Needs Analysis of Serious Games for Vocal Training in Speech Therapy

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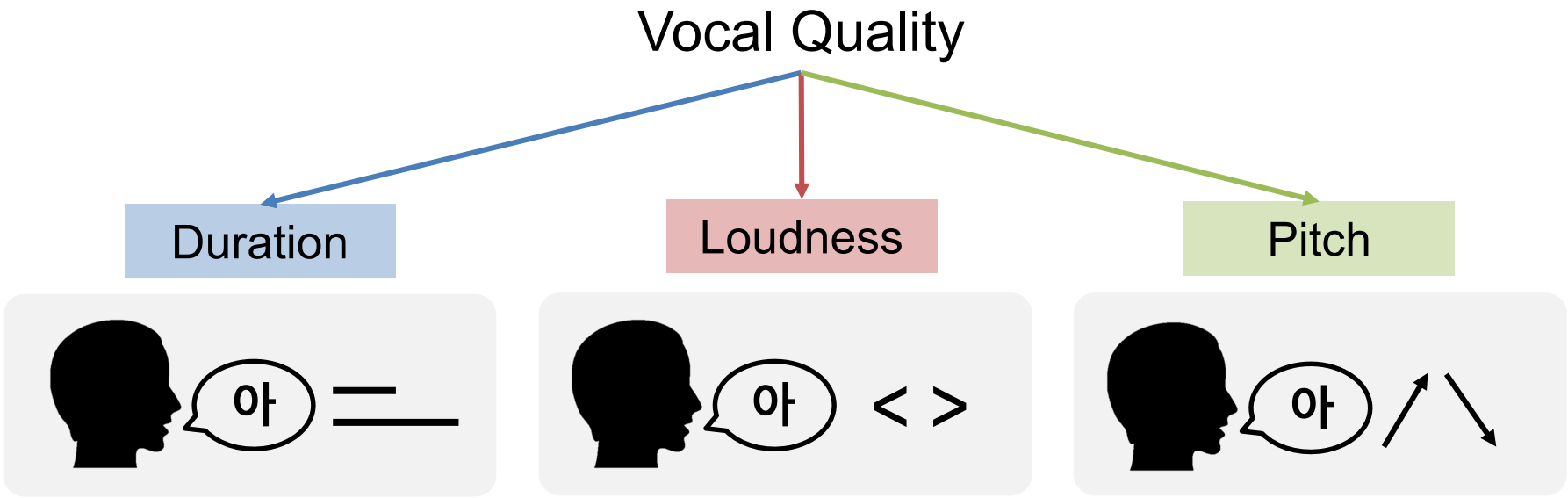
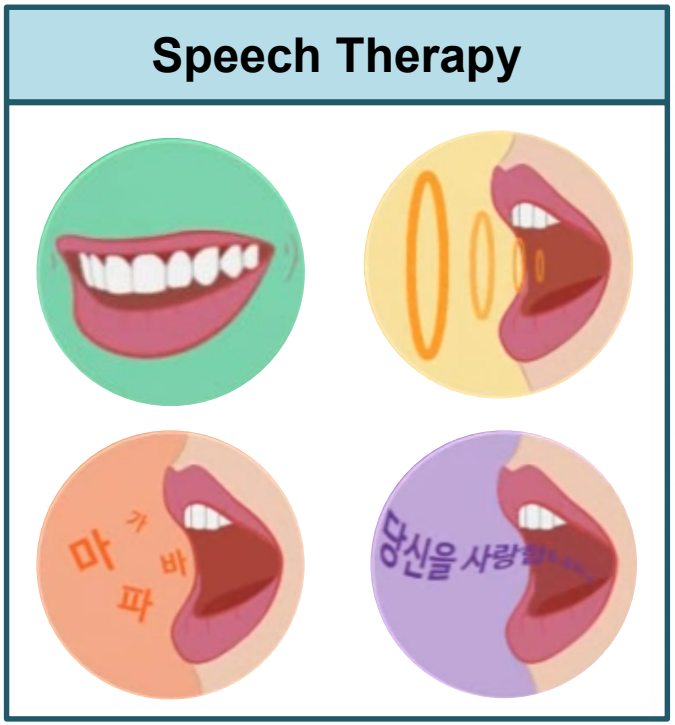
Voice Disorder

- Voice disorder: abnormal production and/or lack of vocal quality, duration, loudness, and/or pitch
- 3 ~ 9% of population having voice disorder, resulting in a significant need of speech therapy (American Speech-Language-Hearing Association, 2016)



Benefits of Speech Therapy

- Help patients with speech disorders acquire self-confidence, independence, and social skills



Self Confidence

Independence

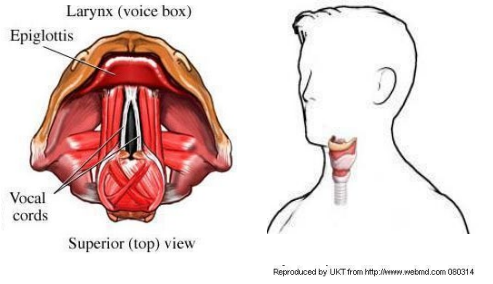
Social Skills

Speech Therapy

- Consisting of three steps: Voice production, articulation, and fluency (Saz, et al., 2009)
- Fundamental basis of speech therapy: Vocal training, practicing how to control voice production

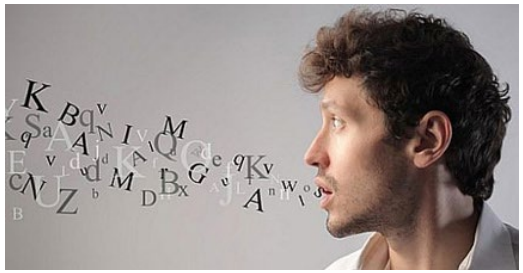
Voice Production

Voice production by **breathing, tone,** and **intensity** control skill



Articulation

Patient **utters** different **words** and receives **evaluation** on the correctness of **pronunciation**



Fluency

Ability to communicate in daily life (answering questions & establish dialog)

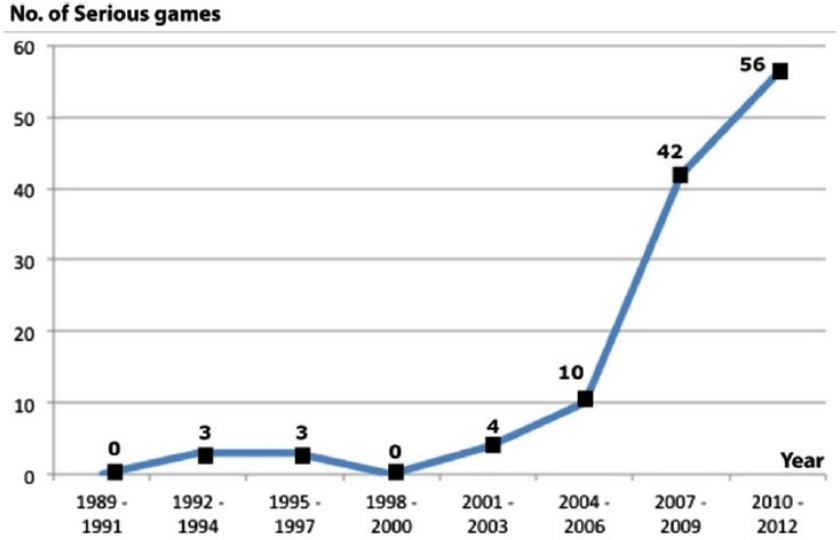
Limitations of Conventional Speech Therapy

- Mechanisation based, hard to maintain a patient's motivation (Navarro-Newball, et al., 2014)
- Not available for the patient practicing at home ⇒ The effect of therapy ⇓
- Subjective evaluation of the therapist due to getting used to the patient's speech pattern

Source: Talking to Teo: Video Game Supported Speech Therapy (Navarro-Newball, et al., 2014)

Computer Game-Based Healthcare Systems

- Benefits of computer games in healthcare, named serious games: motivation, engagement, learning, problem solving, and skill development
- The number of serious games is increasing but few (0.93%) are related to speech therapy (Wattanasoontorn, et al. 2013)



Disease
(Focus on Brain)

Brain related disease	28	25.93%
Others	80	74.07%

Stroke	5	4.63%
Brain Health	5	4.63%
Autism	4	3.70%
NeuroHealth	4	3.70%
Alzheimer	2	1.85%
Parkinson	2	1.85%
Upper limb Rehabilitation	2	1.85%
Cockroach phobia	1	0.93%
Language Disabilities	1	0.93%
Organizational Problem	1	0.93%
Speech disorder	1	0.93%

Source: Serious Games for Health (Wattanasoontorn et al., 2013)

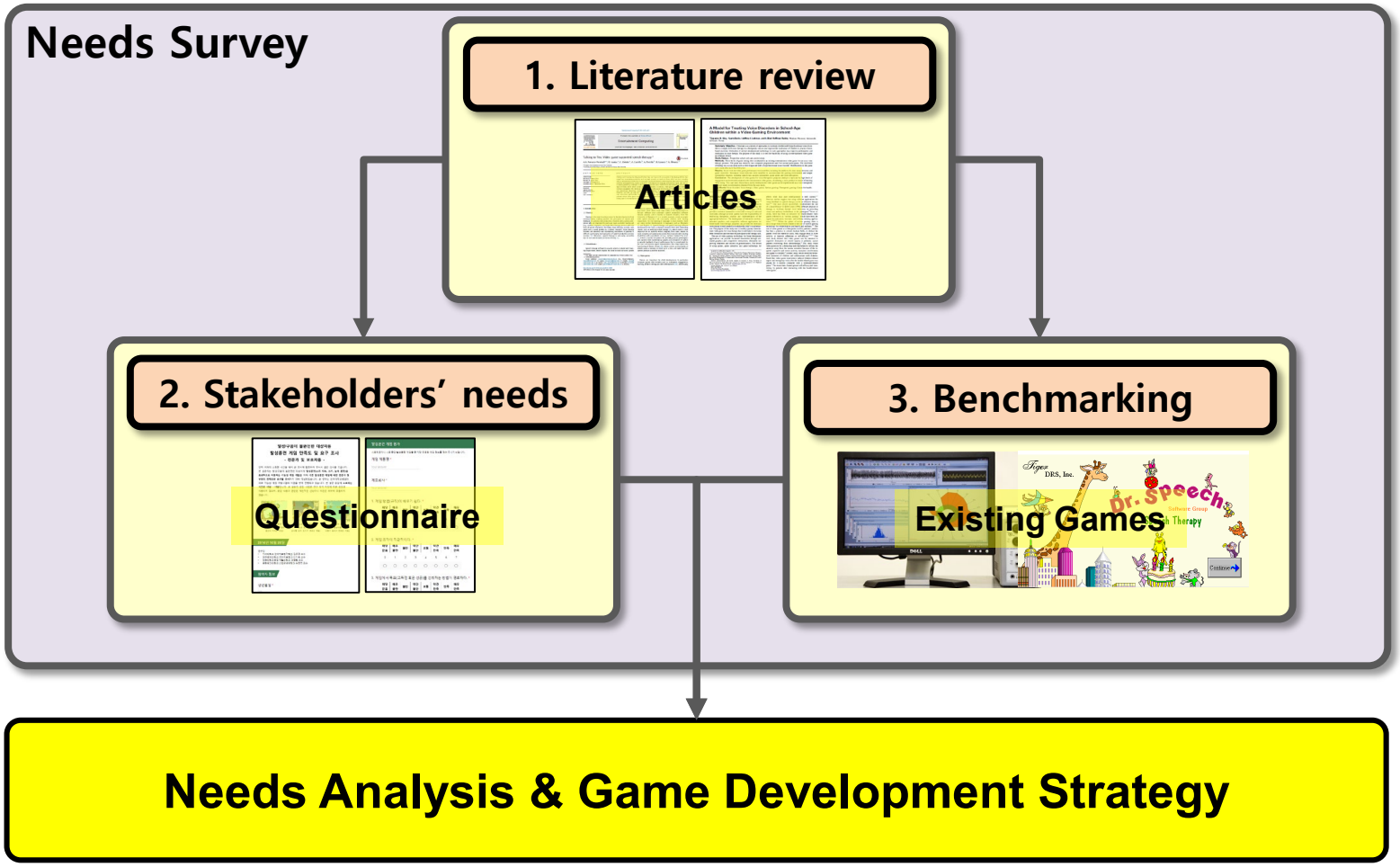
Research Objectives

Identify needs for the development of vocal training games to support speech therapy

Develop vocal training games & evaluate their effectiveness on speech therapy

Not covered in this presentation

Needs Survey & Analysis Process



Literature Review Process

S1. Keywords combination search

S2. Title screening

S3. Abstract screening

S4. Generating final article list to be reviewed

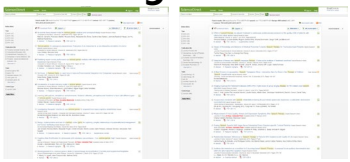
S5. Full article review

Literature search result: 759 articles

Keywords:

- speech therapy
- serious game
- speech therapy method (OR tool OR program OR technique)

Title screening result: 155 articles



Abstract screening result: 46 articles

13 highly related articles

List of Articles

No.	Author	Year	Title	Journal
1	Navarro-Newball, et al.	2014	Talking to Teo: Video game supported speech therapy	Entertainment Computing 5, pp. 401–412
2	King, et al.	2011	A Model for Treating Voice Disorders in School-Age Children within a Video Gaming Environment	Journal of Voice, Vol. 26, No. 5, pp. 656-663
3	Klara Vicsi	1995	A product-oriented teaching and training system for speech handicapped children	Journal of Microcomputer Applications 18, pp. 287-297
4	Shtern, M., et al	2012	A Game System for Speech Rehabilitation	5th International Conference on Motion In Games (MIG), pp. 43-54
5	Grossinho, A., et al	2014	An interactive toolset for speech therapy	11th Conference on Advances in Computer Entertainment Technology
6	Cagatay, et al	2012	A Serious Game for Speech Disorder Children Therapy	7th International Symposium on Health Informatics and Bioinformatics (HIBIT), (pp. 18-23)
7	Faria, et al	2014	Serious Game Using Augmented Reality Techniques for The Rehabilitation of Children with Psychomotor Disabilities	XXIV Congresso Brasileiro de Engenharia Biomédica – CBEB
8	Kostoulas, et al.	2012	Affective speech interface in serious games for supporting therapy of mental disorders	Expert Systems with Applications 39, pp. 11072–11079
9	Wattanasoontorn, et al.	2013	Serious games for health	Entertainment Computing 4, pp. 231–247
10	Igor Mayer	2012	Towards a Comprehensive Methodology for the Research and Evaluation of Serious Games	Procedia Computer Science 15, pp. 233 – 247
11	Phan, et al.	2016	The Development and Validation of the Game User Experience Satisfaction Scale (GUESS)	Human Factors, 1-31
12	Marache-Francisco C. and Brangier E.	2016	Validation of a Gamification Design Guide: Does a Gamification Booklet Help UX Designers to Be More Creative?	5th International Conference on Design, User Experience, and Usability, pp. 284 - 293
13	Lee, et al.	2015	An Analysis of Parents' and Experts' Needs for Smart Content for Speech and Language Therapy Support for People with Speech Disorder	Journal of Speeh-Language & Hearing Disorders, 24(4), 171-182

Literature Review Summary

- Identified applicable game features from 13 articles

No.	Scale	No.	Items	Application	Article									
					1	2	3	4	5	6	7	8	9	10
1	Usability	1	I think it is easy to learn how to play the game.	Ease of use, simple			O				O			O
		3	I always know how to achieve my goals/objectives in the game.	Game mechanics (cause-effect relation) and goal/objectives understanding	O								O	
2	Narratives	9	I can clearly understand the game's story	Game story or message should be clear and simple				O			O			
7	Personal Gratification	23	I feel successful when I overcome the obstacles in the game.	Reward and obstacle									O	
		24	I feel the game constantly motivates me to proceed further to the next stage or level.	Difficulty level	O	O					O		O	
		25	I find my skills gradually improve through the course of overcoming the challenges in the game.	Problem-solving strategies & self-control, skill development								O	O	O
		31	The game function is able to encourage patient	Real-time feedback to make user adjust their speech, Independence performance		O	O	O			O	O	O	
8	Social Connectivity	27	I find the game supports social interaction (e.g., chat) between players.	Interaction with other player or facilitator (therapist, caretaker)										O
...	...	…	...	...										

Identification of Scales for Stakeholders' Needs Survey

GUESS

Game User Experience Satisfaction Scale is comprehensive gaming scale for game evaluation purposes (Phan, et al, 2016).

9 Scales

Usability, Narratives, Play Engrossment, Enjoyment, Creative Freedom, Audio Aesthetics, Personal Gratification, Social Connectivity, Visual Aesthetics

Other Articles

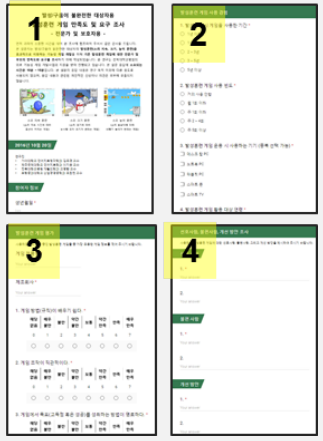
4 Scales

Accuracy, Customization, Game Analytics, Therapy Continuity

Total: 13 Scales (36 items)

Stakeholders' Needs Survey for Vocal Training Game

1. Introduction and general information
2. Serious game use experience
3. Main assessment of 13 game scales
4. Likes & dislikes and suggestion



Identified Scales

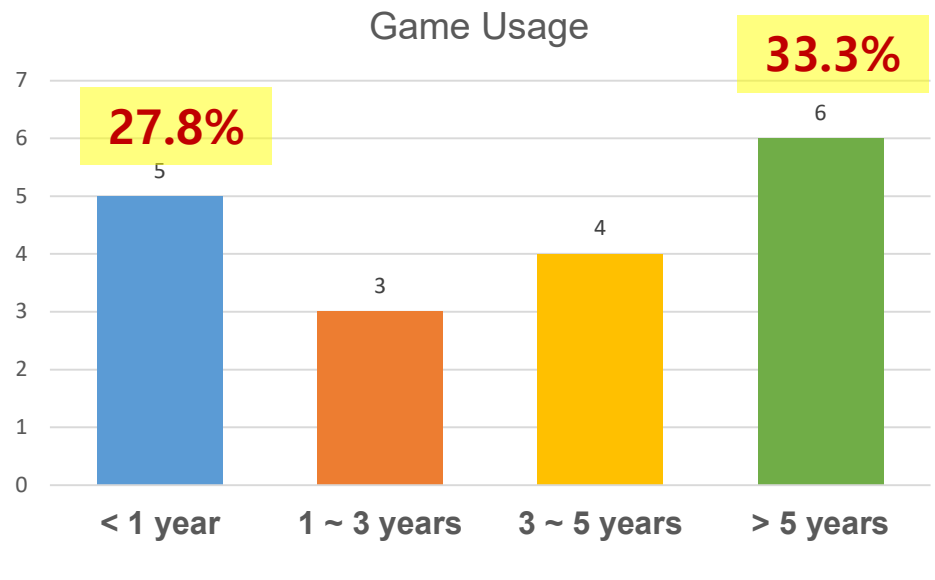
No.	Scales	#items in Questionnaire	Definition
1	Usability	7 (1 ~ 7)	The ease in which the game can be played with clear goals/objectives in mind and with minimal cognitive interferences or obstructions from the user interfaces and controls
2	Narratives	2 (8 ~ 9)	The story aspects of the game (e.g., events and characters) and their abilities to capture the player's interest and shape the player's emotions
3	Play Engrossment	3 (10 ~ 12)	The degree to which the game can hold the player's attention and interest
4	Enjoyment	3 (13 ~ 15)	The amount of pleasure and delight that was perceived by the player as a result of playing the game
5	Creative Freedom	4 (16 ~ 19)	The extent to which the game is able to foster the player's creativity and curiosity and allows the player to freely express his or her individuality while playing the game
6	Audio Aesthetics	2 (20 ~ 21)	The different auditory aspects of the game (e.g., sound effects) and how much they enrich the gaming experience
7	Personal Gratification	6 (22 ~ 26, 31)	The motivational aspects of the game (e.g., challenge) that promote the player's sense of accomplishment and the desire to succeed and continue playing the game
8	Social Connectivity	2 (27 ~ 28)	The degree to which the game facilitates social connection between players through its tools and features
9	Visual Aesthetics	2 (29 ~ 30)	The graphics of the game and how attractive they appeared to the player
10	Accuracy	1 (32)	The accurate interoperation of the input device with the game contents.
11	Customization	1 (33)	The degree to which game parameters are customizable to the player.
12	Game Analytics	2 (34 ~ 35)	The extent to which game results are managed and analyzed for effective training.
13	Therapy Continuity	1 (36)	The extent to which treatment activities in a treatment facility to practices at home.
	Total	36	

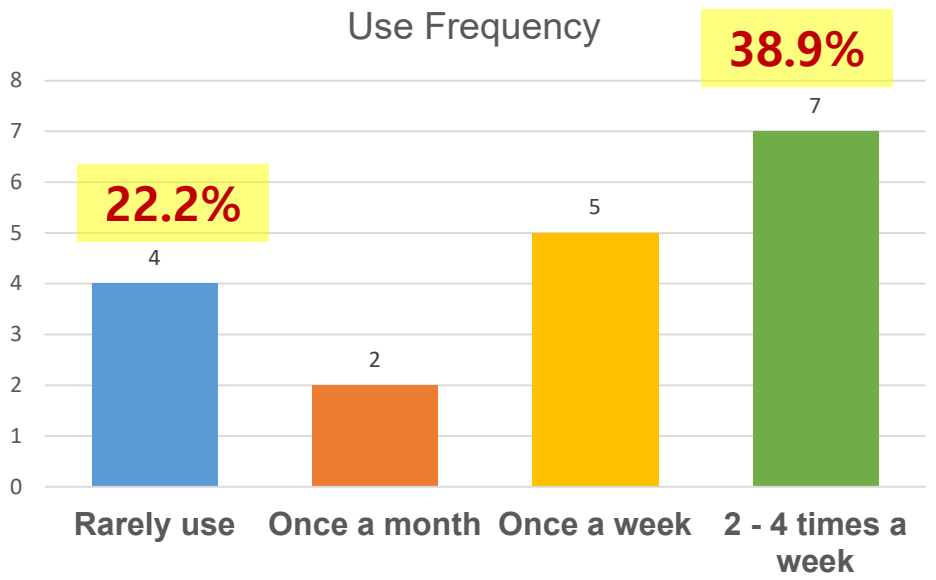
Questionnaire for Stakeholders' Needs Survey (Illustrated)

No	Design Item Statement	N/A	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Disagree
1	I think it is easy to learn how to play the game.	❑	①	②	③	④	⑤	⑥	⑦
2	I find the controls of the game to be straightforward.	❑	①	②	③	④	⑤	⑥	⑦
3	I always know how to achieve my goals/objectives in the game.	❑	①	②	③	④	⑤	⑥	⑦
4	I do not need to go through a lengthy tutorial or read a manual to play the game.	❑	①	②	③	④	⑤	⑥	⑦
5	I find the game's menus to be user friendly.	❑	①	②	③	④	⑤	⑥	⑦
6	I feel the game provides me the necessary information to accomplish a goal within the game.	❑	①	②	③	④	⑤	⑥	⑦
7	I think the information provided in the game (e.g., onscreen messages, help) is clear.	❑	①	②	③	④	⑤	⑥	⑦
…	…	❑	①	②	③	④	⑤	⑥	⑦
31	I feel the game encourages the trainee.	❑	①	②	③	④	⑤	⑥	⑦
32	Input signals from connected devices are properly processed and interoperated with the game.	❑	①	②	③	④	⑤	⑥	⑦
33	The parameters (difficulty, repetition, etc.) of the game can be customized.	❑	①	②	③	④	⑤	⑥	⑦
34	Results of the game can be saved and managed systematically.	❑	①	②	③	④	⑤	⑥	⑦
35	The records of the game can be analyzed and presented in a format that can be effectively utilized in vocal training.	❑	①	②	③	④	⑤	⑥	⑦
36	The game can link treatment activities in a treatment facility to practices at home.	❑	①	②	③	④	⑤	⑥	⑦

Need's Survey Result: Serious Game Usage (1/2)

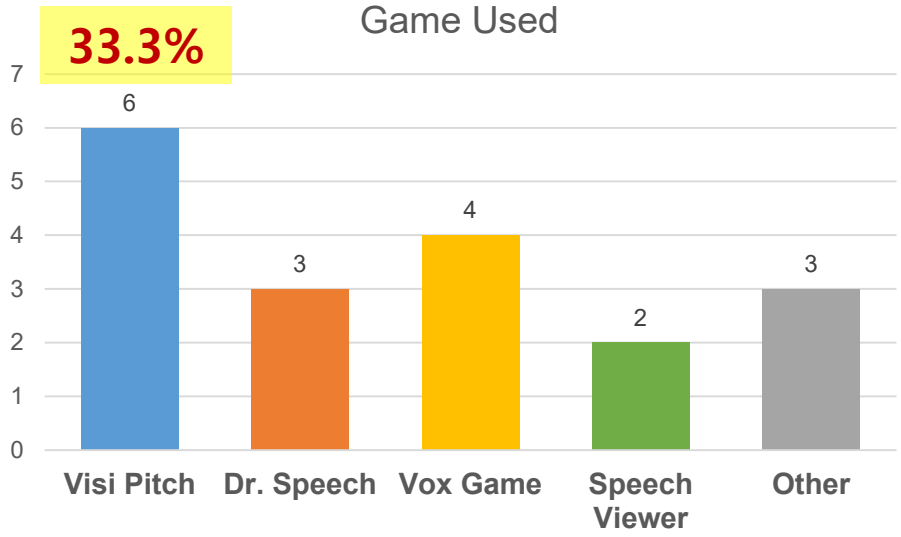
- Participants: 23 (Female: 16; Male: 7)
  - Therapists: 18 (3 to 23-year experience in speech therapy)
  - Parents: 5 (excluded due to lack of experience in speech games)
- Game usage: 33.3% of the participants have used serious games for more than 5 years
- Use frequency: 38.9% of them use serious games for speech therapy 2 to 4 times a week

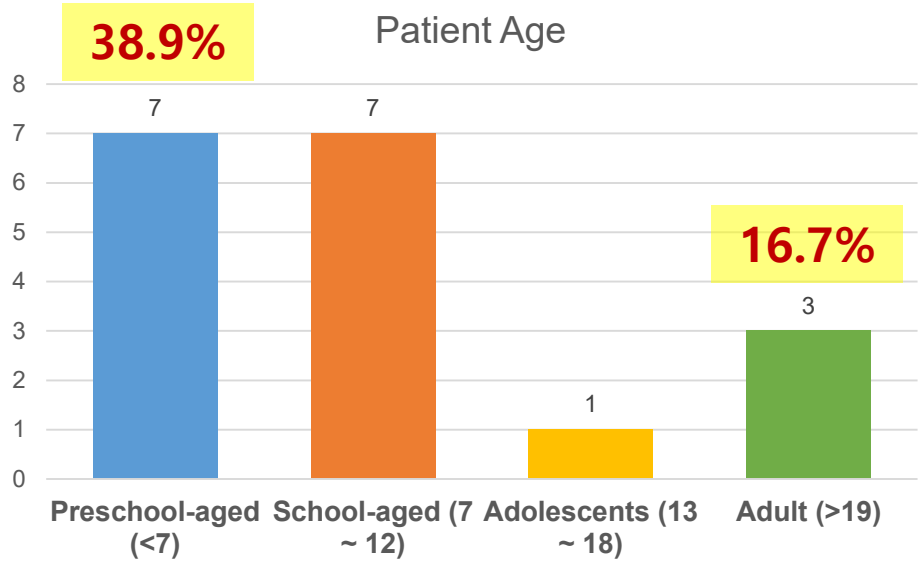




Need's Survey Result: Serious Game Usage (2/2)

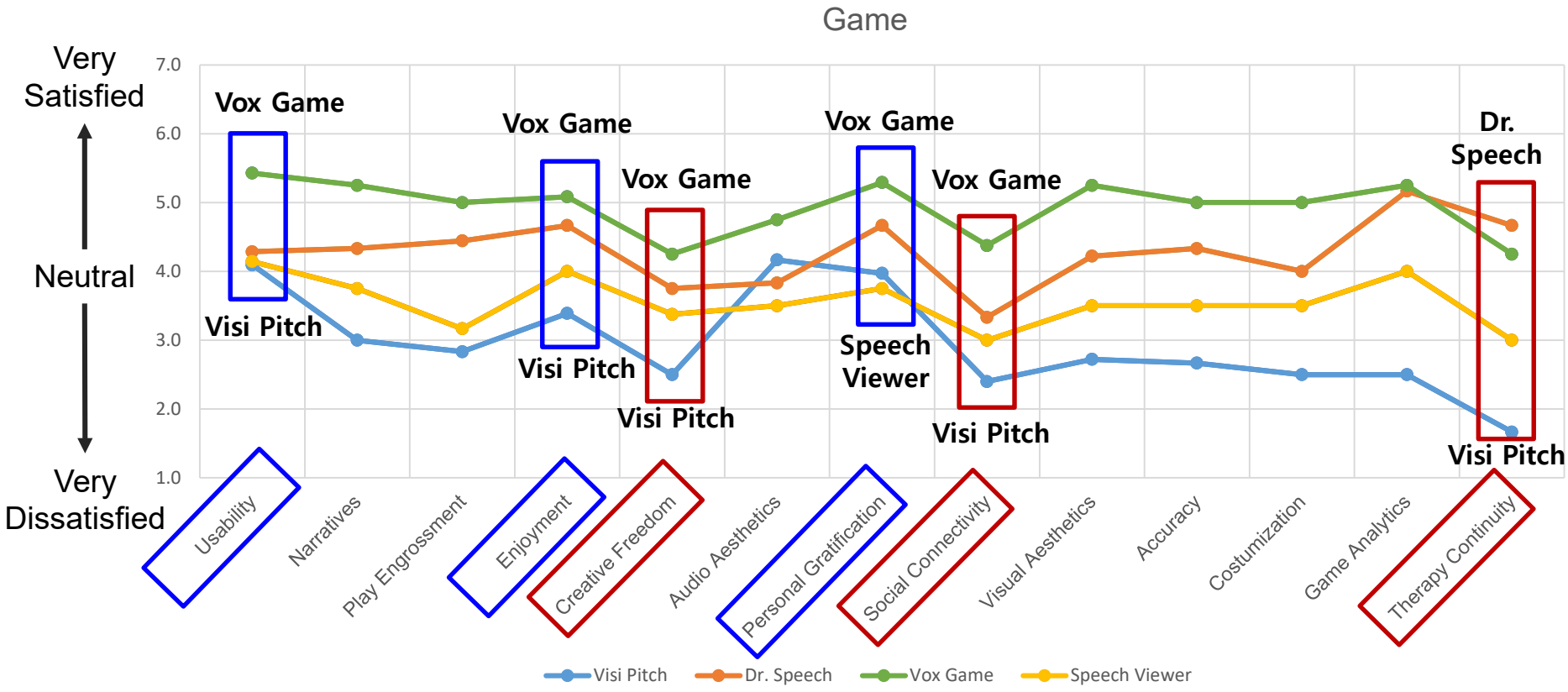
- Device: 43.5% for desktop and 26.1% for notebook
- Game used: 33.3% of the participants use Visi Pitch by Kay Pentax
- Patient age: 38.9% of the participants treat preschool-aged children (< 7 years old) and school-aged children (7 to 12 years old) and 16.7% adults (> 19 years old)



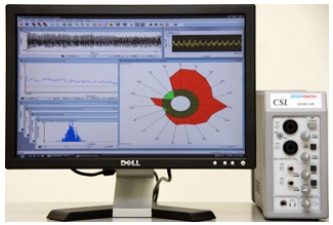
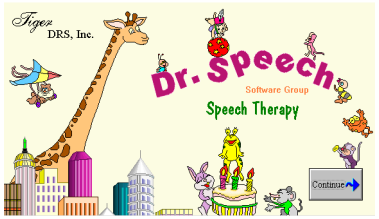


Need's Survey Results Based on the Identified Evaluation Scales for Existing Games

- Overall satisfaction score: Vox Game: 4.9; Dr. Speech: 4.3; Speech Viewer: 3.6; Visi Pitch: 3.0
- Scales satisfied in existing games: usability, personal gratification, enjoyment, etc.
- Scales to be improved: creative freedom, social connectivity, and therapy continuity



Benchmarked Games

	Visi Pitch	Dr. Speech	Talking to Teo
Developer	Kay Pentax (A Division of PENTAX Medical Company)	Daniel Zaoming Huang from Tiger DRS, Inc.	Navarro-Newball et al, 2014, Pontificia Universidad Javeriana, Cali, Colombia
Game Category	• Phonation (continuity, voicing onset, timing) • Amplitude (loudness) • Frequency (pitch)	• Phonation time (continuity) • Loudness • Pitch • Voicing • Speech articulation • Sound awareness	• Articulation
Number of games	3 phonation games 7 frequency/amplitude games	4 games each category	5 game scenarios
			

Visi Pitch (Kay Pentax)

- Different levels of acoustic parameters (e.g., pitch, loudness) provided on the screen during voice production
- Applicable key features: Showing loudness and pitch indicators as feedbacks to let users be aware of their voice level and allow them to make correction

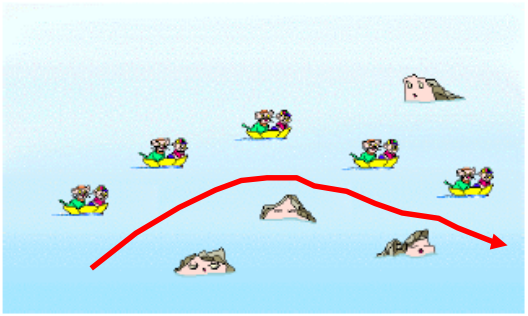
Pitch indicator

Flying height of the bird depends on the user's voice level in loudness or pitch

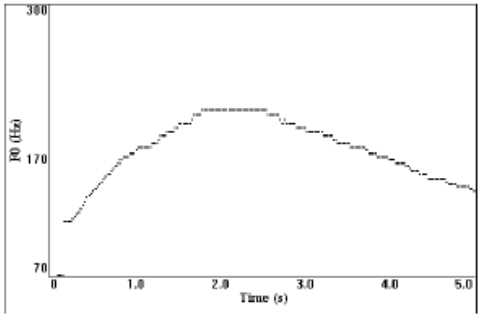
Loudness indicator

Dr. Speech (Tiger DRS)

- A voice-activated game-like tool to provide real-time feedback of client's pitch, loudness, voiced/unvoiced phonation, voicing onset, maximum phonation time, sound and vowel tracking for speech therapy
- Applicable key features: Pitch/loudness recording & graph plotting function for quantitative visualization and analysis of a patient's performance

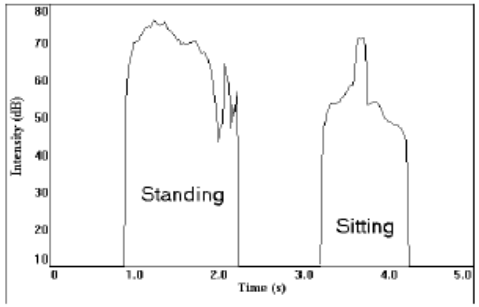


(a) Real-time cartoon display



(b) Objective information of pitch curve

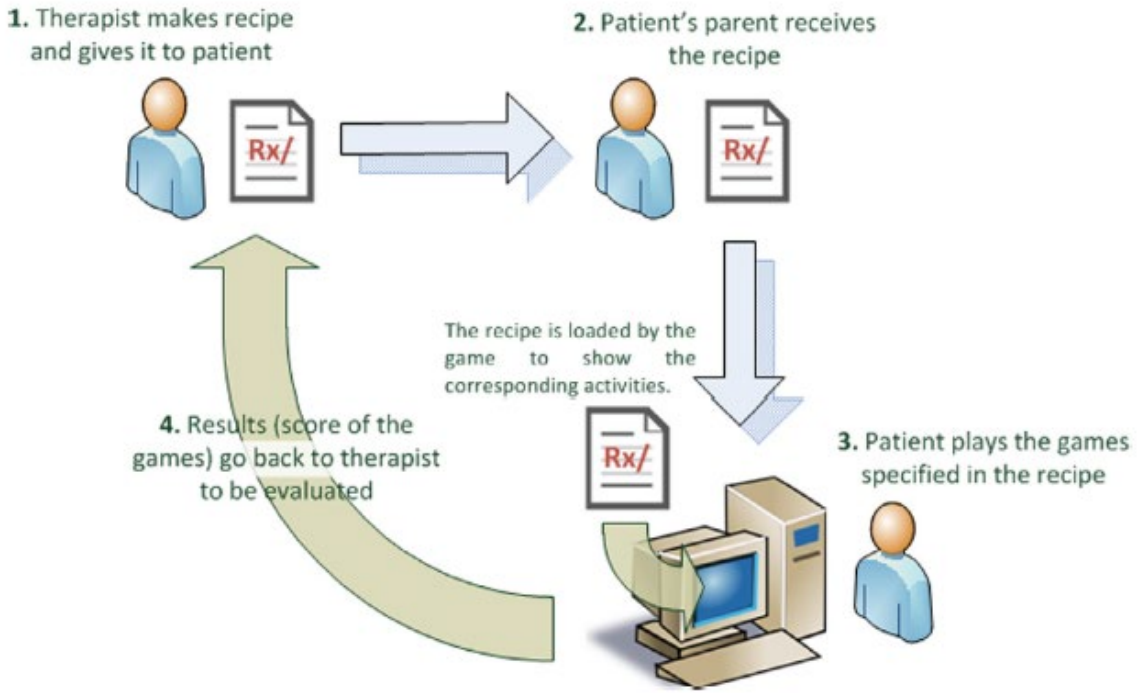
(a) Real-time cartoon display



(b) Objective information of loudness curve

Talking to Teo (Navarro-Newball, et al.)

- A speech therapy tool for articulation training, designed for hearing impaired children in Colombian Spanish
  - Teo (a bear) needs to find other bears in the zoo by practicing several mini games
- Applicable key features: Unassisted therapy activity workflow for therapy at home



Strategies for Vocal Training Game Development

- Important aspects for vocal training game development identified from literature review, stakeholder's needs survey, and benchmarking

No	Scales	Application
1	Usability	Ease of use
		Game mechanics (cause-effect relation) and objectives understanding
2	Narratives	Game story or message should be clear and simple
		Various games
3	Play Engrossment	Tired-less
4	Enjoyment	Fun and bring enthusiasm
5	Creative Freedom	Several type of environment or object or story
6	Audio Aesthetics	Sound effects as a feedback
7	Personal Gratification	Reward and obstacle
		Difficulty level
		Problem-solving strategies & self-control, skill development
		Real-time feedback to make user adjust their speech, Independence performance
8	Social Connectivity	Interaction with other player or facilitator (therapist, caretaker)
9	Visual Aesthetics	Appealing graphics (animation) and user interface, adequate information
		Up-to-date graphics
10	Accuracy	The accurate interoperation of the input with the game contents (microphone accuracy, less-interference)
11	Customization	Depend on user's capability (voice characteristic target (loudness/pitch), duration and repetition)
12	Game Analytics	Record user data, game played, performance, sound recording
13	Therapy Continuity	Integration of therapist's (clinic) and patient's system (home)

Key Features for Vocal Training Game Development

- Based on the identified game development strategy, for effective speech therapy, a vocal training game should provide
  - Explicit goal & reward can be achieved by providing scoring system, counter, and obvious object as target
  - Real-time feedback is represented by loudness or pitch indicator, which shows current status of user's voice.
  - Adaptive play setting by providing customized loudness/pitch target, duration, and repetition
  - Social interaction between therapist and patient can be improved by providing multi player mode.

Discussion

- Contribution
  - Identified important features (13 scales) for vocal training game development from literature survey
  - Identified strengths and weaknesses of existing games
  - Identified needs and strategies for vocal training game development

- Application
  - Applicable to general serious game development

- For future study, development and evaluation of serious games will be conducted based on the identified needs and strategies.

Q & A

Thank you very much for your attention!