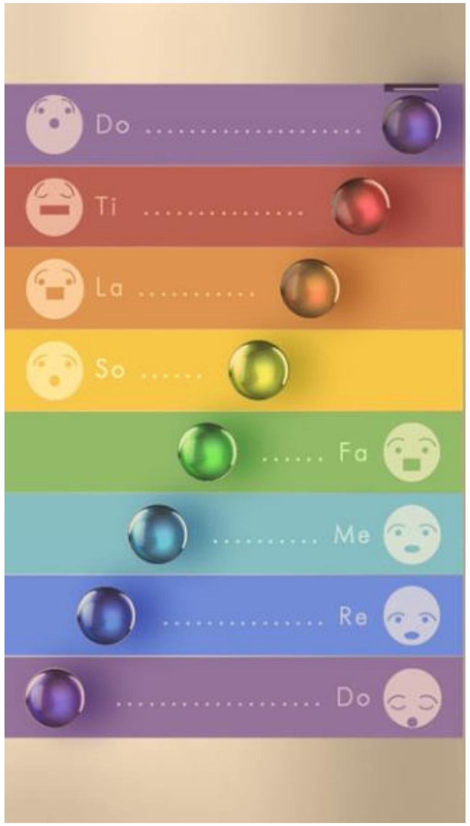
	Yes, totally	Yes	Neutral	No	Not at all
I understood the instructions.					
The game was fun					
The game was easy to play					
I want to play this game again					
I would like to play this game at home					

Rate the games in Singing Lions on 5.

1. Introduction – Xylophone _____/ 5
2. Higher Lower :_____/ 5
3. Sing N Roll : _____/ 5


TIP
touch & listen
Do


Do
So
Me
Do


Do
Ti
La
So
Fa
Me
Re
Do

Prototyping and Testing

Task 1

Playing the Xylophone/introductory level

The users were given the “Xylophone” exercise where they had to understand that musical notes are being mapped to the colours in rainbow. The coloured marbles on the interface would sound the corresponding notes when touched.

Key question

Is the user able to learn that musical notes are mapped to the respective colours of the marbles in the layout?

User Feedback

All 5 users understood that the music notes are arranged in an ascending scale (they loved to play arpeggios up and down) but 2 of them did not seem to understand the visual arrangement in the order of the rainbow colours which was intended in the game (This clearly showed when they did not seem to think of colours as reference to play the initial few levels in High/Low.).

Insight 1

Instead of having only the coloured marbles on the plain layout and the respective horizontal bars lighting up when the user touches them, making the entire layout with horizontal coloured bars (along with the marble) and making them light up more(or become white) when the user touches one of them would be a better idea. This would give them more sense of the rainbow colours.

User Feedback 2

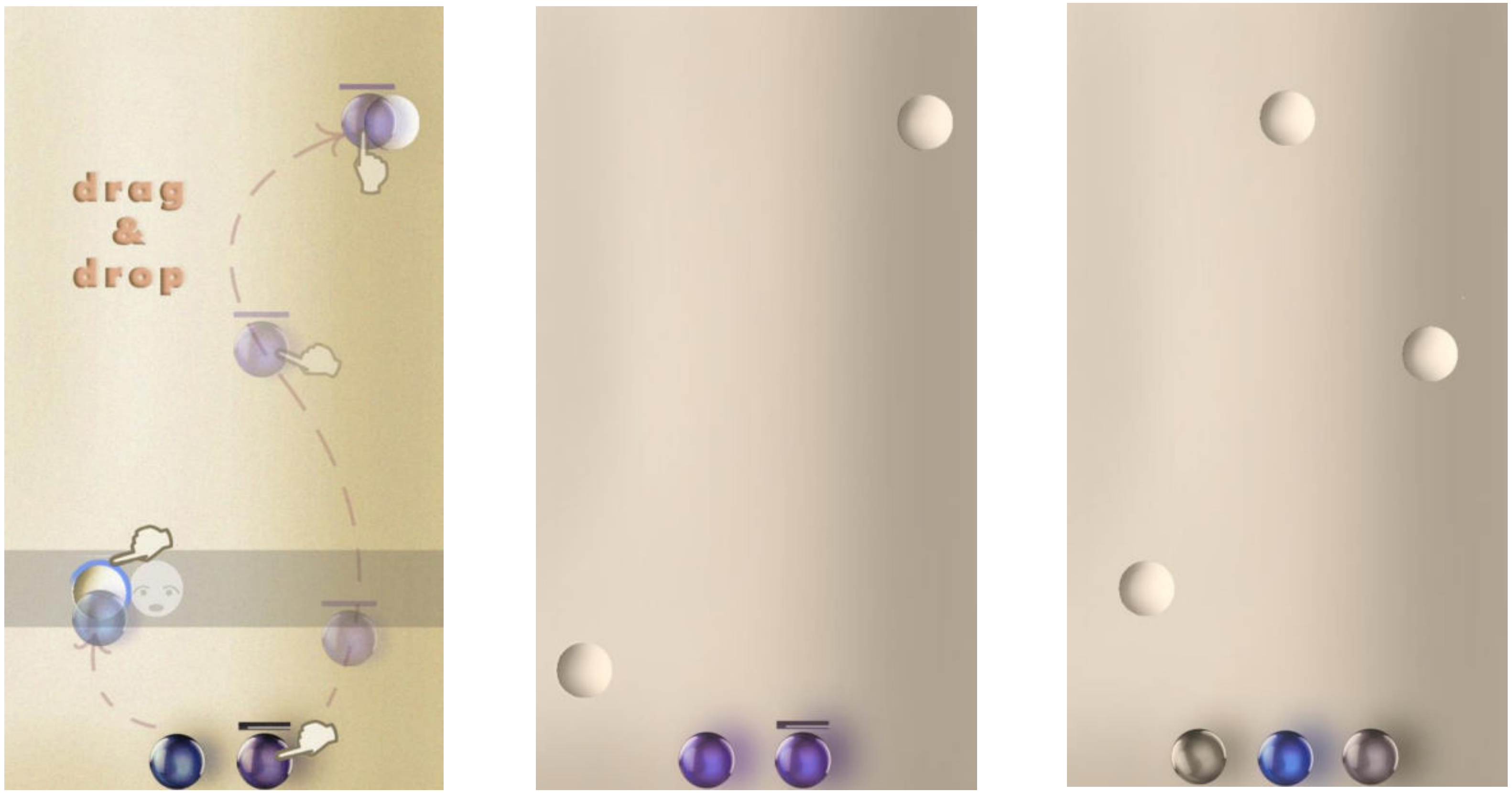
The users kept playing the xylophone’s sub-levels endlessly. Only when prompted, they understood that they should press the next button to proceed.

Insight 2

Since the next button was not understood it can probably be changed to a button with the lion’s face to go back to home page/menu.

Insight 3

Newer marbles can appear automatically after the user touches all of the notes given in a sub-level (instead of making the user hit the “next” button).


drag
&
drop

Prototyping and Testing

Task 2

Playing the High-Low level

The users were given the “High-Low” game where they had to drag and drop the marbles in respective recesses.

Key question

Is the user able to learn that the marbles of different musical pitches/notes belong to their respective recesses on the layout when playing this game?

User Feedback

To listen and match the music notes, users did not try to tap the recesses with rings unless prompted.

A design idea?

A prompt -“crotchet” appearing for 1 second next to the recess + ring, if left untouched for more than 5 seconds.

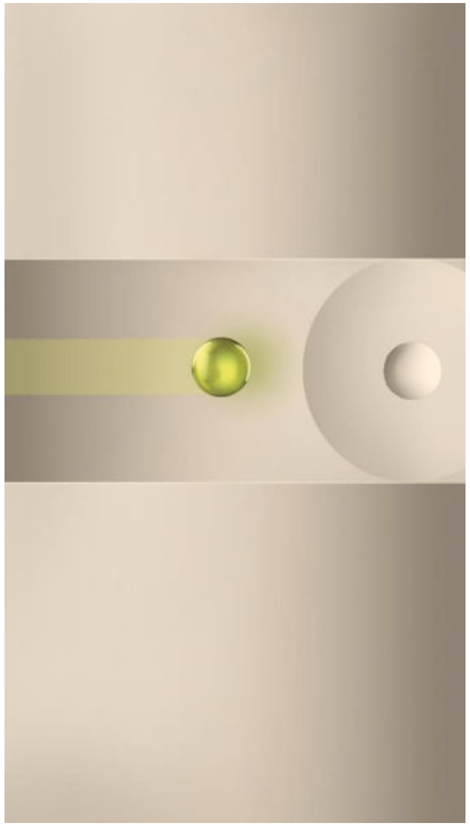
User Feedback 2

When the user goes wrong, he/she is given the same game to retry again and so user tries to guess the answer by trying a different combination. In this process, learning does not happen and guessing takes over.

Insight 2

Can the combinations in the sub-levels be randomized and scores be given at the end?


1 touch to listen
2 sing to roll




WOW!
Well sung!

Prototyping and Testing

Task 3

Playing the Sing N Roll

The users were given the "Sing N Roll" game where they had to sing and roll the marble to make it reach the recess.

Key question

Is the user able to relate to the movements of the marble in the interface with respect to his/her singing?

User Feedback 1

Though most of the users got the idea of moving the marble as one sings or hums, it took a little prompting in the beginning. The users kept touching the marble expecting to drag along as in the previous levels.

Insight 1

A better prompt to make sure the user understands that he has to "sing".

User feedback 2

As the users were young children (5-7), they could not sustain the note beyond a level. They found it very difficult to make the marble reach the recess in such a slow speed, as they prolonged a note.Also, they had problems in singing a note perfectly.

Insight 2

Making the ball's speed to reach the recess faster than it takes currently. This would reduce the breath problems faced by the kids while singing.

User Feedback 3

Also, they had problems in singing a note perfectly.

Insight 3

Tolerance of two tones up and down in the first few sub-levels of Sing 'N Roll can be given.


Gg Hh Ii
Pp Qq Rr
Zz

Prototyping and Testing

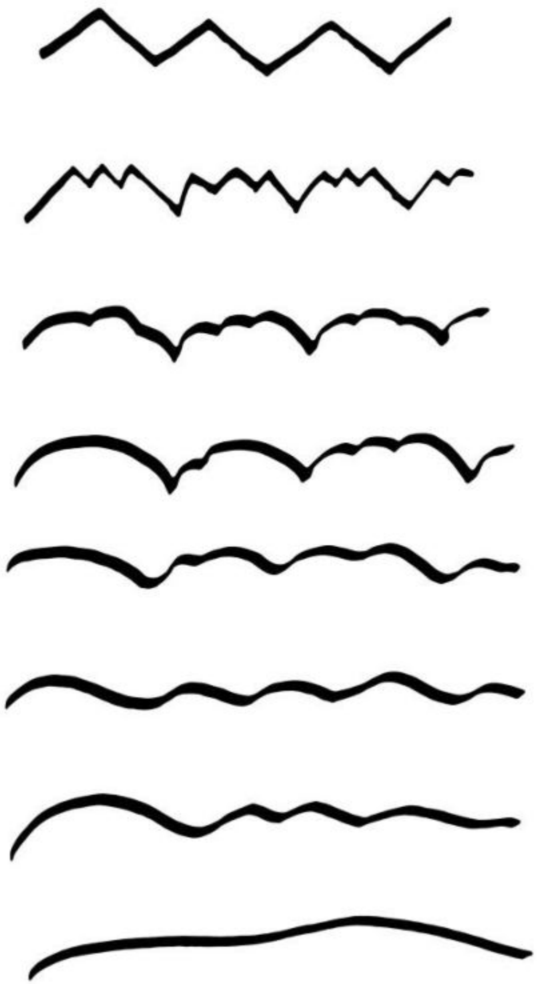
General Insights

-The children did not understand or spend time in figuring out the things given on the instruction screens before every game. A demo video possible?

-The children were not tired of playing the xylophone game. Some went on playing till prompted to try another game.

-When the children lost in the high low game, the prompt or the lion appearing with the score could probably tell them to “listen”.

- The faces of on the horizontal bars where not noticed at all. But one user (of the five tested) was keen on reading out “do , re , me” and tried imitating the smileys when he sang them.



Solving for Timbre Perception

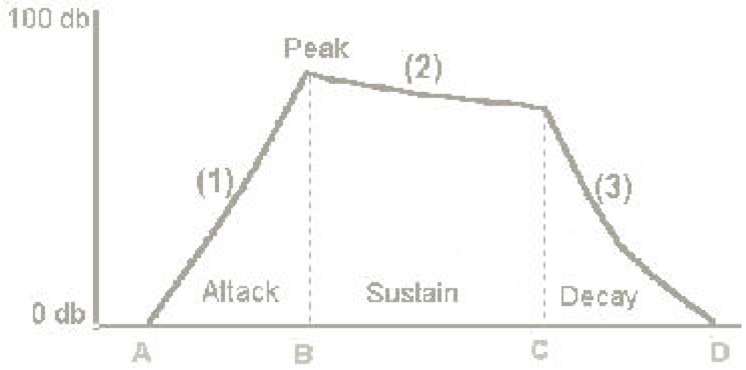
Explorations

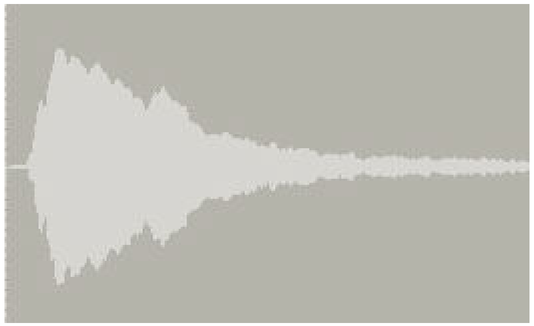
Spectra: The aggregate of simpler waveforms (usually sine waves) that make up what we recognize as a particular sound.

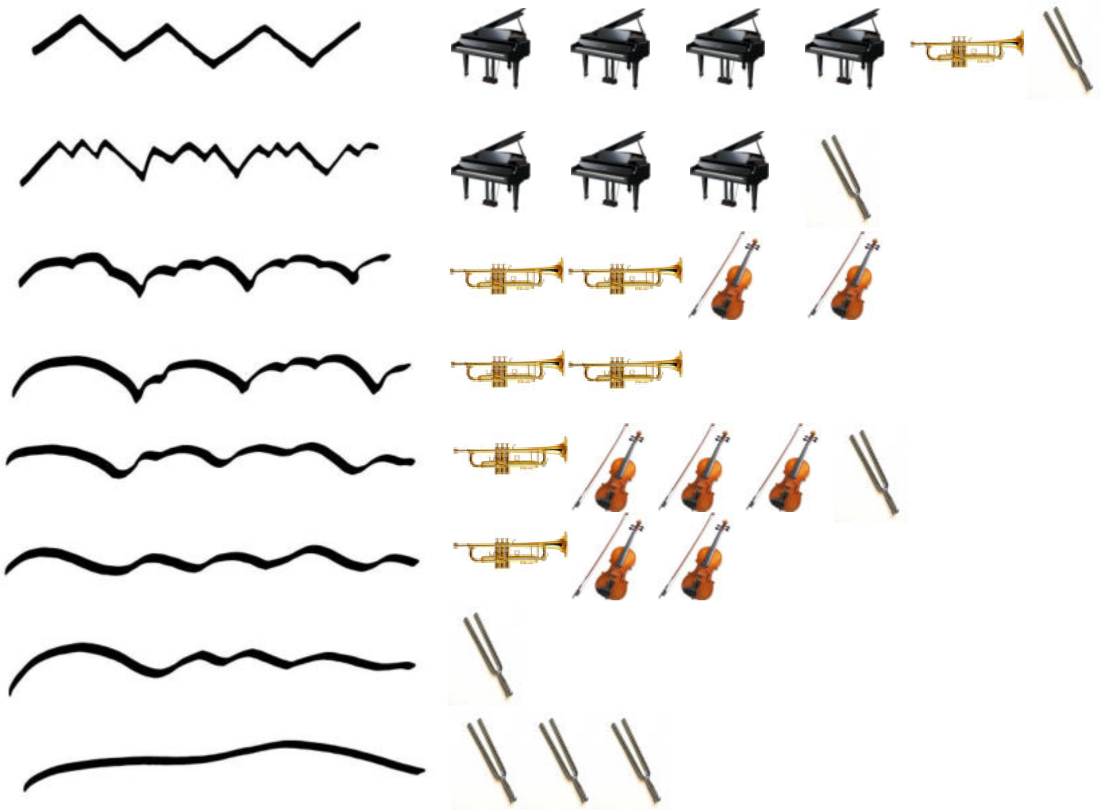
Envelope: the attack, sustain, and decay portions of a sound (often referred to as transients).

Combining these concepts with the KIKI-BOUBA [11] concept as discussed earlier, a small experiment was performed with normal adults. Around 7 individuals were called and they were asked to match 4 music instruments chosen with the many forms shown (similar to the KIKI BOUBA Experiment). The affinities were noted as shown.

There are a range of musical instruments and it would be difficult even for a normal user to differentiate between all of the instruments. Since designing for children with cochlear implants, 4 completely different instruments were chosen for the visualization check. The individuals were also asked to reason out their choices..







"Piano..", "abrupt", "discrete", "breaks", "sharp"...
were the words used

"pom pom!", "windy", "cloudy", "blowing", "bending notes"...
were the words used

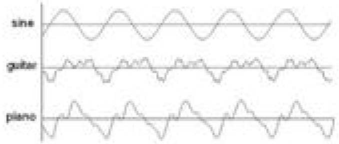
"Wavy", "flowy", "vibrating", "soft"...
were the words used

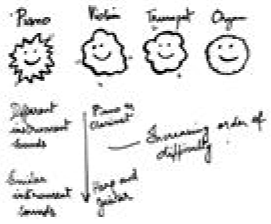
"plain", "flat", "simple" ...
were the words used

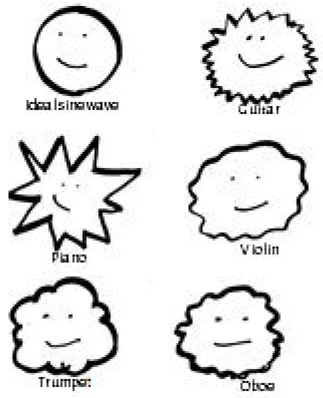
Scope for Extension

The shapes obtained for the different music instruments shall give scope to designing many type of quizzes/ games etc. (Match the sound, drawing shapes etc) and help the users learn timbre perception.

The coloured marble concepts can be extended to training for melody singing and melody construction using drag and drop. The concept of mapping shapes with timbre can be merged with the concept of colours having music notes. This will help the user in perceiving both timbre and pitch together in one game. This way, user learns the basics and advances to more complex concepts as the game progresses.



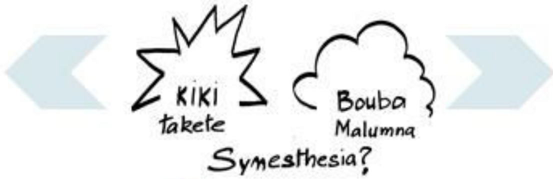




Other Users

Researchers have found that 1 in 20 people truly has amusia, the technical term for tone deafness. Tests have shown that some people with bad singing voices hear music just fine. Amusics are a group of people who can't pick out differences in pitch or follow the simplest tunes.*

Though the game is intended to serve users with Cochlear ear implants, it can also benefit other users with Amusia/tone-deafness.



*http://www.health.harvard.edu/press_releases/tone-deaf-test

References

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[2]McDermott, Hugh J. "Music perception with cochlear implants: a review." *Trends in amplification 8.2 (2004): 4982.*

[3]Joshua H. Goldwyn, Eric Shea-Brown, Jay T. Rubinstein: Encoding and decoding amplitude-modulated cochlear implant stimuli - *a point process analysis. Journal of Computational Neuroscience 28(3): 405-424 (2010)*

[4]Galvin JJ, Fu QJ, Nogaki G. *Melodic contour identification by cochlear implant listeners.Ear and Hearing 2007; 28: 302-319.*

[5]Zhou, Yinsheng, ToniJan Keith Palma Monserrat, and Ye Wang. "MOGAT: a cloudbased mobile game system with auditory training for children with cochlear implants." *Proceedings of the 20th ACM international conference on Multimedia. ACM,2012.*

[6]Jinho Yim, Rohae Myung, Byongjun Lee *The Mobile Phone's Optimal Vibration Frequency in Mobile Environments.*

[7]Seonaidh McDonald, Primary Research Technique Studying Actions in context: *A Qualitative shadowing method for organizational research.*

[8]Gfeller, Kate, et al. "Accuracy of cochlear implant recipients on pitch perception, melody recognition, and speech reception in noise." *Ear and hearing 28.3 (2007): 412423.*

[9]Fu, QianJie, and John J Galvin. "Perceptual learning and auditory training in cochlear implant recipients." *Trends in Amplification 11.3 (2007): 193205.*

[10]OUTLOUD 6 – App http://www.windowsphone.com/en-in/store/app/outloud-sounds-test/053376a0-bf89-4e8d-a535-43b1f72494fe

[11] KIKI BOUBA EFFECT http://en.wikipedia.org/wiki/Bouba/kiki_effect