# Tongue based hearing enhancement system

Suhyun Cha

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Department of Computer Science
Maynooth University, Maynooth
Co. Kildare, Ireland

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Head of Department: Dr Adam Winstanley
Supervisor: Prof Barak Pearlmutter
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**Abstract**

The number of hearing impaired people have been getting increased all over the world. Cochlear implantation is considered as a primary treatment of high degree hearing impairment. However, there still exist some risks and side effects of this surgical procedure even though there have been a lot of trials and researches over few decades since the first surgery had been conducted because it is invasive way. In this study, we made a system that can help people to recognize the sound better when they have some trouble in hearing by giving them stimulus on their tongue in non-invasive way. We used a ready-made device for giving the stimulus on tongue and implemented a computer program for training the user by guessing the right answer after hearing the sound with the ear and perceiving electric stimulus with the tongue at the same time. To organize the system with this device, we made a cochlear implant system simulator to generate the electric signal for stimulation with Matlab script language to realize all the steps in cochlear implant system. Also, we made a computer program that synchronizes with the device and trains the user by accepting and recording the user?s activity in the Visual C# IDE for convenient construction of GUI program. We undertook an experiment with three subjects to verify the effect of this system. During the experiment, the subjects were trained with this system for 15 days with the vowel-consonant-vowel (VCV) sound samples. After training of that period, the two subjects showed great improvement of almost 49% in recognizing sounds with the stimuli in a hardly-hearing situation compared to recognizing them with hearing only in the same situation.

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# Chapter 1

# Introduction

Recall Ludvig van Beethoven (1770 - 1827) the famous German composer. At the age of 26, he began to suffer from tinnitus and hearing impairment. He used many kinds of hearing aids such as an ear horn. It is a well known story that he tried to sense the vibration of a piano's resonator with a stick with his mouth to feel even a small sound-like stimulation and this effort allowed him to continue his music career, overcoming his huge weakness. He must be the first man who is recorded in history to use tactile sense as a sensory substitution for a human auditory sense. The Braille system is another representative example of sensory substitution application with the tactile sense. Also, it is known that the tactile or hearing sensitivity of blind people is much higher than that of people who have normal visual abilities. Braille is tactile writing system for blind people created by Louis Braille (1829). Using embossed patterns on the paper or similar media, people can touch and understand what the bumpy surface means with their finger tip.

As in these examples, many people already know that the sensory disability can be altered and masked, and many neuroscientists have revealed our brain rearranges its structure logically and physically when the impairment appears in the senses. There have been many practical trial and actually effective improvement in this sensory substitution field such as sensory substitution for vision, vestibular nerve (Bach-y Rita et al., 1969; Tyler et al., 2003; Bach-Y-Rita, 2005). Even though the number of hearing impaired people are increasing and the fact that tactile stimuli can activate auditory cortex was found by Novich and Eagleman (2014), it is hard to find a research about sensory substitution for auditory sense.

According to the WHO[1], there are several causes of hearing loss: age, noise, genetic, illness, medication or chemicals, and so on (WHO, 2015), and noise is the most significant reason among these factors by which the half of the people who are suffering from hearing disorder (Daniel, 2007; Oishi and Schacht, 2011). The mechanism of hearing disorder also varies age, prolonged/temporary exposure to noise, genetic, and so on. Most of the hearing loss is due to damage to the cochlea exposed to noise, so many people try to make the sound louder with a hearing aid or make the cochlea work with cochlear implantation surgery to overcome this problem when the disorder is severe.

There are many hearing assist devices or methods: hearing aids, assistive listening device (ALD), cochlear implantation, and so on. When people have a slight impairment, they can often be helped by a hearing aid. However when the disorder is more severe, strong treatment is needed and cochlear implantation is one of the representative hearing disorder mitigation methods. It has been developing over decades, however, serious risks and side effects remain because it requires serious surgery and is invasive.

This dissertation discusses the effect of tactile stimuli on hearing. Especially, this study will describe the confirmation of improvement effectiveness of auditory sensing rate when the eletrotactile stimuli applied on tongue. This electric signals are made from the original sound by transforming it into the frequency domain wave and making it in the form of pulses. Also, the system designed for training of the electrical stimulus corresponding specific sound will be introduced and discussed to verify the hypothesis.

## 1.1 Dissertation structure

The remaining chapters are structured as follows: Chapter 2 will introduce a few concepts about sensory substitution and hearing mechanism for giving

[1] World Health Organization

background information to understand the followed chapters. Also, the previous researches will be commented and the motivation will be dealt in this chapter as well. In Chapter 3, the design of target system and its implementation methodology will be depicted and then Chapter 4 gives a description of the experiment protocols to verity the hypothesis. Chapter 5 will show the results in Section 5.1, discuss and analyze in Section 5.2, and we will see how much the subjects can get improved their hearing score with the tongue stimulation. In Chapter 6, we will deals with the limitation in the experiment of this project and corresponding future works. Also, it will sum up all the theoretical stuff and practical one as well and it will end up with commenting accomplishment in this project.

Chapter 2

# Related work and background

## 2.1 Hearing and cochlear implant

Many kinds of animals hear sounds with their ears to communicate with others. This minimized, optimized and high efficient auditory system consists of several major parts: pinna, outer ear, middle ear, and inner ear. (Figure 2.1) The outer ear is the external part of the ear and gathers vibration of the air and transfer to the middle ear. In the middle ear, eardrum is vibrated by

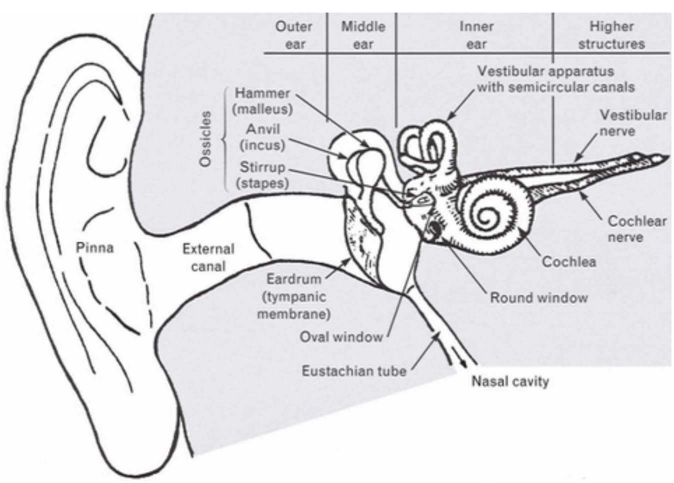



Figure 2.1: Human ear structure (Tierney et al., 1994)

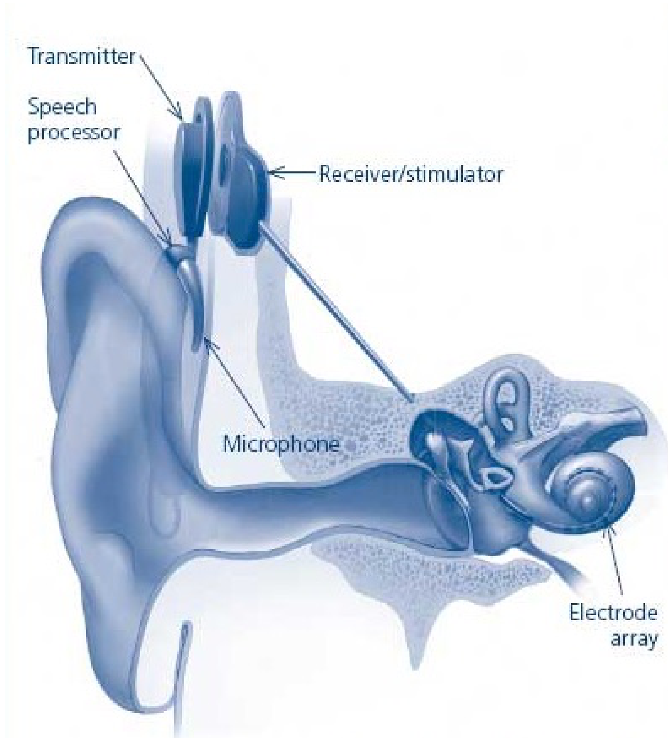



Figure 2.2: Human ear with cochlear implant (NIDCD, 2013)

the transferred air and this vibration is amplified and converted into wave of fluid going through the ossicles. The inner ear, which places at deepest inside, performs a role of sound sensory receptor and sense of balance as well. In the cochlea, main part of the inner ear filled with fluid, there is an array of sensory cells. These cells respond to particular frequency respectively (tonotopy) and transform the mechanical energy to special energy which causes nerve propagation (Von Bekesy, 1960). This energy is transferred to the auditory cortex and finally our brain can perceive this auditory stimulus as 'sound'.

In 1961, William F. House, an American otologist, performed cochlear enthesis surgeries on three hearing impaired persons and let them hear sound. These were the first cochlear implant surgeries. The cochlear implant is an electronic device that stimulates auditory nerves with electric signals transformed from sound signal instead of original one. More precisely, cochlear implants consist of five parts: (external part) a microphone, a speech processor, a transmitter, (internal part) a receiver/stimulator, and an electrode array (NIDCD, 2013). The microphone collects the original sound and transforms it to electronic sound signal by encoding. In a speech processor, sound signal is discriminated; audible sound (speech) signal is taken only and split into several frequency channels by filtering. This split signal is transmitted by the transmitter to the receiver and goes into the stimulator and this part converts them into electric pulses. These pulses are transferred to the array of electrode which stimulates the auditory nerves with the pulses. This treatment got approval of FDA[1] in 1984. Also, More than 3 million people worldwide have received the cochlear implantation surgery as of December 2012 (NIDCD, 2013).

The cochlear implantation is a revolutionary treatment for hearing disorders; however, it still has some potential risks and side effect. Although the cochlear implantation system looks small and simple as it is, the patient will undergo a major surgery. There are many kinds of complications for the cochlear implant surgery in major such as facial nerve stimulation, poor response of the auditory nerve, gradual poking out of the electrode or fault on the location of the electrode, infection like meningitis especially for children, in minor tinnitus, vertigo with sickness, taste disorder (Kubo et al., 2005). Some experts vehemently disagreed with approval of the cochlear implantation surgery due to the side effects at that time and there are still strong arguments both for and against this surgery.

## 2.2 Neuroplasticity and sensory substitution

We use senses to perceive outer environment and communicate with others. There are five senses representatively and other senses such as visceral sense, equilibrium sense. People sense using sensory organization like skin, eyes, ears, nose, and mouth and perceive them with our brain.

[1]U.S. Food and Drug Administration

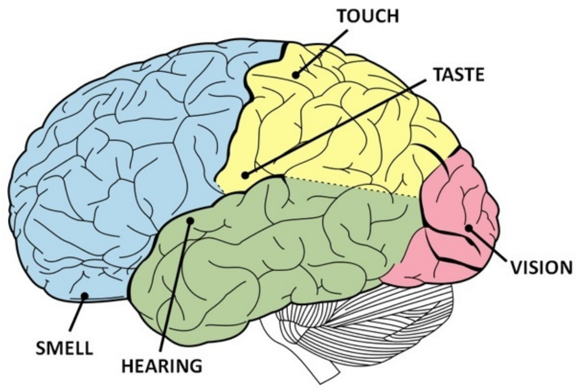


Figure 2.3: Human brain and five senses (Wiki-commons, 2015)

Before around 20th century, neuroscientists believed that brain structure was fixed and could not be changed after childhood development. However, after that, modern neuro-scientific researches show that the correspondences of the area in the brain and the senses are not fixed and the experience or training could change the physical structure of the brain, which is the arrangement of neurons, as well as the functional structure. This is neuroplasticity. Plasticity is a concept of physics and material science that means objects forced from outside reform their shape and hold it even though the force is removed. Similarly, our brain can change some part of it to roll and function differently as well as reorganizing neural cells and structure through continuous fabricated information or altered experience. This neuroplasticity is a kind of adaptation. For example, the auditory cortex of a hearing impaired person using lip reading to understand other's saying responds to seeing movement of lips (Calvert et al., 1997). Also, visual cortex cell reacts to the Braille's tactile stimuli instead of doing nothing even though the somatosensory area is located far from the visual cortex (Sadato et al., 1996). The brain reorganizes the neurons adaptively to make it substitute a sensory system for damaged one, so if someone has a hearing loss, cross modal plasticity will compensate by intensifying other sensory system function. Like these cases, making the brain work different is possible by experience and this is the concept of sensory substitution when it comes to the senses.

## 2.3 Previous work

W. James advanced that nervous tissue seemed to have a attribute of plasticity (James, 2011) and it is known evidence of neuroplasticity was shown by Karl Lashley (1923), which demonstrates rearrangement of neural structure. This early research on plasticity was quite innovative at that time but other people did not accept that concept and ignore it (JOJA, 2002).

More innovative research and the results began to appear in earnest about 40 years later started by a celebrated American neuroscientist, Paul Bach-y-Rita. He developed a device which called TVSS (Tactile Vision Sensory Substitution) and this is the most nearest application that uses the concept of sensory substitution up to now (Bach-y Rita et al., 1969). He thought that other senses than vision could take place impaired sense of vision and he believed that our brain could adapt this new pathway of seeing not through the eyes but through the tactile receptor. This device uses an image converter which transforms the captured image using video camera into a tactile signal and stimulates the back of the blind people. This was the first trial of stimulating skin, which is the receptor of tactile sense, with a tactile signal for sensory substitution and actually people could feel and detect what they see through this device. He kept researching about the sensory substitution and he found out that perception rate is different from the area of our body (Bach-y Rita et al., 1969). He had perception test on abdomen, back, thigh, fingertip, and tongue and he concluded that tongue is the most sensitive and effective part among these for perceiving tactile stimulation. Moreover, tongue is very stable place for electro-tactile stimulation due to the closed structure of mouth and the saliva which is good conductive component for electro-stimulation. He adapted this fact to the early TVSS device and developed a device for blind people that captures video, changes into electrical stimulation pattern, and stimulates the surface of the tongue with the electric signals.[2] Also, there is another type of sensory substitution of vision, which uses sound. Meijer made a system for auditory image representation (Meijer, 1992). His approach was transform of image information to sound

[2] BrainPort® V100, Wicab Inc., Middleton, USA

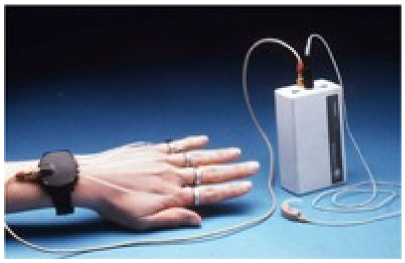
spectrogram. The vOICe[3] is the program for this type of sensory substitution and it can be adapted to a type of glasses with ear set.

Close to the ear, there also have been some efforts for substitute our ears. The biggest role of human ear is hearing and balancing. The vestibular functional disorder which causes the postural wobbling and unstable actions could be helped by electrically stimulating tongue with the information of the head-posture (Bach-Y-Rita, 2005; Tyler et al., 2003). For hearing, M. Schüroan had an experiment about the relationship between the tactile stimulation and the auditory cortex reaction and found that these stimuli facilitate auditory sense of the people who has hearing disorder as well as normal hearing ability listeners (Schürmann et al., 2006). Some tactual stimulating devices were developed such as Tickle Talker™, which uses electrotactile stimulation on fingers, and Tactaid, which uses vibrotactile stimulation on skin (Lynch et al., 1992). Also, a vibrotactile sensory substitution device, which is a type of vest, was disclosed (Novich and Eagleman, 2014). This vest consists of cloth part and sound-to-touch mapping device. It uses user's smart device as a sound analyzer and compressor to collect sounds and digitize them, and then the touching signal generator processes transferred signal and gives them on the back of the user. (Figure 2.4)

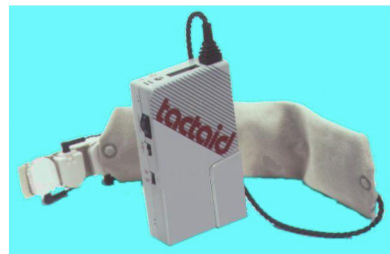
## 2.4 Conclusion, motivation and the research question

Sensory substitution for hearing disorder has also been advanced even though it looks slower compared to the vision which has abundant effort and development. Especially tactile devices has been researched for improvement of speech recognition over few decades and many devices have been launched. However, it is still too early stage to alternate the conventional treatment, cochlear implantation, despite of its disadvantages and impossible cases while visionary sensory substitution devices have become popular. So using the sensory substitution attribute of our brain, impaired auditory sense might

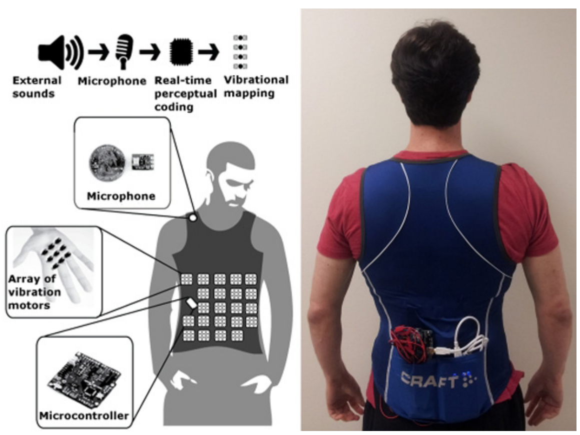
[3] http://www.seeingwithsound.com/



(a) Tickel Talker




(b) Tactaid




(c) VEST(Tactile vest)

Figure 2.4: Tactile auditory sensory substitution devices

be helped enough to recognize sound, and it would be much better if the substitute is handy, easy wearing, and safe enough to use it. To realize and verify this, we used electro-tactile stimulation on tongue for sensory substitution of hearing. As mentioned above, tongue is a manageable and sensitive organization to percept tactile stimuli, so tactile sense on tongue could alternate the auditory nerve in the inner ear. In Chapter 3, a concrete process to verify this hypothesis will be described. During pursuing this research, there were some news articles that there had been similar approach for electro-tactile sensory substitution for hearing impaired using tongue in Colorado State University in USA, no result of some experiment or analysis have been announced.[4]

[4] http://source.colostate.edu/words-mouth-csu-device-lets-hear-tongue/

# Chapter 3

# System design and implementation

The goal of this study is to let the hearing impaired recognize sounds. A lot more information is in the form audio only or with video than text including daily life conversation. So, the form of the information for the substitution organization should be directly converted from audio signal not passing through the process of dictation and encoding unless we attach the proper system for that. For this reason, the structure of cochlear implant system is adopted. As described in Chaper 2, the electric signal is generated by transforming the audio sound lively in the cochlear implantation system.

The main hypothesis in this thesis is that simultaneous auditory signal transduced on the tongue with the sound arrived at the ear can ameliorate the hearing loss. The fact that we use here the tactile sense can substitute auditory sense and the assumption is the tactile nerves, which are located on the tongue, will play a role as auditory nerves. Cochlear implant system, the device that mimics the part for stimulating auditory nerve, is adapted to stimulate the tongue. The stimulated target is changed so the stimulating manner should be changed. To stimulate the tongue, we use a commercial device, mutebutton™ (Neuromode Device Ltd., Dublin, Ireland). It is a device for tinnitus treatment and has an audio output socket and a tip which would be located on tongue. This device is a sound playing and electric signal


Figure 3.1: Tongue stimulating device

generating device at the same time designed to deliver electrical signals to the human tongue and the corresponding audio sound signals to the human ear working with SD flash memory (size of 8.5cm x 11.5cm). The tongue electrode array is based on intro-oral device with 32 medical implantable grade stainless steel electrodes. Stimulus magnitude can be controlled in 18 steps from the minimum voltage of 3V to the maximum voltage of 12V by rotating amplitude control wheel which is location on the back of the device and this allows the user to adjust the levels to their own comfort levels, and the sound level can be also adjusted with a separate dial. The model number used in the experiment is MB2011 and the firmware version is 1.0.

## 3.1 Cochlear implant system simulator

This is the concept that the cochlear implant system stimulates the tactile nerves on the tongue, so the system that generates the electric signals for stimulating tongue is needed. We referred to Loizou (1999) for the structure of the cochlear implant system simulator.

The system consists of three parts: band pass filter, envelope detector, pulses and packet generator. When an audio signal goes through this simulator, it will make a WAV file consisting of original sound and proper pulse data array for the device which will be appeared on the electrodes of the tip. This system is made in Matlab script using MATLAB and Filter design & Analysis Toolbox (Release R2015a, The MathWorks, Inc., Natick, Massachusetts, United States) to use various mathematical libraries and matrix calculations. We will pick a sound sample of /i:vi:/ as an example to show the results of each step.

### 3.1.1 Source audio signal

All the processing processes assume that the signal sampling rate is 44.1kHz because the proper sampling frequency is that to be played in the device. Also, we chose the the maximum bandwidth to deal with the sound to be 8kHz according to the human speech bandwidth (Deller et al., 2000).

### 3.1.2 Band pass filter

Band splitting in cochlear implantation system is to separate the captured signal according as the frequency levels which correspond with the auditory nerves. Similarly, this simulator will split the signal into eight different bands. Prior to this, sound from WAV file should be transformed into frequency domain using Fourier transform, which is a mathematical function to transform a wave of time domain into frequency domain. The sound consists of the signals of various frequencies, which are known as 'tone'. With the transformed signal, we can figure out the characteristics of sound signal. Going through this band pass filter, the transformed signal is first split into eight bands. The reason for the number of bands is that proper number of electrodes to distinguish sentences for cochlear implant system is eight (Loizou et al., 1999). For choosing the manner of frequency splitting, we chose to split the frequency band evenly 1kHz so the bands were like (0 to 1kHz), (1 to 2kHz) and so on because of the simplicity even though mel

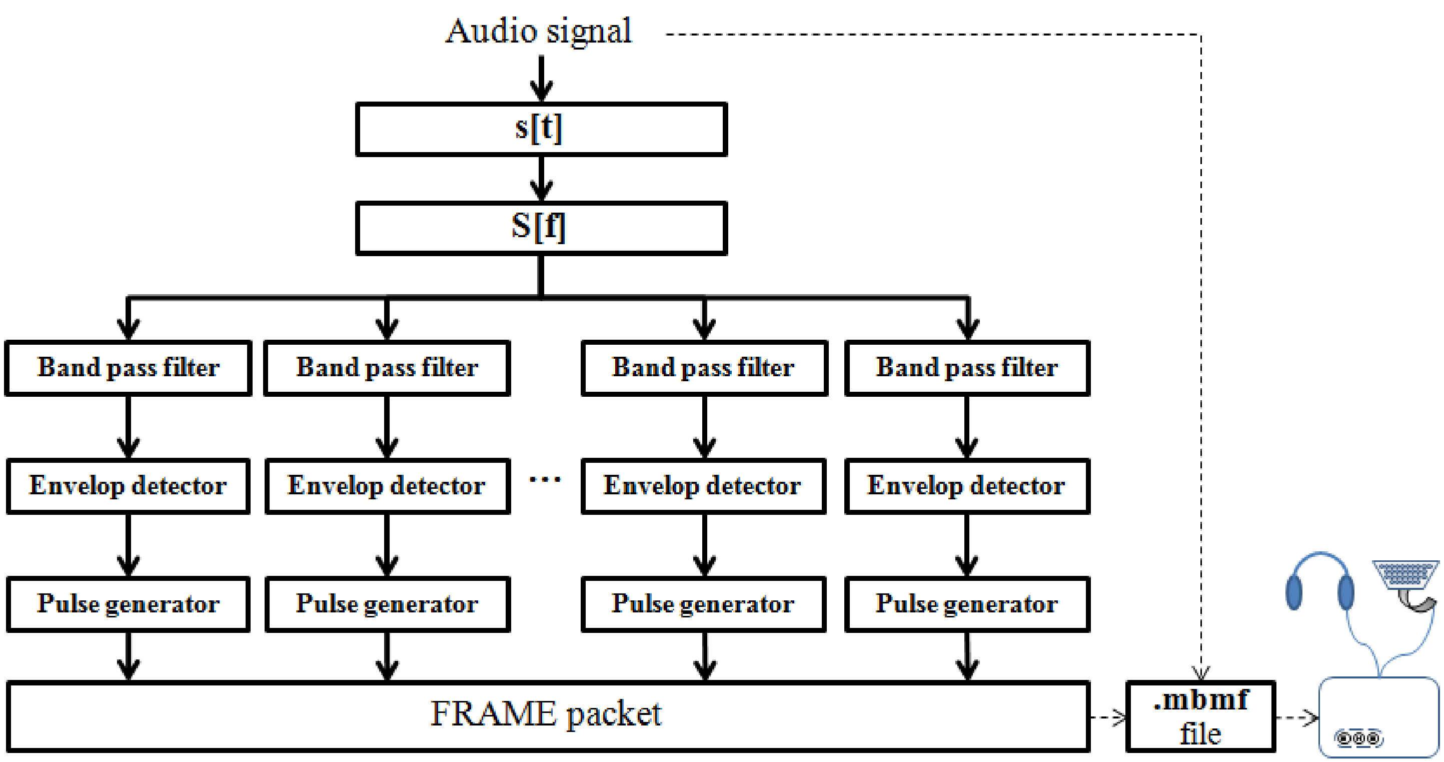



Figure 3.2: Overall Structure of the cochlear implant system simulator

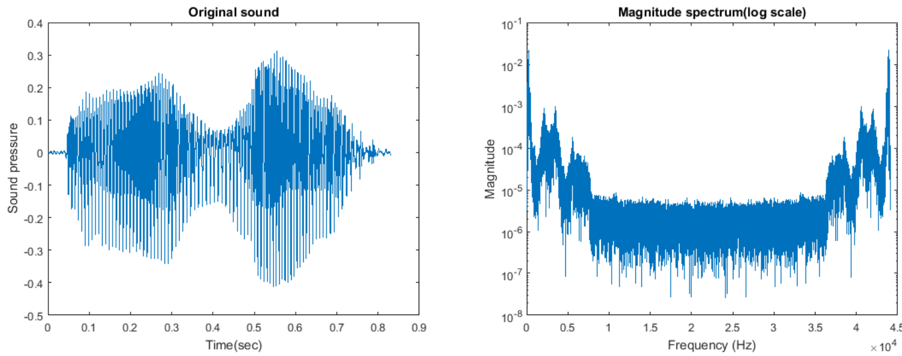



Figure 3.3: Left figure shows the speech signal of /i:vi:/ sound spoken by a male speaker and original audio signal wave. The figure on the right shows the magnitude spectra. Almost all of the frequency components exist inside of 8kHz.

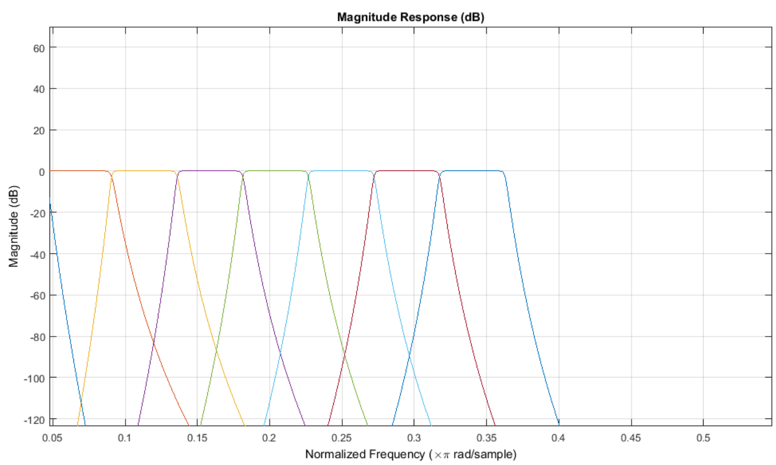



Figure 3.4: Frequency response of each band pass filter

scale (Stevens et al., 1937) which is a perceptual scale by listeners is general strategy for sound processing. Designing band pass filter, 3dB cutoff frequency of each side of the each filter was considered to be overlapped with the adjacent band pass filter due to neglecting overlapping effect. We chose the filter order of 30, higher than normal filter, so we could have the signal cut clearer.

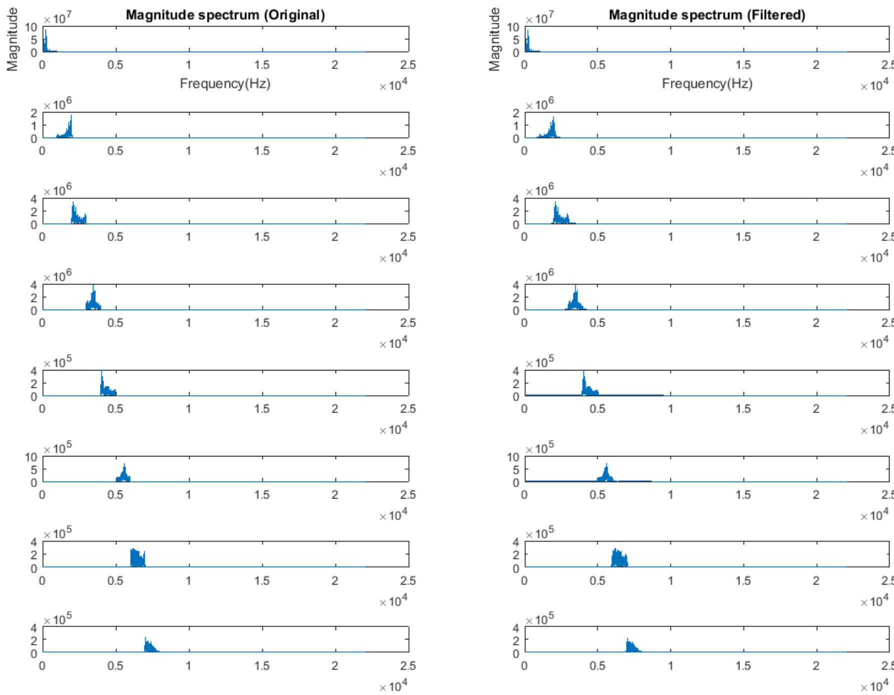
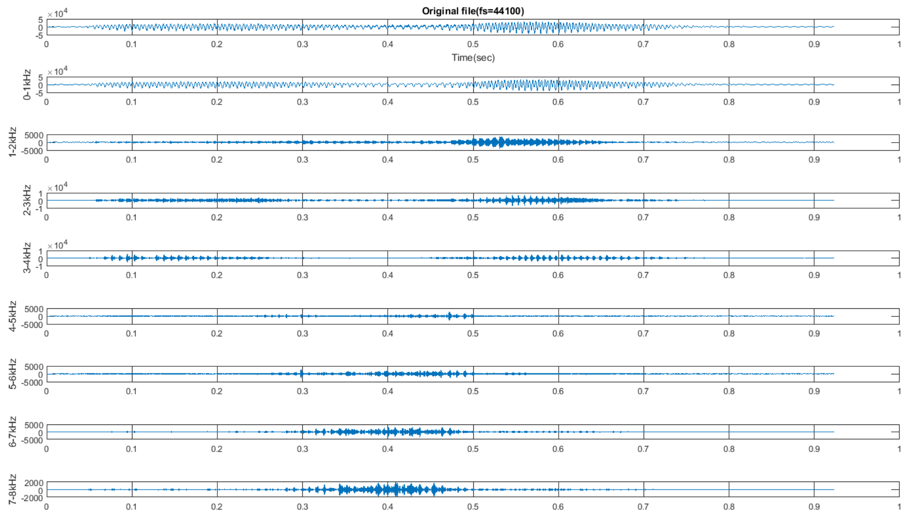


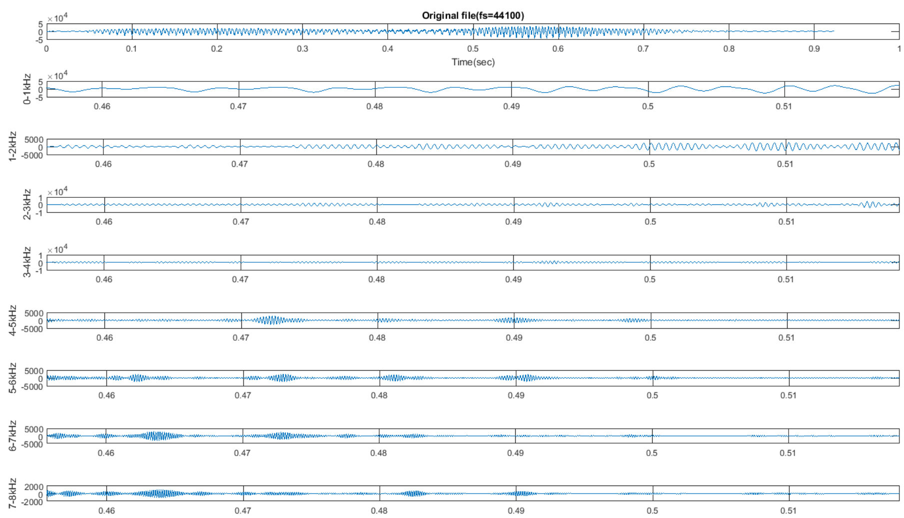

Figure 3.5: Original signal displaying each section (left) and the result of the band pass filter (right)

### 3.1.3 Envelope detector

Signal which is split into eight frequency bands is converted back into time domain signal and goes into the envelope detector which will extract the envelope of the signal. An envelope of a signal represents amplitude of the analytic signal and shows information about the characteristic of a signal, which shows how the signal magnitude changes as time varies. Every phoneme has its unique frequency characteristic so every different sound has the different frequency wave pattern. To extract an envelope from the signal, Hilbert transformer is used.




(a)




(b)

Figure 3.6: Output of the band pass filter of /i:vi:/ sound sample. (b) is magnified version of (a) to show the difference of each band frequency.

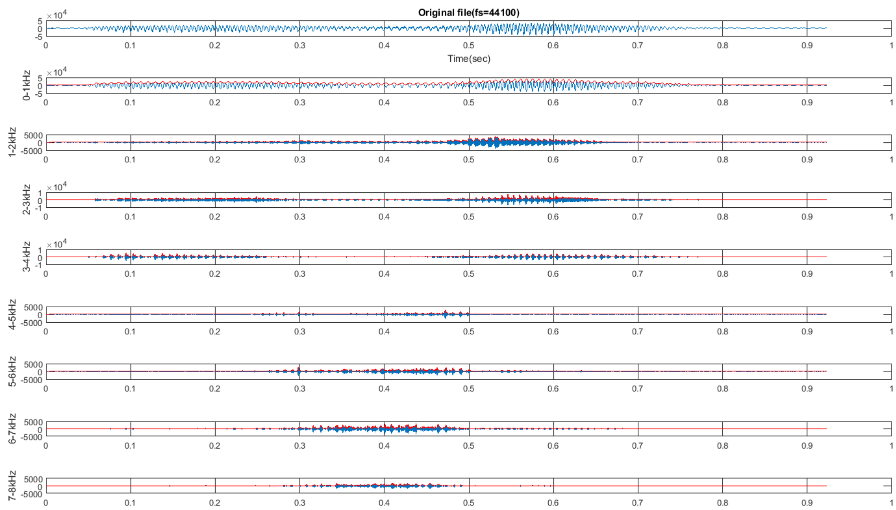



Figure 3.7: Envelope of each signal (red)

### 3.1.4 Pulse and packet generator

In cochlear implant system, pulses would be generated according to the envelope in the proper form for the electrodes which stimulate the auditory nerves. In this simulator, the device plays the role of electrodes with the electrode tip to stimulate the tongue. So it needs proper pulse attributes such as signal duration or amplitude and arrangement of the pulses to be played. The device will generate electric signals in the frequency of 0.232 ms so the result of the envelope detector should be sampled in every 1024 samples. In this simulator, the averaged values of every 1024 samples were taken. Before making this matrix rearranged in a 16 bit integer array to make it fit to the device format, electrodes need to be grouped because the number of bands (8) does not fit to the number of electrodes (32). Also, even though tongue is one of the most sensitive site among human skins enough to percept a stimulus spaced almost 0.5 mm (Van Boven and Johnson, 1994), the more space each electrode has, the easier the tongue and the brain can detect the signal levels. For these reasons, every 4 electrodes adjacent are

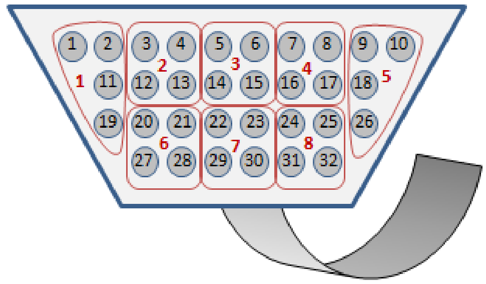



Figure 3.8: Electrode groupping

grouped according to the location and generates same electric signals and deliver the same stimulus.

| Electrode group number | Frequency |
|---|---|
| 1 | 0-1000Hz |
| 2 | 1000-2000Hz |
| 3 | 2000-3000Hz |
| 4 | 3000-4000Hz |
| 5 | 4000-5000Hz |
| 6 | 5000-6000Hz |
| 7 | 6000-7000Hz |
| 8 | 7000-8000Hz |

Table 3.1: Frequency allocation for each electrode

**Electrode grouping** This device uses a WAV file of 44.1kHz sampling frequency and 16 bit little-endian encoded to play the sound at the same time with 2 channels of original sound information and 1 channel of pulse array information. The simulator should make a result file to be able to work on the device. Original sound data should be encoded 16 bit format so all the data would be normalized to the scale of 32768 (signed). If the audio source is not encoded in 44.1kHz, it should be changed, and this format changed signal data is written in a new WAV file and the pulse information is added in the form of additional channel to the WAV file.

## 3.2 Tongue based Hearing Enhancement System (TonHES)

We designed a system which would interact with user for training and experiment. Even though the device can let the subject to listen to the sound and get the stimulus, the system which will gather the user's guesses and make the user trained by showing the right answer about what they had heard was needed. So, this system shows whether the answer, which the user has selected, is correct and collects the all results as well as their activity during choosing the answer. For development, Visual C# IDE[1] was used because it is convenient to construct a windows form based GUI program whose environment normal users are familiar with. We use NAUDIO 1.7.3[2] to control the audio input for synchronization of the program with the device.

For this system, the user will have two different signal to recognize sound: audio signal and electro-tactile signal. The tongue simulating operates by the file which made by the cochlear implant system simulator. This plays sound and generate electric signal on the tongue tip at the same time. The user clicks the answer, their best guess, after hearing and feeling a sound sample.

We define the sound set structure first which was used for the experiment in this study. The sound set consists of two parts: information sound part for measuring sound level and test sound part. Information part is to indicate the set ID and provide the basis of the sound level. Test part is for test sound sample beginning with short beep sound and ending with 8sec of silence.

### 3.2.1 Test set selection

When the program is executed, a small window form pops up. In this form, the user will select proper set as planed and their ID. This information is used for reading answer set of the test and result file generation.

[1]Integrated Development Environment
[2]https://naudio.codeplex.com/

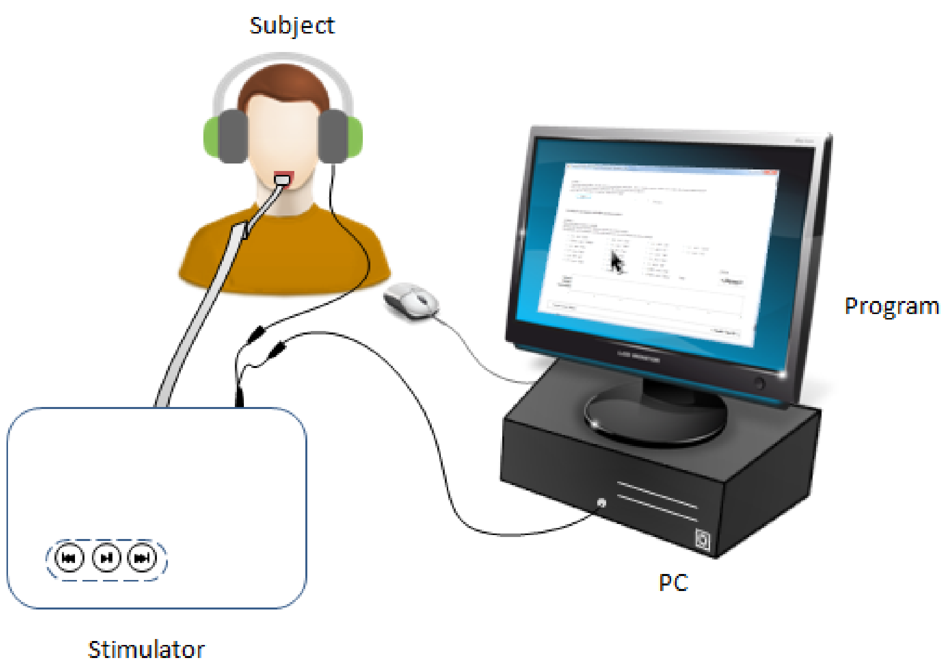



Figure 3.9: System diagram

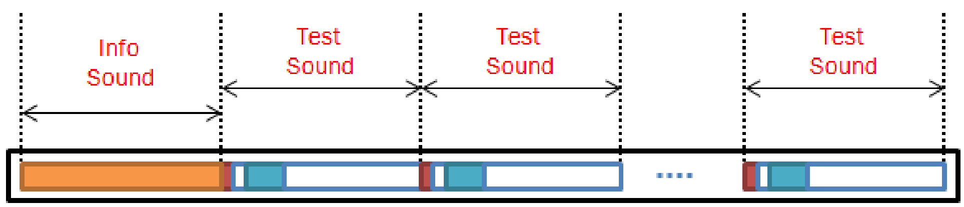



Figure 3.10: Sound set structure

### 3.2.2 Input level estimation for synchronization

The most significant process in this system is synchronization. As the device, mutebutton$^{TM}$, is just one way like a conventional music player with a button on it to start playing which plays the files only in the external memory and does not provide any connection with computer for any control or interaction, there is no way to be aware of the state of the playing. To solve this problem, played audio sound would work as an input of the program using sound duplicator. By listening to some detectable sound, which

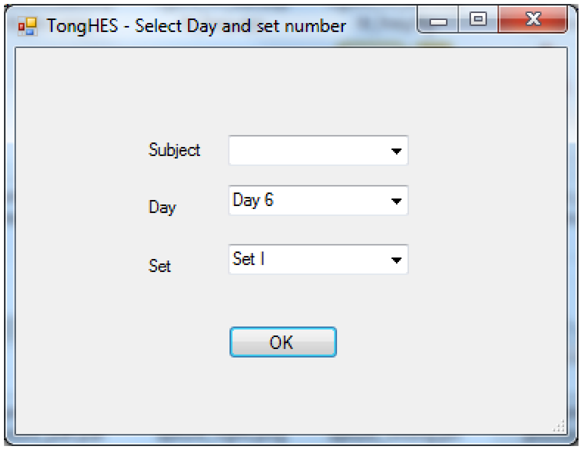



Figure 3.11: A screen shot of the pop-up window for setting up the test session

plays a role of sound tag like beep sound, the program can detect a certain point of played sound. At first, the program will listen to the basis sound to detect the sound level and calculate the threshold level for accurate synchronization. A consistent sound is easy for detection and decision, so a 5sec of 21kHz sound sample is used for this step. This frequency over human's audible frequency so does not bother the listener. The sampling frequency of the file which is played by the device is 44.1kHz and the duration of audio recording part of the program is 0.1sec, so there would be 4410 samples in one buffer. The program calculates the expected sound level by getting mean value of the signal power of 20 samples captured within 2sec. The sound is consistent so the mean value of this captured sound should be $\sqrt{x/4410}$ when x is the averaged value of 20 samples without minimum and maximum value for the case of unexpected interrupt. In addition to the excluding abnormal value, this system accepts the result of signal level only when the standard deviation of all samples is less than 10% of the mean value for accuracy as well. This estimated signal level is used for calculating beep sound recognition threshold. Each sound sample begins with a short beep sound (0.3sec) and the mean value of all autocorrelation of the every 4410 beep sound samples is almost 726.8 so maximum cross-correlation threshold is ex-

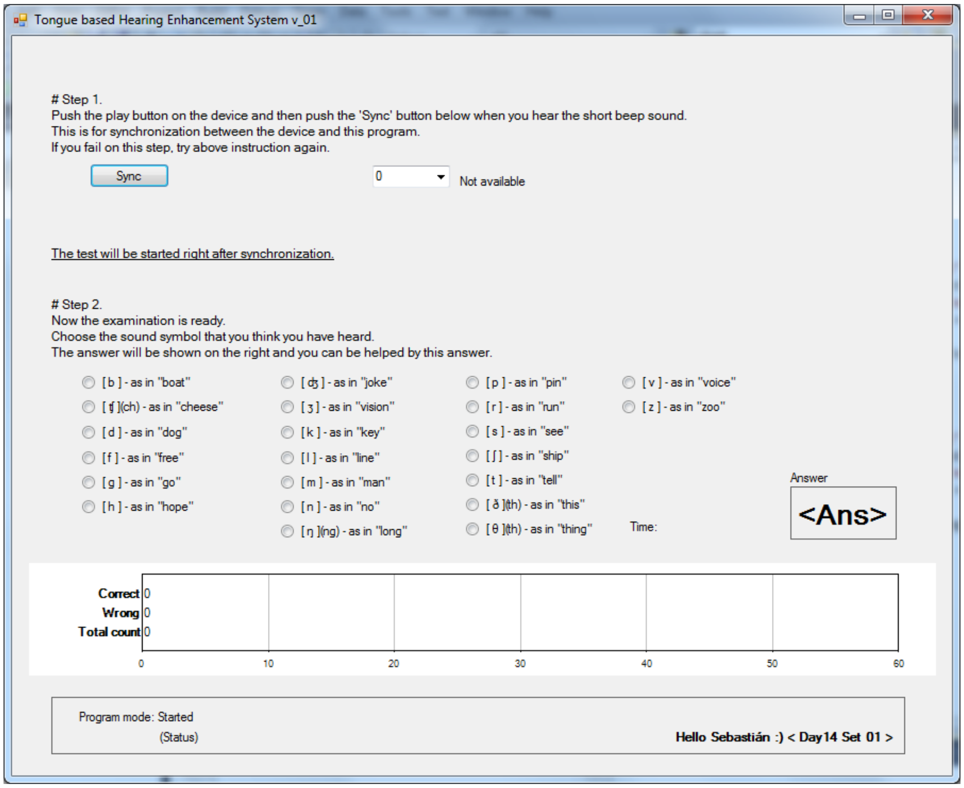



Figure 3.12: A screen shot of the main program

pected to be *calculated signal level* × *mean value of the beep signal level* × *the number of samples* when the beep sound played. To make it flexible for various input PC environment, there is a dropdown list for choosing the input device and the system will check the availability automatically. If the input device is not available, the test cannot be processed.

We tried to adapt some sound recognition schemes, such as audio codes, to detect the sample count in the session. This could be helpful when the synchronization breaks, however, we just considered the beep sound recognition due to the time limit.

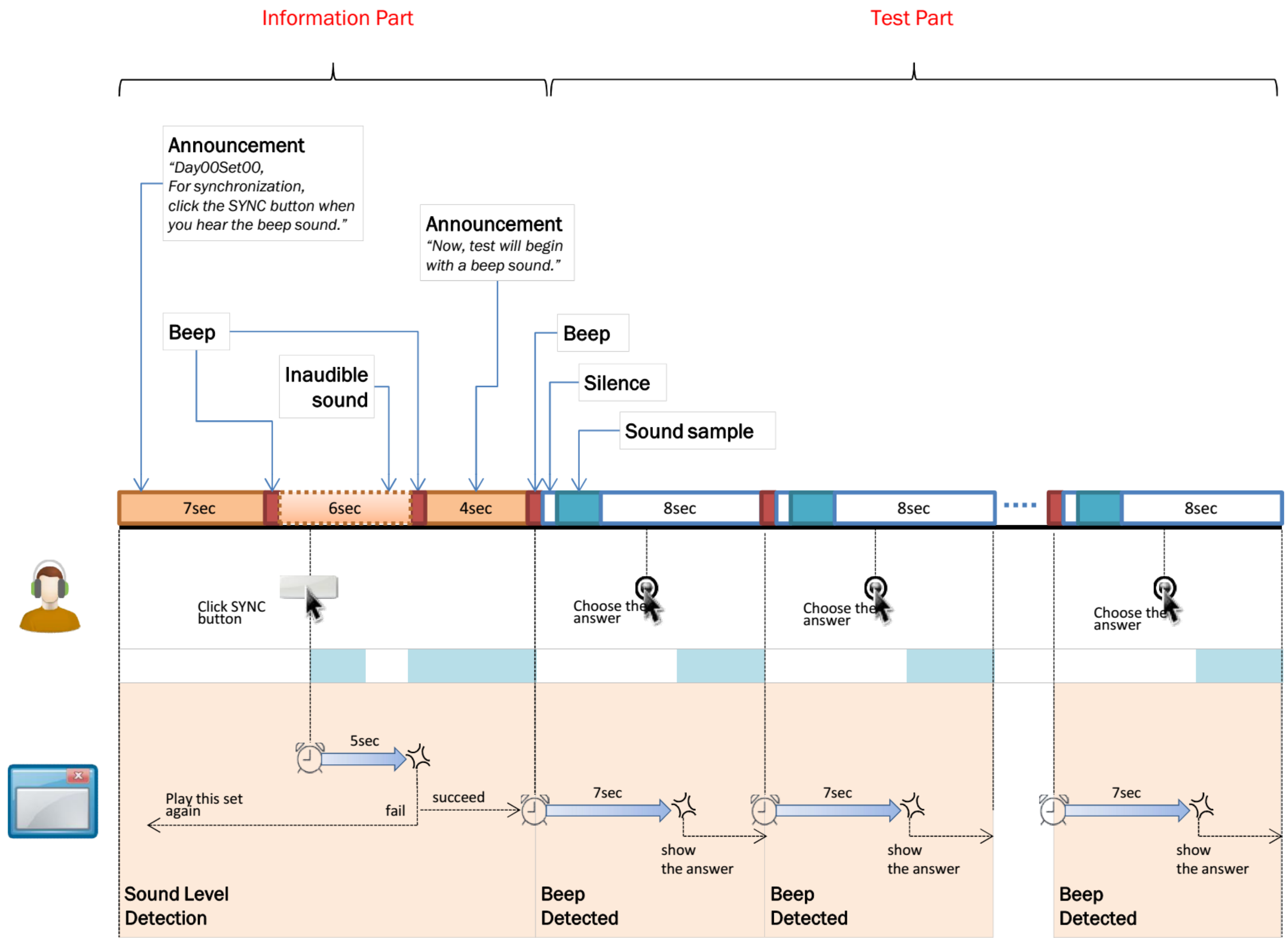



Figure 3.13: This figure shows the user activity and synchronized process between the played sound and the program. When the audio session started, the program will know it is started and is time to catch the audio sound level when the SYNC button is clicked by the user. Every time it catches the beep sound, it knows every sample is started.

### 3.2.3 Choice selection and showing answer

After preparing for synchronization, the test session begins. The program waits for the beep sound after a timeout of the sound level detection (in the information part) or each choice detection (in the test part). It recognizes the beep sound by calculating cross correlation and comparing with the threshold which was obtained in the input level estimation stage. Once beep sound detected, a timer counts 7sec and it shows the answer when the time is over until the next beep sound is detected. The answer has been read already from a file which has a sequence of encoded numbers for sound symbols when the windows form is loaded by using the transferred information of previous windows form. The user should select the choice according as their guess in 5sec after the sound is played and then the answer will be shown around 2sec until the next beep is detected. Figure 3.13 shows the synchronization and timeout process.

### 3.2.4 Display of program status and user activity logging

To give the information to the user such as program status and the experiment progress, there is a progress bar and status box. 'Datavisualization.Charting.Chart' component is used to implement the progress bar and this progress bar shows three bars: the number of the user got correct or wrong and the samples count. In the status box, the subject can check the program status such as success or failure of the audio level calculation, recognition of the next sound sample, session identification number, and so on. This information lets the user know whether the program is working well. Also, this system records all the user activity of choosing answers with its occurrence time. This data will be used to analyze user confusion or hesitation between similar choices due to the similarity in the sound classification.

# Chapter 4

# Experiment

This experiment was designed to measure the alleviating level of hearing loss by the corresponding tactile stimulus with the sound on the tongue. This included training course to be familiar with the stimuli as well as the recognition rate measurement. The training was undertaken like a test, but their tongue could learn the stimuli while they were taking. After scheduled training, the subjects had a test to measure the improvement.

## 4.1 Subjects

We had three subjects with normal hearing of ages of 24 (male), 27 (male), and 24 (female). They did not have any oral diseases such as ulceration on tongue or oral mucosa and any ear disorder such as hyperacusis. Also, they all had English reading, comprehension and written.

| | **Subject 0** | **Subject 1** | **Subject 2** |
|---|---|---|---|
| **Gender** | Male | Male | Female |
| **Age** | 24 | 27 | 24 |

Table 4.1: Profile of the subjects

## 4.2 Sound samples

Consonants are quite important for perception of meaning (Owren and Cardillo, 2006). Owren also quoted that hearing impairment has discriminated effects on consonants and vowel recognition, and consonant perceptual performance is worse than the one of vowels. As mentioned in Chapter 3, the goal of this study is to verify that directly encoded signal according as the frequency response of the sound signal can be recognized by stimulating the tongue. We choose consonants as a sample sound. Also, almost speech recognition experiments are established on the consonant recognition measurement with vowel-consonant-vowel format sound (VCV) like /a:ba:/ and /i:bi:/ (Tierney et al., 1994). For this experiment, 22 VCV samples with V=/i:/ were taken from the Lexical Access From Features (LAFF) VCV database of MIT Speech Communication Group.[1] We changed the original sampling frequency of these samples of 16.1Hz into 44.1kHz to fit the stimulation device requirement. In addition to this, we took samples of two different male speakers to consider the effect of the specific characteristic of sound sample such as length of the pause, so we could have the speaker diversity.

| ID | Phoneme | ID | Phoneme | ID | Phoneme | ID | Phoneme |
|---|---|---|---|---|---|---|---|
| 0 | v | 6 | th/θ/ | 12 | n | 18 | g |
| 1 | z | 7 | sh/ʃ/ | 13 | ng/ŋ/ | 19 | p |
| 2 | th /ð/ | 8 | h | 14 | r | 20 | t |
| 3 | zh/ʒ/ | 9 | ch/ʧ/ | 15 | l | 21 | k |
| 4 | f | 10 | dj/ʤ/ | 16 | b | - | - |
| 5 | s | 11 | m | 17 | d | - | - |

Table 4.2: Set of consonant used in this experiment

## 4.3 Noise addition

The type of hearing loss is classified according to the frequency domain characteristics. There are five categories in hearing loss normally: ski-slope

[1] http://dspace.mit.edu/handle/1721.1/25142

(mild loss in the low frequency, deep loss in the high frequency), reverse-slope (opposite to ski-slope), flat loss (approximately the same loss at all frequencies), cookie-bite (deepest loss in the middle and the curve is higher at lower and higher frequency), and reverse cookie-bite (lightest in the middle and lower at both end sides frequency) (HEAR-IT-AISBL, 2015). In this study, we will simulate the flat noise in frequency domain by adding white noise without specifying impaired frequency section. Figure 4.1 shows sound signal corruption by changing SNR level.

## 4.4 Experiment plan

### 4.4.1 Pre-test: Measurement of recognition profile

Phoneme recognition ability of each subject was measured individually before main training session started using randomly arranged 60 VCV sound samples with different noise level of 15dB, 10dB, and 5dB. These noise level bases were taken based on the consonant recognition score in white noise as in Andrassy and Hoege (2006). Even though there is a data for the common recognition rate of those SNR levels, it would depend on who the subject is and how the experiment environment such as audio sound level is. So we measured the recognition ability of subjects in each SNR. To reduce the effect of unfamiliarity of VCV sound and noised sound, the subjects had been trained with 60 samples in each SNR level, 180 samples in total, before the measurement as well as the two sets of clear sound.

### 4.4.2 Training 1

The training continued for 15 days including intermediate and final measurement. The intermediate progress measurement was scheduled at the end of first half of total training period and the final one would be after the end of the whole training period.

In this training period, each subject would have three sessions a day and each session consists of 60 VCV sound samples. All the subjects had the same set (arrangement) of consonants. It took 10 minutes to execute one

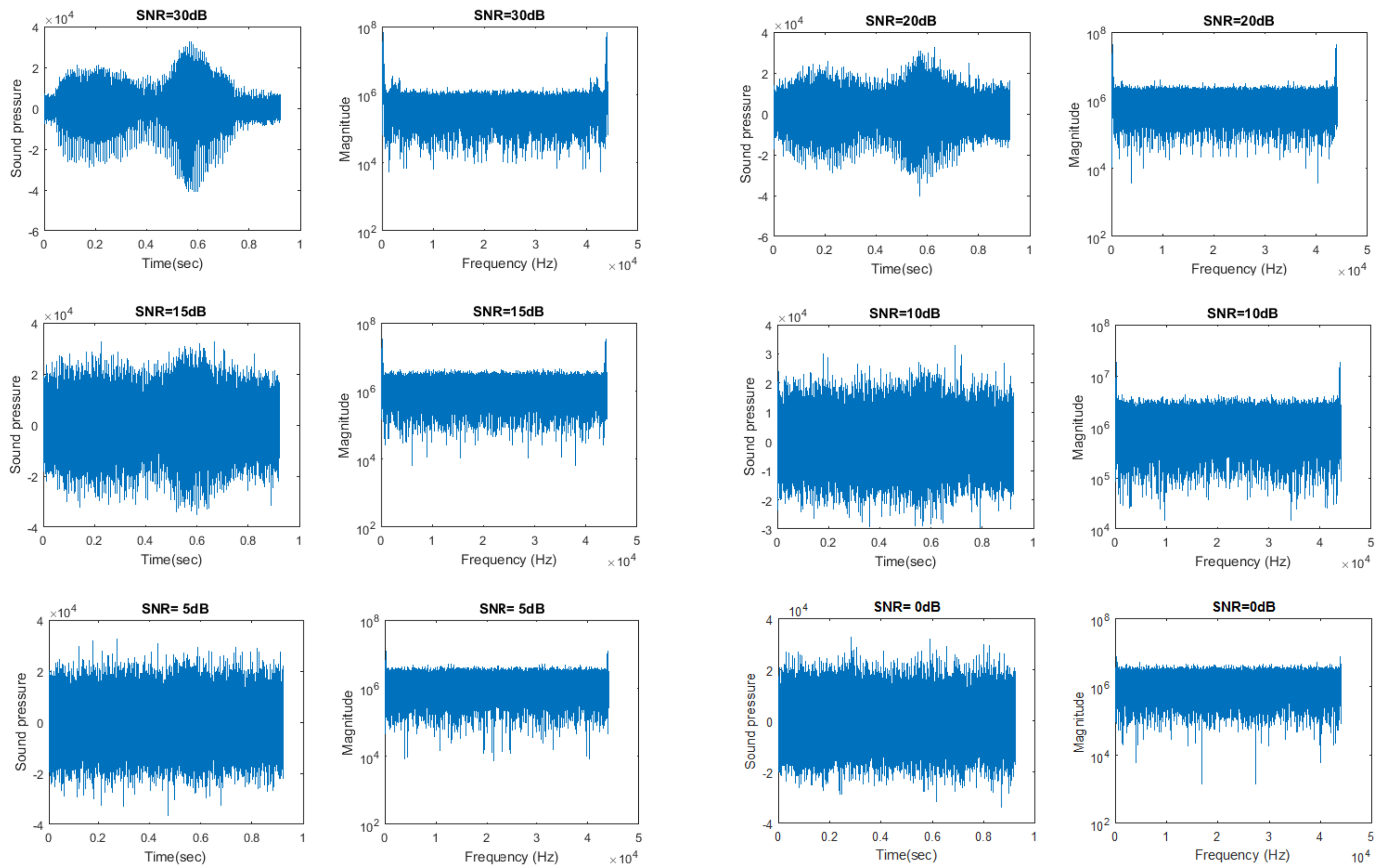



Figure 4.1: Sound signal corruption by changing noise signal level

session including all the silence between the sound samples to give subjects some time to choose the answer. (Refer to the sound set structure in Chapter 3.) In everyday training, the first session began with a set of clear sound to facilitate the mapping between the stimulus on tongue and the corresponding sound. It was followed by corrupted sound by noise sound set (two sets of clear sound for the first day) and the noise level getting higher as day passes from 30dB. Each VCV sound samples were played in audio signal as well as the electro-tactile signal at the some time. Detailed training schedules for subjects are shown in Appendix.

### 4.4.3 Intermediate measurement

After training of eight days (seven days for Subject 2), the recognition ability of each subject was measured with and without the tongue tip in various SNR levels of 15dB, 10dB, and 5dB. In the test, the subjects took five sessions: first two without the stimuli on the tongue and later three with it. All the number of appearances of each consonant were set to be distributed almost evenly in each SNR level, and each set of same SNR level consisted of 40 for non-stimuli and 60 for with-stimuli. Table 4.6 shows the number of appearance of each consonant for the first half training 1 and intermediate test. Detail test data are shown in Appendix.

### 4.4.4 Training 2

After intermediate measurement, the number of the consonant was reduced to realize more concentration of the experiment by selecting fewer consonant. The consonant selection was conducted upon consideration of consonant confusion group and its achievement. We adopted a confusion matrix from Fant et al. (1966) not from Miller and Nicely (1955) because it includes more consonant sounds such as /ʧ/, /ʤ/, /r/, and /l/ which are not included in the Miller & Nicely's. This classification of consonants is based on the manner of articulation so the consonant members in each manner have similar frequency statistics. This feature coincides with this study because we use the frequency characteristics of the sounds. Also, choosing the representative consonant for each category will be helpful to observe the effect of the tactile stimulation on the tongue over the all kinds of consonants.

| No. | Classification | Phonemes |
|---|---|---|
| 1 | Voiced fricative | v, z, th/ð/, zh/ʒ/ |
| 2 | Unvoiced fricitive and whisper | f, s, th/θ/, sh/ʃ/, h |
| 3 | Unvoiced affricate | ch/ʧ/ |
| 4 | Voiced affricate | dj/ʤ/ |
| 5 | Nasal | m, n, ng/ŋ/ |
| 6 | Liquid | r, l |
| 7 | Voiced stop | b, d, g |
| 8 | Unvoiced stop | p, t, k |

Table 4.3: Consonant classification

Base strategy to select the consonant was the lowest marked consonant, but some groups that seemed to be recognized regardless of SNR level were excluded and more than one consonant was selected for some groups if they are tied. So, all the selection of consonants for each subject was described in the table below.

| Class No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| **Subject 0** | z, v | f, s | ch/ʧ/ | dj/ʤ/ | m | - | g | - |
| **Subject 1** | z | f, s | ch/ʧ/ | dj/ʤ/ | m | - | g | k |
| **Subject 2** | th/θ/ | f | - | dj/ʤ/ | n | - | - | t, p |

Table 4.4: Consonant selection for each subject

We made training set using those selected consonants adaptively to the daily result for each subject. The marks of all subjects were analyzed every day and the weak ones appeared more than others in the training session. They would have three sessions a day same to the Training 1, but the first two sessions were more delivered concentrated training of less marked consonant among selected ones and the last session consisted of evenly distributed and randomly mixed samples.

Training schedules for each subject are shown in Appendix.

### 4.4.5 Final measurement

After all the15 days of training, the subjects had four examination sessions of 15dB, 10dB, 5dB, and 0dB SNR. Each session consisted of the selected consonants in randomly arranged order for each subject with and without stimuli on tongue and the number of appearance was regulated evenly. They were tested 3 to 5 times for each phoneme according as the number of their consonant. Precise structure and the statistics were shown in the Appendix.

| | No stimuli | | | | | | | | | | | | With stimuli | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SNR | 15dB | | | 10dB | | | 5dB | | | 0dB | | | 15dB | | | 10dB | | | 5dB | | | 0dB | | |
| Speaker | 1 | 2 | | 1 | 2 | | 1 | 2 | | 1 | 2 | | 1 | 2 | | 1 | 2 | | 1 | 2 | | 1 | 2 | |
| Subject 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 1 | 3 | 4 | 2 | 1 | 3 | 2 | 2 | 4 | 2 | 1 | 3 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 |
| 1 | 3 | 1 | 4 | 1 | 2 | 3 | 2 | 2 | 4 | 1 | 2 | 3 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 |
| 4 | 1 | 3 | 4 | 2 | 1 | 3 | 2 | 2 | 4 | 2 | 1 | 3 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 |
| 5 | 3 | 1 | 4 | 1 | 2 | 3 | 2 | 2 | 4 | 1 | 2 | 3 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 |
| 9 | 1 | 2 | 3 | 3 | 1 | 4 | 1 | 2 | 3 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 |
| 10 | 2 | 1 | 3 | 1 | 3 | 4 | 2 | 1 | 3 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 |
| 11 | 1 | 2 | 3 | 3 | 1 | 4 | 1 | 2 | 3 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 |
| 18 | 2 | 1 | 3 | 1 | 3 | 4 | 2 | 1 | 3 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 |
| Total | 14 | 14 | 28 | 14 | 14 | 28 | 14 | 14 | 28 | 14 | 14 | 28 | 16 | 16 | 32 | 16 | 16 | 32 | 16 | 16 | 32 | 16 | 16 | 32 |
| Subject 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 3 | 1 | 4 | 1 | 2 | 3 | 2 | 2 | 4 | 1 | 2 | 3 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 |
| 4 | 1 | 3 | 4 | 2 | 1 | 3 | 2 | 2 | 4 | 2 | 1 | 3 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 |
| 5 | 3 | 1 | 4 | 1 | 2 | 3 | 2 | 2 | 4 | 1 | 2 | 3 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 |
| 9 | 1 | 2 | 3 | 3 | 1 | 4 | 1 | 2 | 3 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 |
| 10 | 2 | 1 | 3 | 1 | 3 | 4 | 2 | 1 | 3 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 |
| 11 | 1 | 2 | 3 | 3 | 1 | 4 | 1 | 2 | 3 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 |
| 18 | 2 | 1 | 3 | 1 | 3 | 4 | 2 | 1 | 3 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 |
| 21 | 1 | 3 | 4 | 2 | 1 | 3 | 2 | 2 | 4 | 2 | 1 | 3 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 |
| Total | 14 | 14 | 28 | 14 | 14 | 28 | 14 | 14 | 28 | 14 | 14 | 28 | 16 | 16 | 32 | 16 | 16 | 32 | 16 | 16 | 32 | 16 | 16 | 32 |
| Subject 2 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | 2 | 3 | 5 | 3 | 2 | 5 | 2 | 3 | 5 | 3 | 2 | 5 | 2 | 3 | 5 | 3 | 2 | 5 | 2 | 3 | 5 | 3 | 2 | 5 |
| 4 | 3 | 2 | 5 | 2 | 3 | 5 | 2 | 3 | 5 | 3 | 2 | 5 | 3 | 2 | 5 | 2 | 3 | 5 | 3 | 2 | 5 | 2 | 3 | 5 |
| 12 | 3 | 2 | 5 | 2 | 3 | 5 | 2 | 3 | 5 | 3 | 2 | 5 | 3 | 2 | 5 | 2 | 3 | 5 | 3 | 2 | 5 | 2 | 3 | 5 |
| 19 | 2 | 3 | 5 | 3 | 2 | 5 | 2 | 3 | 5 | 3 | 2 | 5 | 2 | 3 | 5 | 3 | 2 | 5 | 2 | 3 | 5 | 3 | 2 | 5 |
| 20 | 3 | 2 | 5 | 2 | 3 | 5 | 2 | 3 | 5 | 3 | 2 | 5 | 3 | 2 | 5 | 2 | 3 | 5 | 3 | 2 | 5 | 2 | 3 | 5 |

Table 4.5: The number of each consonant in the final test

| Consonant No. | Training | | | | | | | Test | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | No stimuli | | | With stimuli | | |
| | Clear | 30dB | 20dB | 20dB (mix) | 15dB | 15dB (mix) | 10dB | 15dB | 10dB | 5dB | 15dB | 10dB | 5dB |
| 0 | 19(18) | 4 | 5 | 9 | 8 | 9 | 13(3) | 1 | 2 | 2 | 3 | 3 | 2 |
| 1 | 19(18) | 4 | 5 | 9 | 8 | 9 | 11(4) | 2 | 2 | 2 | 3 | 3 | 3 |
| 2 | 19(18) | 4 | 5 | 9 | 8 | 9 | 12(7) | 1 | 2 | 2 | 3 | 3 | 3 |
| 3 | 19(18) | 4 | 5 | 8 | 8 | 9 | 12(3) | 2 | 1 | 2 | 3 | 2 | 3 |
| 4 | 19(18) | 4 | 5 | 9 | 8 | 9 | 10(6) | 2 | 1 | 2 | 3 | 2 | 3 |
| 5 | 19(18) | 4 | 5 | 8 | 8 | 9 | 14(4) | 2 | 2 | 2 | 3 | 2 | 3 |
| 6 | 19(18) | 4 | 5 | 9 | 8 | 9 | 12(5) | 2 | 1 | 2 | 2 | 4 | 3 |
| 7 | 19(18) | 4 | 6 | 8 | 8 | 9 | 13(3) | 2 | 2 | 2 | 3 | 2 | 3 |
| 8 | 19(18) | 4 | 5 | 9 | 8 | 9 | 10(4) | 2 | 2 | 1 | 3 | 2 | 3 |
| 9 | 19(18) | 4 | 6 | 8 | 8 | 9 | 11(6) | 2 | 2 | 2 | 2 | 4 | 2 |
| 10 | 19(18) | 4 | 5 | 9 | 8 | 9 | 11(6) | 2 | 2 | 1 | 3 | 3 | 3 |
| 11 | 19(18) | 4 | 6 | 8 | 8 | 8 | 12(3) | 2 | 2 | 2 | 3 | 2 | 3 |
| 12 | 19(18) | 4 | 5 | 9 | 7 | 9 | 11(6) | 2 | 2 | 1 | 3 | 3 | 2 |
| 13 | 19(18) | 5 | 5 | 8 | 8 | 9 | 12(4) | 2 | 2 | 2 | 3 | 2 | 3 |
| 14 | 19(18) | 4 | 5 | 9 | 8 | 9 | 11(5) | 2 | 1 | 2 | 2 | 3 | 3 |
| 15 | 19(18) | 5 | 6 | 8 | 8 | 8 | 9(3) | 2 | 2 | 2 | 2 | 4 | 2 |
| 16 | 19(18) | 4 | 5 | 9 | 7 | 9 | 13(2) | 2 | 1 | 2 | 3 | 2 | 3 |
| 17 | 19(18) | 5 | 5 | 8 | 8 | 9 | 12(6) | 2 | 2 | 2 | 3 | 2 | 3 |
| 18 | 19(18) | 4 | 5 | 9 | 8 | 9 | 12(5) | 1 | 2 | 2 | 3 | 3 | 2 |
| 19 | 19(18) | 5 | 5 | 9 | 8 | 9 | 11(5) | 2 | 2 | 2 | 3 | 2 | 3 |
| 20 | 19(18) | 4 | 5 | 9 | 8 | 9 | 13(5) | 1 | 2 | 2 | 2 | 3 | 3 |
| 21 | 19(18) | 4 | 5 | 9 | 8 | 9 | 11(3) | 2 | 2 | 1 | 3 | 3 | 2 |
| Total | - | | | | | | | 40 | 40 | 40 | 60 | 60 | 60 |

Table 4.6: The number of training and intermediate test for each consonant. Numbers in the round brackets are for Subject 2 who was on day behind.

# Chapter 5

# Results and evaluation

The experiment were taken using MB2011 mutebutton$^{TM}$ for playing audio file and stimulating tongue, and MDR-XD200 Stereo Headphones for audio signals. All the subject used same headphone and their own mutebutton$^{TM}$.

Figure 5.1: Subjects of the experiment

## 5.1 Results

### 5.1.1 Pre-test

First of all, the subjects are measured with 60 samples in SNR of 15dB, 10dB, and 5dB. As mentioned in the experiment plan, they had a chance to be familiar with the VCV sound before this test listening to each consonant more than 2 times in each SNR level.

| | Subject0 | Subject1 | Subject2 |
|---|---|---|---|
| **Score of 15dB** | 7/20(35%) | 7/20(35%) | 9/20(45%) |
| **Score of 10dB** | 3/20(15%) | 5/20(25%) | 3/20(15%) |
| **Score of 5dB** | 3/20(15%) | 2/20(10%) | 3/20(15%) |

Table 5.1: Consonant recognition score before training

Even though the samples are not that many, their marks were not so high and getting lower as worse SNR level, so we could ensure that the noise could simulate the impairment properly and the SNR levels were reasonable for the experiment to check the improvement.

### 5.1.2 First half training

They had been trained from clear VCV to 10dB sound as per the schedule. As seen in 30dB data in Figure 5.2, they had already been familiar with the VCV sound as much as they got almost over 80% and this means they could recognize the sound when it is clearer. Also, it is assured that they had more trouble in recognizing if the sound has more noise as seen in the pre-test as reported by the decrement according as the SNR level got lower. On the other hand, when we read the data in the section of same SNR, the trend lines come out slightly different from the overall trend. The partial trend lines in 20dB show upward trend or more gradual for Subject 0 and 1, and the results of Subject 0 and 2 look gentler in 15dB than overall ones (Figure 5.3). Having less steep in the same SNR level could result from the tongue stimuli or just familiarization with the noised sound at the same time, so the effect of the tactile stimuli on tongue is not uncertain yet.

### 5.1.3 Intermediate test

Second test that was interim check for measuring the effect of the training and the experiment strategy was conducted in the middle of the experiment.

Subject 1 showed 10%, 4% and 20% improvement in each SNR level respectively and Subject 0 showed 20% improvement at lowest SNR. On the other hand, Subject 2 showed irregular results such as higher recognition

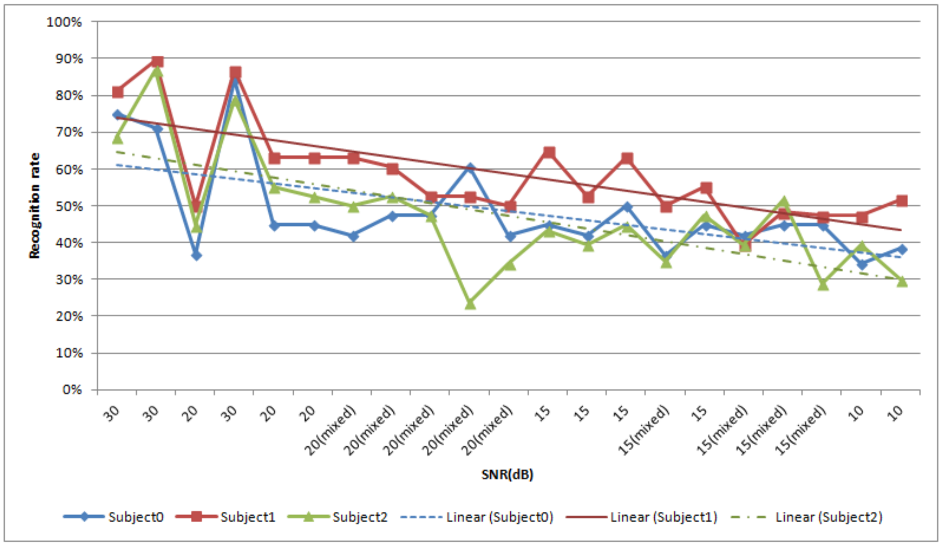



Figure 5.2: Scores of the first half training


Figure 5.3: Scores in the SNR level of 20dB (left) and 15dB (right)

| | SNR (dB) | Subject 0 | | | Subject 1 | | | Subject 2 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Score | Total | Rate | Score | Total | Rate | Score | Total | Rate |
| No Stimuli | 15 | 15 | 40 | 38% | 20 | 40 | 50% | 13 | 40 | 33% |
| | 10 | 13 | 40 | 33% | 18 | 40 | 45% | 15 | 40 | 38% |
| | 5 | 10 | 40 | 25% | 14 | 40 | 35% | 10 | 40 | 25% |
| With Stimuli | 15 | 23 | 60 | 38% | 33 | 60 | 55% | 31 | 60 | 52% |
| | 10 | 18 | 60 | 30% | 28 | 60 | 47% | 18 | 60 | 30% |
| | 5 | 18 | 60 | 30% | 25 | 60 | 42% | 12 | 60 | 20% |

Table 5.2: Result of intermediate test

rate at lower SNR or wide variation of the reception rate of tongue stimulus added session (52%→30%→20%). This inaccuracy could be due to the lack of training. It is not enough to tell the effect of the tongue stimuli with this result and we did not have enough time to take the experiment so we decided to reduce the number of consonants to concentrate on training of the stimuli more as described in Section 4.4. Table 5.3 shows aggregated scores for each consonant classified group. Potential consonants were selected which seemed possible to be improved in recognition rate on the basis described in that section. All the detailed results of the intermediate test are described in Appendix.

### 5.1.4 Final test

As mentioned above, all the trainings during the second half period were concentrated on the selected subjects. There are the results of the final test in four different SNR level. Considering all the recognition rate relationships between the each tested consonant are independent, Cousineau's method was used to reduce error bars (Cousineau, 2005).

Subject 0 showed general improvement with the tongue stimuli. Even though the result at 5dB was unexpected, they are in the error range so it does not make an issue to make a decision. Compared to the result of the intermediate test, Subject 0 have been more accustomed to the VCV samples even at 5dB for hearing. Also, we can read the trend that the stimulus made the slope gentle and this subject got almost 40% improvement at the lowest SNR level, 0dB. In addition to this, overall improvement estimated 8%.

| Group No. | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Subject 0 | | | | | | | | |
| 15dB | Non stimuli | 50% | 30% | 50% | 0% | 50% | 100% | 100% | 80% | 58% |
| | With stimuli | 30% | 20% | 50% | 100% | 70% | 100% | 80% | 100% | 58% |
| | Improvement | -40% | -33% | 0% | ? | 40% | 0% | -20% | 25% | 1% |
| 10dB | Non stimuli | 30% | 40% | 50% | 50% | 70% | 70% | 60% | 80% | 53% |
| | With stimuli | 10% | 50% | 50% | 30% | 30% | 100% | 70% | 60% | 48% |
| | Improvement | -67% | 25% | 0% | -40% | -57% | 43% | 17% | -25% | -8% |
| 5dB | Non stimuli | 40% | 60% | 0% | 0% | 40% | 100% | 50% | 80% | 53% |
| | With stimuli | 20% | 50% | 0% | 30% | 40% | 100% | 80% | 40% | 47% |
| | Improvement | -50% | -17% | - | ↑ | 0% | 0% | 60% | -50% | -11% |
| | | Subject 1 | | | | | | | | |
| 15dB | Non stimuli | 30% | 80% | 50% | 50% | 70% | 100% | 100% | 10% | 68% |
| | With stimuli | 60% | 60% | 50% | 70% | 70% | 100% | 100% | 80% | 73% |
| | Improvement | 100% | -25% | 0% | 40% | 0% | 0% | 0% | 700% | 9% |
| 10dB | Non stimuli | 50% | 80% | 50% | 50% | 70% | 70% | 60% | 50% | 60% |
| | With stimuli | 40% | 90% | 50% | 70% | 60% | 100% | 100% | 60% | 72% |
| | Improvement | -20% | 13% | 0% | 40% | -14% | 43% | 67% | 20% | 19% |
| 5dB | Non stimuli | 30% | 100% | 50% | 0% | 100% | 100% | 50% | 40% | 65% |
| | With stimuli | 50% | 70% | 50% | 100% | 80% | 100% | 50% | 60% | 67% |
| | Improvement | 67% | -30% | 0% | ↑ | -20% | 0% | 0% | 50% | 3% |
| | | Subject 2 | | | | | | | | |
| 15dB | Non stimuli | 30% | 60% | 100% | 0% | 70% | 100% | 100% | 80% | 65% |
| | With stimuli | 20% | 100% | 50% | 0% | 90% | 100% | 100% | 90% | 75% |
| | Improvement | -33% | 67% | -50% | - | 29% | 0% | 0% | 13% | 15% |
| 10dB | Non stimuli | 40% | 90% | 100% | 0% | 80% | 100% | 100% | 70% | 70% |
| | With stimuli | 50% | 90% | 50% | 0% | 70% | 100% | 100% | 40% | 68% |
| | Improvement | 25% | 0% | -50% | - | -13% | 0% | 0% | -43% | -2% |
| 5dB | Non stimuli | 40% | 60% | 0% | 0% | 60% | 100% | 80% | 40% | 55% |
| | With stimuli | 40% | 70% | 0% | 0% | 80% | 100% | 100% | 40% | 60% |
| | Improvement | 0% | 17% | - | - | 33% | 0% | 25% | 0% | 9% |

Table 5.3: Group scores for each subject

Subject1 showed improvement with a wide variation. At the highest SNR level, 15dB, this subject showed greater recognition rate without the stimulus, however, the overall trend of the recognition rate with the tongue stimulus is presented in a very slow slope. Moreover, we can observe a huge improvement, almost 55%, at 0dB which is lowest even if we consider the error bar. The overall improvement of experiment is almost 10%.

For Subject 2, the result is not so corresponding to the expectation. Although the error bars are considered, we can see that tongue recognition rate is going down more rapidly than the non-stimuli experiment. For this subject, the tongue stimulus might look working as barrier factor.

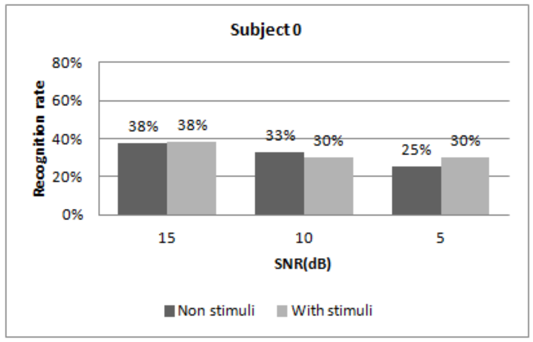
Additionally, we separated a recognition rate into each speaker version for Subject 0 and 1 which showed effect of the tongue stimuli to assure the effect of the same tongue stimuli for various speakers. We did not analyze different speaker effect for Subject 2 because no improvement was observed.

## 5.2 Discussion

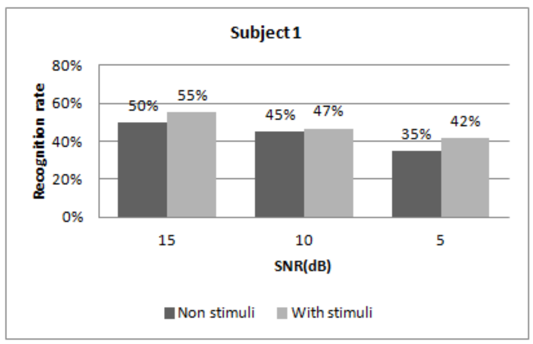
As seen in the previous sections, two subjects (Subject 0, 1) showed huge improvement in the lowest SNR level. Even though their error bars are not so small due to the small amount of data, we could reduce it using the independency among the recognition rates of each consonant. Especially, Subject 1 showed a stable result when tongue stimuli were applied. This coincides with our expectation that it should have monotonous trend when the subject started to recognize with his tongues because there is no variation within the tongue stimuli. As a result, this result could be told quite positive to say a possibility of recognizing speech by hearing additionally with tongue stimuli. Also, Subject 0 got gentler slope when the tongue stimuli applied than hearing only. Those two subjects said they started to distinguish the stimulus and it helped more when the SNR level got worse.

Subject 2 showed some possibility in the intermediate test. However, this subject showed any effect of the tongue stimuli after all. It is considered that the subject is still not familiar with the stimuli and cannot distinguish the stimulus. By considering that all the first three remarks are similar and the last SNR level got the worst result when tongue stimuli added, we can just assume that this subject cared more about the sound than the tactile stimuli when the sound quality is worse and that is why the subject could get the second highest mark at the lowest SNR level.

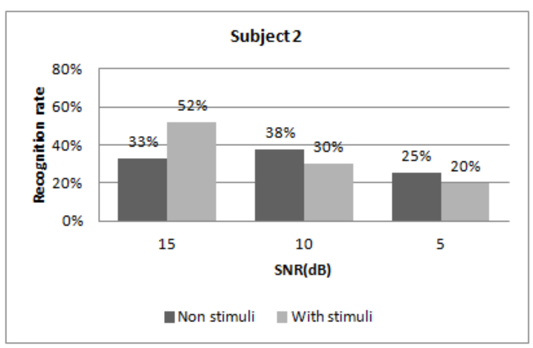
Also, we showed separated speaker results for Subject 0 and 1. We expected that the recognition rate with tongue would be uniform once the subject is familiar with the tongue stimuli. The result showed pretty flat compared to the non-stimuli results as expected and they got higher rate at least in the minimum SNR level than non-stimuli results. However, the recognition rate of each speaker?s sound was quite different interestingly. Even though the subjects were trained with the frequency spectrum of the sound of Speaker 2, the recognition rate was higher when the subjects heard speaker 1 (with the stimuli of Speaker 2).




(a)

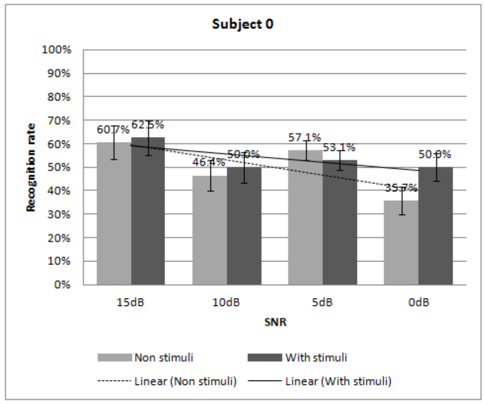



(b)

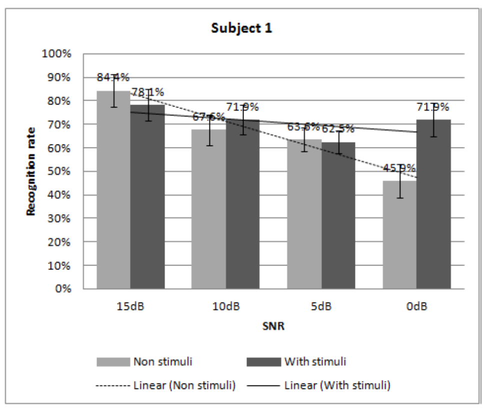



(c)

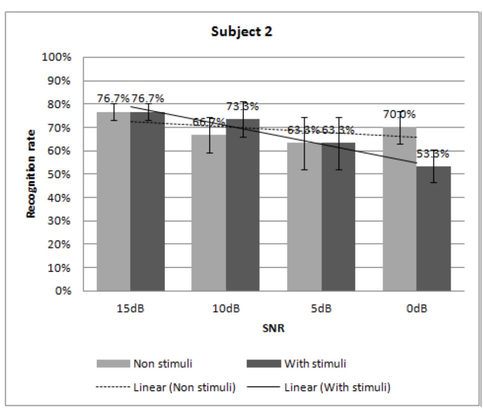
Figure 5.4: Results of the intermediate test of each subject




(a)

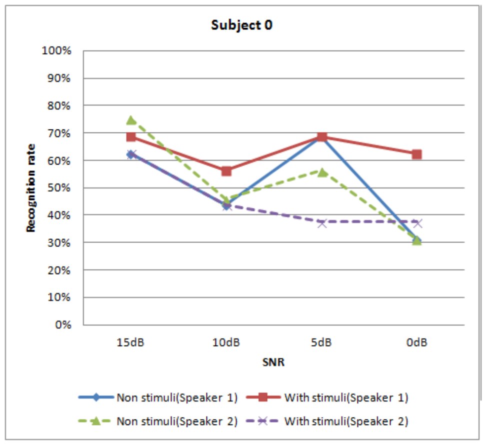



(b)

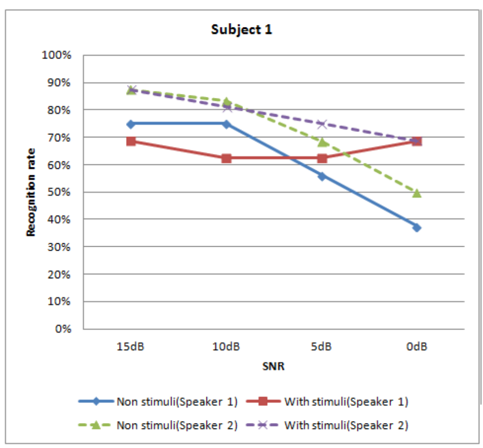



(c)

Figure 5.5: Results of the final test of each subject




(a)




(b)

Figure 5.6: Speaker separated results

# Chapter 6

# Conclusion and further work

In this chapter we summarize this study, draw a conclusion, and suggest further work.

As mentioned in Chapter 1 and 2, the more people are suffering from hearing impairment and requiring suitable treatment. Most popular treatment is cochlear implantation surgery, which is invasive way. The invasive approach for nerve related treatment, especially for ear which is near to brain, has various risk opportunities and side effects. To solve this problem, we studied about non-invasive way for hearing loss improvement. We have tried to use another sense among several senses we have as an assistive or replacing the ear, auditory sensor, and chosen tactile sense for that. We have also shown that the tongue is proper organization enough for perceiving the electric tactile stimulation. Implementation of tongue based hearing enhancement system was conducted with combining already existed device for tongue stimulation and a computer program for training users. Aside from this, we made another program which separates the frequency component and converts to the electric pulses corresponding to the original sound for generation of the tongue stimuli. For evaluation, we had experiment on three subjects. They were trained for 15 days with the VCV sound samples using the system we developed in different SNR level and measured the recognition rate of those samples. In the final measurement, two of them showed improvement in recognizing with their tongue stimuli. Their average recognition rate was 61% when they had additional stimuli on tongue while their rate was almost 41% in average when SNR level was 0dB with listening to the sound only. It showed 49% of improvement and this means that people who have problem on hearing sound could be helped with this tactile stimuli by training. This could be more suggestive because encoding and decoding, which is recognition of the code, would be one of the most import part of the technique and we used frequency conversion which each sound has its unique property of, not using word meaning encoding like sign language.

The main limitation of the implementation was un-controllability of the tongue stimulator. The only way to operate the device was ready-made file of electrical pulse information with original sound. In the system, we implemented synchronization part using auto-correlation and cross-correlation which is sound recognition technique to solve this problem. However, we still could not handle the sample arrangement adaptively during the training and it made the training restricted to be adaptive.

We also would like to mention the subjects which were not quite enough to generalize the result. Due to the lack of the device and time, we could have just three subjects and two showed corresponding results to our hypothesis while one of the subjects showed monotonic outcome in spite of the training. Though, we could tell the improvement because the experiment is undertaken in with-in-subject manner.

As for the further work, more adaptive training system can be possible to implement which controls the repetition rate of the samples in accordance with the marks of their recognition rate. This would help the trainee experience more on the weak point and to be correct more. In this study, we set the sample arrangement manually after analyzing the previous training daily based, however it could be realized by assigning the proper sample to the upcoming training automatically according as the analysis of instantaneous mark or accumulated mark. Second, noise could be reshaped for each type of impairment on simulating hearing impairment because there are various types in hearing impairment according as the frequency characteristics and the training efficiency of frequency response stimuli could vary with them.

Also, the fact that we showed should be analyzed in the bio-medical view. We found out that the electric tactile stimuli could help hearing, but we could not extend the study of the mechanism. This study would broaden the application area and efficiency.

# Appendix A

# Training and experiment data

| Day | Subject 0 | | | Subject 1 | | | Subject 2 | | | SNR(dB) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Score | Total | Rate | Score | Total | Rate | Score | Total | Rate | |
| 1 | 12 | 16 | 75% | 13 | 16 | 81% | 11 | 16 | 69% | 30 |
| | 27 | 38 | 71% | 34 | 38 | 89% | 33 | 38 | 87% | 30 |
| | 14 | 38 | 37% | 19 | 38 | 50% | 17 | 38 | 45% | 20 |
| 2 | 32 | 38 | 84% | 33 | 38 | 87% | 30 | 38 | 79% | 30 |
| | 17 | 38 | 45% | 24 | 38 | 63% | 21 | 38 | 55% | 20 |
| | 17 | 38 | 45% | 24 | 38 | 63% | 20 | 38 | 53% | 20 |
| 3 | 16 | 38 | 42% | 24 | 38 | 63% | 19 | 38 | 50% | 20(mix) |
| | 18 | 38 | 47% | 23 | 38 | 61% | 20 | 38 | 53% | 20(mix) |
| | 18 | 38 | 47% | 20 | 38 | 53% | 18 | 38 | 47% | 20(mix) |
| 4 | 23 | 38 | 61% | 20 | 38 | 53% | 9 | 38 | 24% | 20(mix) |
| | 16 | 38 | 42% | 19 | 38 | 50% | 13 | 38 | 34% | 20(mix) |
| | 27 | 60 | 45% | 39 | 60 | 65% | 26 | 60 | 43% | 15 |
| 5 | 16 | 38 | 42% | 20 | 38 | 53% | 15 | 38 | 39% | 15 |
| | 19 | 38 | 50% | 24 | 38 | 63% | 17 | 38 | 45% | 15 |
| | 22 | 60 | 37% | 30 | 60 | 50% | 21 | 60 | 35% | 15(mix) |
| 6 | 17 | 38 | 45% | 21 | 38 | 55% | 18 | 38 | 47% | 15 |
| | 16 | 38 | 42% | 15 | 38 | 39% | 15 | 38 | 39% | 15(mix) |
| | 27 | 60 | 45% | 29 | 60 | 48% | 31 | 60 | 52% | 15(mix) |
| 7 | 17 | 38 | 45% | 18 | 38 | 47% | 11 | 38 | 29% | 15(mix) |
| | 13 | 38 | 34% | 18 | 38 | 47% | 15 | 38 | 39% | 10 |
| | 23 | 60 | 38% | 31 | 60 | 52% | 18 | 60 | 30% | 10 |
| 8 | 16 | 38 | 42% | 16 | 38 | 42% | - | - | - | 10 |
| | 18 | 60 | 30% | 26 | 60 | 43% | - | - | - | 10 |
| | 11 | 56 | 20% | 18 | 56 | 32% | - | - | - | 10 |

Table A.1: Marks of the first half training

| | Set | SNR(dB) (dB) | Subject 0 | | | Subject 1 | | | Subject 2 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Score | Total | Rate | Score | Total | Rate | Score | Total | Rate |
| No Stimuli | 1 | 15 | 8 | 18 | 44% | 8 | 18 | 44% | 6 | 18 | 33% |
| | | 10 | 9 | 21 | 43% | 12 | 21 | 57% | 10 | 21 | 48% |
| | | 5 | 2 | 21 | 10% | 7 | 21 | 33% | 6 | 21 | 29% |
| | 2 | 15 | 7 | 22 | 32% | 12 | 22 | 55% | 7 | 22 | 32% |
| | | 10 | 4 | 19 | 21% | 6 | 19 | 32% | 5 | 19 | 26% |
| | | 5 | 8 | 19 | 42% | 7 | 19 | 37% | 4 | 19 | 21% |
| With Stimuli | 3 | 15 | 9 | 23 | 39% | 13 | 23 | 57% | 11 | 23 | 48% |
| | | 10 | 6 | 18 | 33% | 8 | 18 | 44% | 6 | 18 | 33% |
| | | 5 | 6 | 19 | 32% | 5 | 19 | 26% | 5 | 19 | 26% |
| | 4 | 15 | 6 | 18 | 33% | 11 | 18 | 61% | 12 | 18 | 67% |
| | | 10 | 5 | 23 | 22% | 10 | 23 | 43% | 7 | 23 | 30% |
| | | 5 | 5 | 19 | 26% | 11 | 19 | 58% | 4 | 19 | 21% |
| | 5 | 15 | 8 | 19 | 42% | 9 | 19 | 47% | 8 | 19 | 42% |
| | | 10 | 7 | 19 | 37% | 10 | 19 | 53% | 5 | 19 | 26% |
| | | 5 | 7 | 22 | 32% | 9 | 22 | 41% | 3 | 22 | 14% |

Table A.2: Result of intermediate test in detail

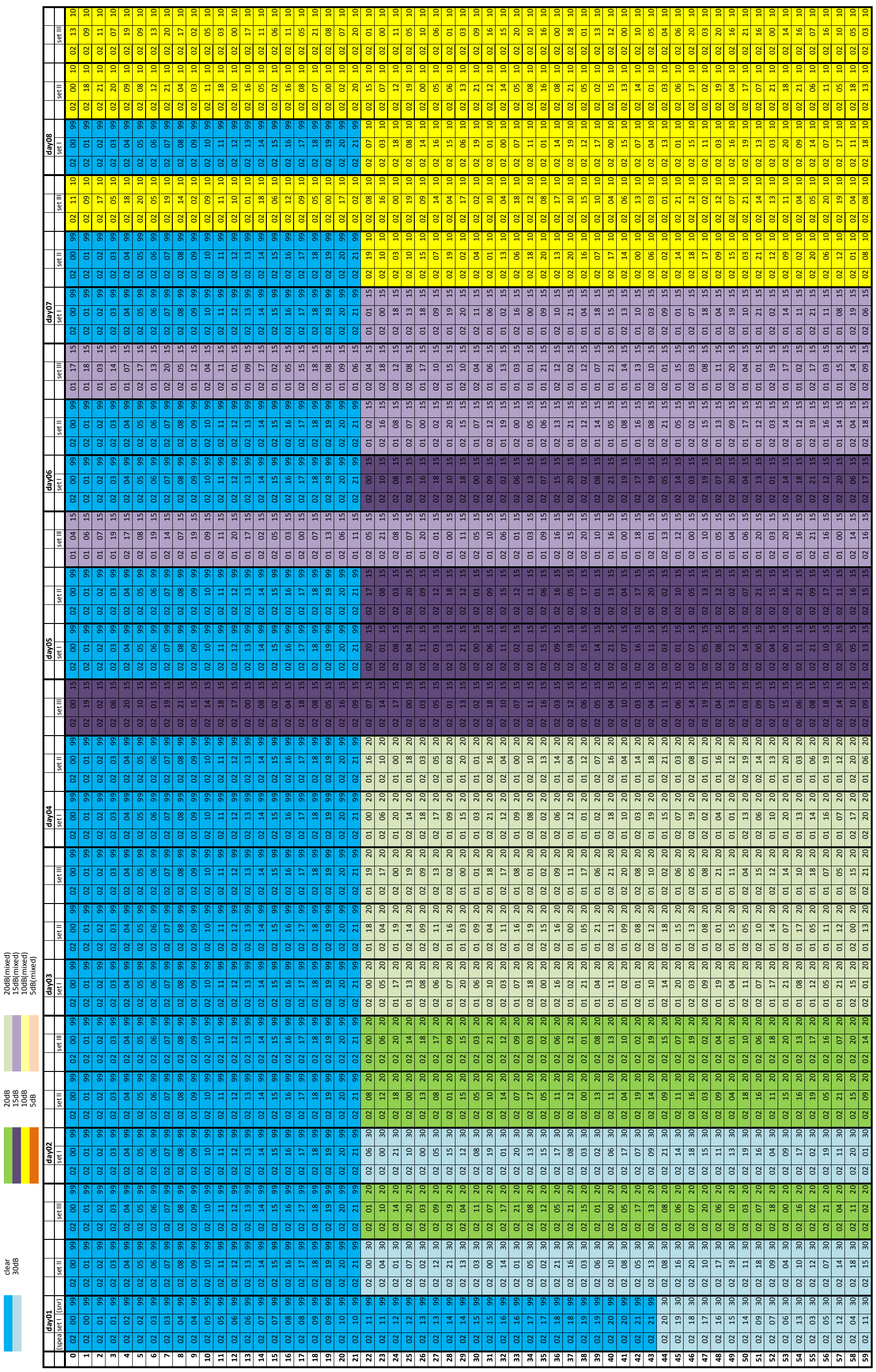



Figure A.1: Training schedule for the first half duration

| | No tongue stimuli | | | | | | With tongue stimuli | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 01 | | | 02 | | | 01 | | | 02 | | | 03 | | |
| 0 | 01 | 11 | 15 | 01 | 04 | 15 | 02 | 17 | 05 | 01 | 20 | 10 | 01 | 03 | 05 |
| 1 | 02 | 10 | 15 | 02 | 01 | 10 | 01 | 09 | 15 | 02 | 14 | 15 | 01 | 21 | 10 |
| 2 | 01 | 10 | 05 | 01 | 10 | 15 | 02 | 05 | 15 | 02 | 20 | 05 | 01 | 08 | 15 |
| 3 | 02 | 08 | 10 | 01 | 03 | 15 | 02 | 12 | 10 | 02 | 02 | 05 | 02 | 01 | 15 |
| 4 | 01 | 16 | 05 | 01 | 09 | 15 | 02 | 06 | 15 | 01 | 18 | 05 | 01 | 02 | 10 |
| 5 | 01 | 21 | 10 | 02 | 20 | 15 | 01 | 04 | 05 | 01 | 12 | 15 | 02 | 08 | 05 |
| 6 | 01 | 11 | 10 | 01 | 00 | 05 | 01 | 17 | 15 | 02 | 01 | 15 | 02 | 07 | 10 |
| 7 | 01 | 01 | 05 | 02 | 04 | 10 | 01 | 17 | 10 | 02 | 14 | 05 | 01 | 01 | 10 |
| 8 | 02 | 03 | 15 | 01 | 14 | 15 | 02 | 06 | 10 | 01 | 12 | 05 | 02 | 09 | 05 |
| 9 | 01 | 11 | 05 | 02 | 11 | 05 | 02 | 11 | 15 | 01 | 06 | 10 | 02 | 19 | 05 |
| 10 | 01 | 02 | 10 | 02 | 09 | 15 | 01 | 20 | 05 | 01 | 13 | 05 | 02 | 01 | 10 |
| 11 | 01 | 03 | 05 | 01 | 13 | 10 | 02 | 21 | 05 | 02 | 08 | 15 | 02 | 20 | 15 |
| 12 | 01 | 18 | 05 | 02 | 05 | 05 | 02 | 06 | 05 | 01 | 11 | 15 | 01 | 10 | 15 |
| 13 | 01 | 14 | 10 | 01 | 08 | 15 | 02 | 04 | 05 | 02 | 02 | 15 | 02 | 14 | 10 |
| 14 | 01 | 04 | 05 | 01 | 00 | 10 | 01 | 08 | 10 | 02 | 04 | 10 | 02 | 03 | 15 |
| 15 | 02 | 00 | 05 | 02 | 08 | 05 | 02 | 07 | 05 | 01 | 07 | 10 | 02 | 00 | 15 |
| 16 | 02 | 01 | 05 | 02 | 03 | 05 | 01 | 15 | 10 | 02 | 12 | 10 | 01 | 11 | 05 |
| 17 | 01 | 17 | 05 | 01 | 03 | 10 | 02 | 08 | 15 | 01 | 10 | 05 | 02 | 15 | 10 |
| 18 | 01 | 07 | 15 | 02 | 12 | 10 | 01 | 14 | 05 | 01 | 02 | 15 | 01 | 09 | 10 |
| 19 | 01 | 09 | 10 | 01 | 19 | 15 | 01 | 15 | 15 | 01 | 21 | 10 | 01 | 19 | 05 |
| 20 | 02 | 17 | 15 | 01 | 06 | 15 | 01 | 00 | 15 | 01 | 10 | 05 | 02 | 11 | 15 |
| 21 | 02 | 02 | 10 | 01 | 13 | 05 | 02 | 16 | 10 | 02 | 01 | 05 | 01 | 01 | 15 |
| 22 | 02 | 04 | 05 | 01 | 02 | 05 | 01 | 07 | 05 | 02 | 16 | 15 | 02 | 03 | 10 |
| 23 | 01 | 05 | 15 | 01 | 06 | 10 | 01 | 14 | 15 | 01 | 16 | 15 | 02 | 08 | 05 |
| 24 | 02 | 12 | 15 | 01 | 14 | 05 | 02 | 04 | 15 | 02 | 05 | 10 | 01 | 12 | 10 |
| 25 | 02 | 13 | 05 | 02 | 07 | 15 | 02 | 15 | 15 | 01 | 09 | 10 | 01 | 05 | 10 |
| 26 | 02 | 13 | 10 | 02 | 00 | 15 | 01 | 13 | 10 | 02 | 20 | 10 | 01 | 21 | 15 |
| 27 | 01 | 17 | 15 | 01 | 02 | 15 | 02 | 16 | 15 | 01 | 08 | 05 | 02 | 21 | 15 |
| 28 | 02 | 04 | 15 | 02 | 10 | 10 | 02 | 04 | 05 | 02 | 02 | 05 | 01 | 04 | 15 |
| 29 | 02 | 09 | 10 | 01 | 18 | 15 | 01 | 18 | 10 | 01 | 15 | 05 | 02 | 07 | 15 |
| 30 | 02 | 15 | 10 | 01 | 21 | 15 | 01 | 02 | 05 | 01 | 03 | 10 | 01 | 11 | 05 |
| 31 | 01 | 05 | 05 | 01 | 07 | 05 | 01 | 10 | 15 | 01 | 05 | 15 | 02 | 14 | 05 |
| 32 | 02 | 08 | 15 | 02 | 15 | 05 | 01 | 17 | 15 | 02 | 10 | 10 | 01 | 06 | 10 |
| 33 | 01 | 20 | 10 | 02 | 05 | 15 | 02 | 13 | 15 | 01 | 16 | 10 | 02 | 18 | 05 |
| 34 | 02 | 21 | 10 | 02 | 18 | 10 | 02 | 09 | 10 | 02 | 12 | 05 | 01 | 17 | 05 |
| 35 | 02 | 17 | 05 | 02 | 11 | 15 | 02 | 11 | 05 | 02 | 05 | 15 | 02 | 01 | 05 |
| 36 | 02 | 16 | 10 | 01 | 09 | 05 | 01 | 03 | 15 | 02 | 05 | 05 | 01 | 17 | 05 |
| 37 | 02 | 19 | 15 | 01 | 12 | 15 | 01 | 15 | 10 | 02 | 13 | 15 | 02 | 10 | 05 |
| 38 | 01 | 13 | 15 | 02 | 16 | 05 | 02 | 12 | 15 | 02 | 09 | 15 | 02 | 17 | 15 |
| 39 | 02 | 18 | 05 | 02 | 06 | 15 | 02 | 21 | 15 | 02 | 00 | 10 | 02 | 10 | 15 |
| 40 | 01 | 01 | 15 | 02 | 00 | 10 | 02 | 15 | 10 | 02 | 11 | 10 | 01 | 04 | 10 |
| 41 | 02 | 21 | 15 | 02 | 19 | 10 | 02 | 19 | 10 | 01 | 09 | 05 | 02 | 18 | 15 |
| 42 | 02 | 16 | 15 | 02 | 19 | 05 | 01 | 01 | 10 | 01 | 12 | 15 | 02 | 21 | 10 |
| 43 | 01 | 17 | 10 | 02 | 05 | 10 | 02 | 18 | 15 | 02 | 19 | 15 | 01 | 13 | 05 |
| 44 | 02 | 01 | 15 | 02 | 14 | 15 | 02 | 03 | 05 | 02 | 00 | 10 | 01 | 20 | 15 |
| 45 | 01 | 06 | 05 | 02 | 07 | 05 | 01 | 19 | 15 | 02 | 03 | 05 | 01 | 20 | 10 |
| 46 | 01 | 18 | 10 | 02 | 12 | 05 | 02 | 16 | 05 | 02 | 14 | 10 | 02 | 08 | 10 |
| 47 | 01 | 19 | 05 | 02 | 06 | 05 | 01 | 19 | 15 | 01 | 18 | 15 | 02 | 09 | 10 |
| 48 | 02 | 20 | 10 | 02 | 02 | 05 | 01 | 06 | 15 | 02 | 10 | 10 | 01 | 01 | 05 |
| 49 | 02 | 09 | 05 | 02 | 13 | 15 | 02 | 05 | 05 | 01 | 00 | 05 | 01 | 07 | 05 |
| 50 | 01 | 15 | 15 | 02 | 15 | 15 | 01 | 02 | 10 | 01 | 19 | 10 | 01 | 02 | 15 |
| 51 | 01 | 21 | 05 | 02 | 07 | 10 | 01 | 14 | 10 | 02 | 06 | 05 | 01 | 07 | 15 |
| 52 | 01 | 15 | 10 | 01 | 20 | 05 | 02 | 06 | 10 | 02 | 03 | 10 | 01 | 19 | 05 |
| 53 | 02 | 20 | 05 | 02 | 03 | 10 | 01 | 00 | 15 | 01 | 10 | 10 | 01 | 21 | 05 |
| 54 | 01 | 16 | 15 | 01 | 15 | 05 | 02 | 02 | 10 | 01 | 00 | 10 | 01 | 13 | 15 |
| 55 | 02 | 17 | 10 | 01 | 05 | 10 | 02 | 00 | 05 | 01 | 18 | 10 | 02 | 18 | 10 |
| 56 | 01 | 08 | 10 | 01 | 07 | 10 | 01 | 16 | 05 | 01 | 04 | 15 | 01 | 20 | 05 |
| 57 | 01 | 19 | 10 | 01 | 10 | 10 | 02 | 15 | 05 | 01 | 07 | 15 | 01 | 05 | 05 |
| 58 | 02 | 14 | 05 | 01 | 12 | 10 | 01 | 11 | 10 | 02 | 17 | 10 | 01 | 06 | 05 |
| 59 | 02 | 11 | 10 | 01 | 01 | 10 | 01 | 16 | 05 | 02 | 13 | 05 | 02 | 13 | 10 |

Figure A.2: Intermediae test schedule

| | day09 | | | | | | | | | day10 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | set I | | | set II | | | set III | | | set I | | | set II | | | set III | | |
| 0 | 02 | 00 | 99 | 02 | 18 | 99 | 02 | 10 | 15 | 02 | 00 | 99 | 02 | 10 | 15 | 01 | 11 | 15 |
| 1 | 02 | 00 | 99 | 01 | 18 | 99 | 01 | 04 | 15 | 02 | 00 | 99 | 02 | 10 | 15 | 01 | 00 | 15 |
| 2 | 02 | 00 | 99 | 01 | 18 | 99 | 02 | 00 | 15 | 01 | 00 | 99 | 01 | 10 | 15 | 02 | 05 | 15 |
| 3 | 01 | 00 | 99 | 02 | 00 | 15 | 01 | 11 | 15 | 02 | 01 | 99 | 02 | 08 | 15 | 01 | 10 | 15 |
| 4 | 01 | 00 | 99 | 01 | 00 | 15 | 02 | 00 | 15 | 02 | 01 | 99 | 02 | 08 | 15 | 01 | 09 | 15 |
| 5 | 02 | 01 | 99 | 02 | 01 | 15 | 01 | 04 | 15 | 01 | 01 | 99 | 01 | 08 | 15 | 02 | 01 | 15 |
| 6 | 02 | 01 | 99 | 01 | 01 | 15 | 01 | 01 | 15 | 02 | 04 | 99 | 02 | 09 | 15 | 02 | 10 | 15 |
| 7 | 02 | 01 | 99 | 02 | 04 | 15 | 01 | 09 | 15 | 02 | 04 | 99 | 02 | 09 | 15 | 01 | 11 | 15 |
| 8 | 01 | 01 | 99 | 01 | 04 | 15 | 02 | 18 | 15 | 01 | 04 | 99 | 01 | 09 | 15 | 02 | 00 | 15 |
| 9 | 01 | 01 | 99 | 02 | 05 | 15 | 01 | 11 | 15 | 02 | 08 | 99 | 02 | 00 | 15 | 02 | 10 | 15 |
| 10 | 02 | 04 | 99 | 01 | 05 | 15 | 01 | 10 | 15 | 02 | 08 | 99 | 02 | 00 | 15 | 01 | 01 | 15 |
| 11 | 02 | 04 | 99 | 02 | 09 | 15 | 02 | 00 | 15 | 01 | 08 | 99 | 01 | 00 | 15 | 01 | 05 | 15 |
| 12 | 02 | 04 | 99 | 01 | 09 | 15 | 01 | 05 | 15 | 02 | 09 | 99 | 02 | 01 | 15 | 01 | 10 | 15 |
| 13 | 01 | 04 | 99 | 02 | 10 | 15 | 02 | 01 | 15 | 02 | 09 | 99 | 02 | 01 | 15 | 02 | 11 | 15 |
| 14 | 01 | 04 | 99 | 01 | 10 | 15 | 02 | 18 | 15 | 01 | 09 | 99 | 01 | 01 | 15 | 01 | 18 | 15 |
| 15 | 02 | 05 | 99 | 02 | 11 | 15 | 01 | 04 | 15 | 02 | 10 | 99 | 02 | 04 | 15 | 01 | 00 | 15 |
| 16 | 02 | 05 | 99 | 01 | 11 | 15 | 02 | 11 | 15 | 02 | 10 | 99 | 02 | 04 | 15 | 02 | 05 | 15 |
| 17 | 02 | 05 | 99 | 02 | 18 | 15 | 01 | 01 | 15 | 01 | 10 | 99 | 01 | 04 | 15 | 02 | 18 | 15 |
| 18 | 01 | 05 | 99 | 01 | 18 | 15 | 02 | 05 | 15 | 02 | 11 | 99 | 02 | 11 | 15 | 02 | 11 | 15 |
| 19 | 01 | 05 | 99 | 02 | 09 | 15 | 01 | 00 | 15 | 02 | 11 | 99 | 02 | 11 | 15 | 02 | 05 | 15 |
| 20 | 02 | 09 | 99 | 01 | 09 | 15 | 02 | 18 | 15 | 01 | 11 | 99 | 01 | 11 | 15 | 01 | 04 | 15 |
| 21 | 02 | 09 | 99 | 02 | 01 | 15 | 01 | 04 | 15 | 02 | 18 | 99 | 02 | 18 | 15 | 02 | 11 | 15 |
| 22 | 02 | 09 | 99 | 01 | 01 | 15 | 01 | 09 | 15 | 02 | 18 | 99 | 02 | 18 | 15 | 01 | 11 | 15 |
| 23 | 01 | 09 | 99 | 02 | 10 | 15 | 02 | 04 | 15 | 01 | 18 | 99 | 01 | 18 | 15 | 02 | 01 | 15 |
| 24 | 01 | 09 | 99 | 01 | 10 | 15 | 01 | 18 | 15 | 02 | 00 | 99 | 02 | 05 | 15 | 02 | 10 | 15 |
| 25 | 02 | 10 | 99 | 02 | 00 | 15 | 02 | 05 | 15 | 01 | 00 | 99 | 02 | 05 | 15 | 02 | 04 | 15 |
| 26 | 02 | 10 | 99 | 01 | 00 | 15 | 02 | 01 | 15 | 02 | 01 | 99 | 01 | 05 | 15 | 02 | 00 | 15 |
| 27 | 02 | 10 | 99 | 02 | 04 | 15 | 01 | 05 | 15 | 02 | 00 | 99 | 02 | 00 | 15 | 01 | 01 | 15 |
| 28 | 01 | 10 | 99 | 01 | 04 | 15 | 02 | 18 | 15 | 02 | 01 | 99 | 02 | 00 | 15 | 01 | 18 | 15 |
| 29 | 01 | 10 | 99 | 02 | 11 | 15 | 01 | 05 | 15 | 01 | 01 | 99 | 02 | 01 | 15 | 02 | 18 | 15 |
| 30 | 02 | 11 | 99 | 01 | 11 | 15 | 01 | 00 | 15 | 02 | 04 | 99 | 02 | 01 | 15 | 01 | 05 | 15 |
| 31 | 02 | 11 | 99 | 02 | 18 | 15 | 01 | 09 | 15 | 02 | 01 | 99 | 02 | 04 | 15 | 02 | 09 | 15 |
| 32 | 02 | 11 | 99 | 01 | 18 | 15 | 02 | 10 | 15 | 02 | 04 | 99 | 02 | 04 | 15 | 01 | 04 | 15 |
| 33 | 01 | 11 | 99 | 01 | 01 | 15 | 02 | 00 | 15 | 01 | 04 | 99 | 02 | 05 | 15 | 02 | 09 | 15 |
| 34 | 01 | 11 | 99 | 02 | 01 | 15 | 02 | 09 | 15 | 02 | 05 | 99 | 02 | 05 | 15 | 02 | 18 | 15 |
| 35 | 02 | 18 | 99 | 01 | 01 | 15 | 01 | 11 | 15 | 02 | 04 | 99 | 02 | 09 | 15 | 01 | 09 | 15 |
| 36 | 02 | 18 | 99 | 02 | 04 | 15 | 01 | 09 | 15 | 02 | 05 | 99 | 02 | 09 | 15 | 01 | 18 | 15 |
| 37 | 02 | 18 | 99 | 01 | 04 | 15 | 02 | 04 | 15 | 01 | 05 | 99 | 02 | 10 | 15 | 02 | 01 | 15 |
| 38 | 01 | 18 | 99 | 02 | 04 | 15 | 02 | 01 | 15 | 02 | 09 | 99 | 02 | 10 | 15 | 01 | 00 | 15 |
| 39 | 01 | 18 | 99 | 01 | 05 | 15 | 01 | 11 | 15 | 02 | 05 | 99 | 02 | 11 | 15 | 02 | 00 | 15 |
| 40 | 02 | 00 | 99 | 02 | 05 | 15 | 01 | 10 | 15 | 02 | 09 | 99 | 02 | 11 | 15 | 01 | 10 | 15 |
| 41 | 01 | 00 | 99 | 01 | 05 | 15 | 02 | 11 | 15 | 01 | 09 | 99 | 02 | 18 | 15 | 01 | 05 | 15 |
| 42 | 01 | 00 | 99 | 02 | 09 | 15 | 01 | 01 | 15 | 02 | 10 | 99 | 02 | 18 | 15 | 01 | 04 | 15 |
| 43 | 02 | 01 | 99 | 01 | 09 | 15 | 02 | 01 | 15 | 02 | 09 | 99 | 02 | 00 | 15 | 01 | 01 | 15 |
| 44 | 01 | 01 | 99 | 02 | 09 | 15 | 02 | 04 | 15 | 02 | 10 | 99 | 01 | 00 | 15 | 02 | 04 | 15 |
| 45 | 01 | 01 | 99 | 01 | 10 | 15 | 02 | 10 | 15 | 01 | 10 | 99 | 02 | 01 | 15 | 02 | 09 | 15 |
| 46 | 02 | 04 | 99 | 02 | 10 | 15 | 01 | 01 | 15 | 02 | 11 | 99 | 01 | 01 | 15 | 01 | 09 | 15 |
| 47 | 01 | 04 | 99 | 01 | 10 | 15 | 01 | 05 | 15 | 02 | 10 | 99 | 02 | 04 | 15 | 02 | 04 | 15 |
| 48 | 01 | 04 | 99 | 02 | 11 | 15 | 01 | 18 | 15 | 02 | 11 | 99 | 01 | 04 | 15 | 02 | 00 | 15 |
| 49 | 02 | 05 | 99 | 01 | 11 | 15 | 02 | 00 | 15 | 01 | 11 | 99 | 02 | 05 | 15 | 01 | 05 | 15 |
| 50 | 01 | 05 | 99 | 02 | 11 | 15 | 02 | 05 | 15 | 02 | 18 | 99 | 01 | 05 | 15 | 01 | 18 | 15 |
| 51 | 01 | 05 | 99 | 01 | 18 | 15 | 02 | 10 | 15 | 02 | 11 | 99 | 02 | 09 | 15 | 01 | 01 | 15 |
| 52 | 02 | 09 | 99 | 02 | 18 | 15 | 02 | 09 | 15 | 02 | 18 | 99 | 01 | 09 | 15 | 02 | 18 | 15 |
| 53 | 01 | 09 | 99 | 01 | 18 | 15 | 01 | 00 | 15 | 01 | 18 | 99 | 02 | 10 | 15 | 02 | 04 | 15 |
| 54 | 01 | 09 | 99 | 02 | 00 | 15 | 01 | 11 | 15 | 02 | 00 | 99 | 01 | 10 | 15 | 02 | 10 | 15 |
| 55 | 02 | 10 | 99 | 01 | 00 | 15 | 01 | 04 | 15 | 02 | 18 | 99 | 02 | 11 | 15 | 01 | 05 | 15 |
| 56 | 01 | 10 | 99 | 02 | 00 | 15 | 02 | 09 | 15 | 02 | 00 | 99 | 01 | 11 | 15 | 01 | 10 | 15 |
| 57 | 01 | 10 | 99 | 01 | 04 | 15 | 02 | 18 | 15 | 01 | 00 | 99 | 02 | 18 | 15 | 01 | 09 | 15 |
| 58 | 02 | 11 | 99 | 02 | 04 | 15 | 01 | 01 | 15 | 02 | 10 | 99 | 01 | 18 | 15 | 02 | 11 | 15 |
| 59 | 01 | 11 | 99 | 02 | 04 | 15 | 02 | 05 | 15 | 01 | 10 | 99 | 01 | 18 | 15 | 02 | 10 | 15 |

| | day11 | | | | | | | | | day12 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | set I | | | set II | | | set III | | | set I | | | set II | | | set III | | |
| 0 | 02 | 10 | 99 | 02 | 00 | 99 | 01 | 10 | 15 | 02 | 00 | 15 | 02 | 00 | 20 | 02 | 18 | 15 |
| 1 | 02 | 10 | 99 | 01 | 00 | 99 | 02 | 00 | 15 | 01 | 00 | 15 | 02 | 00 | 20 | 02 | 11 | 15 |
| 2 | 02 | 10 | 20 | 02 | 00 | 20 | 01 | 00 | 15 | 02 | 00 | 20 | 01 | 00 | 15 | 02 | 04 | 15 |
| 3 | 02 | 10 | 15 | 01 | 00 | 20 | 01 | 10 | 15 | 01 | 00 | 20 | 01 | 00 | 15 | 01 | 05 | 15 |
| 4 | 02 | 10 | 15 | 02 | 00 | 15 | 01 | 04 | 15 | 02 | 00 | 99 | 02 | 18 | 20 | 01 | 01 | 15 |
| 5 | 01 | 10 | 99 | 02 | 00 | 15 | 01 | 18 | 15 | 01 | 00 | 99 | 02 | 18 | 15 | 01 | 09 | 15 |
| 6 | 01 | 10 | 20 | 01 | 00 | 15 | 02 | 18 | 15 | 02 | 18 | 20 | 01 | 18 | 20 | 01 | 04 | 15 |
| 7 | 01 | 10 | 15 | 01 | 00 | 15 | 01 | 00 | 15 | 01 | 18 | 20 | 01 | 18 | 15 | 02 | 09 | 15 |
| 8 | 01 | 10 | 15 | 02 | 05 | 99 | 02 | 18 | 15 | 02 | 00 | 20 | 02 | 00 | 20 | 02 | 00 | 15 |
| 9 | 02 | 10 | 20 | 01 | 05 | 99 | 01 | 11 | 15 | 01 | 00 | 20 | 01 | 00 | 15 | 01 | 18 | 15 |
| 10 | 01 | 10 | 20 | 02 | 05 | 20 | 01 | 18 | 15 | 02 | 00 | 15 | 02 | 18 | 15 | 01 | 11 | 15 |
| 11 | 02 | 10 | 15 | 01 | 05 | 20 | 01 | 00 | 15 | 01 | 00 | 15 | 01 | 18 | 15 | 02 | 18 | 15 |
| 12 | 01 | 10 | 15 | 02 | 05 | 15 | 02 | 05 | 15 | 02 | 01 | 15 | 02 | 10 | 20 | 01 | 00 | 15 |
| 13 | 01 | 10 | 20 | 01 | 05 | 15 | 02 | 00 | 15 | 01 | 01 | 15 | 01 | 10 | 20 | 02 | 00 | 15 |
| 14 | 02 | 01 | 99 | 02 | 05 | 15 | 02 | 11 | 15 | 02 | 01 | 20 | 02 | 10 | 15 | 01 | 01 | 15 |
| 15 | 02 | 01 | 99 | 01 | 05 | 15 | 02 | 01 | 15 | 01 | 01 | 20 | 01 | 10 | 15 | 02 | 09 | 15 |
| 16 | 02 | 01 | 20 | 02 | 11 | 99 | 02 | 04 | 15 | 02 | 01 | 99 | 02 | 18 | 15 | 02 | 01 | 15 |
| 17 | 02 | 01 | 15 | 01 | 11 | 99 | 01 | 01 | 15 | 01 | 01 | 99 | 01 | 18 | 15 | 01 | 00 | 15 |
| 18 | 02 | 01 | 15 | 02 | 11 | 20 | 02 | 05 | 15 | 02 | 10 | 15 | 02 | 10 | 15 | 01 | 04 | 15 |
| 19 | 01 | 01 | 99 | 01 | 11 | 20 | 01 | 09 | 15 | 01 | 10 | 15 | 01 | 10 | 15 | 02 | 04 | 15 |
| 20 | 01 | 01 | 20 | 02 | 11 | 15 | 01 | 10 | 15 | 02 | 10 | 20 | 02 | 01 | 20 | 01 | 09 | 15 |
| 21 | 01 | 01 | 15 | 01 | 11 | 15 | 02 | 10 | 15 | 01 | 10 | 20 | 01 | 01 | 20 | 01 | 05 | 15 |
| 22 | 01 | 01 | 15 | 02 | 11 | 15 | 01 | 04 | 15 | 02 | 10 | 99 | 02 | 01 | 15 | 01 | 18 | 15 |
| 23 | 02 | 01 | 15 | 01 | 11 | 15 | 01 | 18 | 15 | 01 | 10 | 99 | 02 | 01 | 15 | 02 | 01 | 15 |
| 24 | 01 | 01 | 20 | 02 | 00 | 15 | 02 | 11 | 15 | 02 | 18 | 20 | 01 | 01 | 15 | 02 | 01 | 15 |
| 25 | 02 | 04 | 99 | 01 | 00 | 15 | 02 | 10 | 15 | 01 | 18 | 20 | 01 | 01 | 15 | 01 | 10 | 15 |
| 26 | 02 | 04 | 99 | 02 | 01 | 15 | 01 | 05 | 15 | 02 | 18 | 15 | 02 | 10 | 15 | 02 | 18 | 15 |
| 27 | 02 | 04 | 20 | 01 | 01 | 15 | 02 | 09 | 15 | 01 | 18 | 15 | 01 | 10 | 15 | 01 | 10 | 15 |
| 28 | 02 | 04 | 15 | 02 | 04 | 15 | 02 | 01 | 15 | 02 | 18 | 20 | 02 | 18 | 15 | 02 | 04 | 15 |
| 29 | 02 | 04 | 15 | 01 | 04 | 15 | 01 | 01 | 15 | 01 | 18 | 20 | 01 | 18 | 15 | 02 | 10 | 15 |
| 30 | 01 | 04 | 99 | 02 | 05 | 15 | 02 | 05 | 15 | 02 | 18 | 15 | 02 | 01 | 15 | 01 | 11 | 15 |
| 31 | 01 | 04 | 20 | 01 | 05 | 15 | 02 | 10 | 15 | 01 | 18 | 15 | 01 | 01 | 15 | 02 | 10 | 15 |
| 32 | 01 | 04 | 15 | 02 | 09 | 15 | 02 | 00 | 15 | 02 | 04 | 15 | 02 | 04 | 20 | 02 | 09 | 15 |
| 33 | 01 | 04 | 15 | 01 | 09 | 15 | 02 | 04 | 15 | 01 | 04 | 15 | 01 | 04 | 20 | 01 | 10 | 15 |
| 34 | 01 | 04 | 20 | 02 | 10 | 15 | 02 | 11 | 15 | 02 | 04 | 20 | 02 | 04 | 15 | 02 | 11 | 15 |
| 35 | 02 | 09 | 99 | 01 | 10 | 15 | 01 | 11 | 15 | 01 | 04 | 20 | 01 | 04 | 15 | 02 | 11 | 15 |
| 36 | 01 | 09 | 99 | 02 | 11 | 15 | 01 | 09 | 15 | 02 | 04 | 99 | 02 | 04 | 15 | 02 | 09 | 15 |
| 37 | 02 | 09 | 20 | 01 | 11 | 15 | 01 | 18 | 15 | 01 | 04 | 99 | 01 | 04 | 15 | 01 | 11 | 15 |
| 38 | 01 | 09 | 20 | 02 | 18 | 15 | 02 | 04 | 15 | 02 | 05 | 20 | 02 | 05 | 15 | 02 | 05 | 15 |
| 39 | 02 | 09 | 15 | 01 | 18 | 15 | 02 | 11 | 15 | 01 | 05 | 20 | 01 | 05 | 15 | 02 | 11 | 15 |
| 40 | 01 | 09 | 15 | 02 | 01 | 15 | 01 | 04 | 15 | 02 | 05 | 15 | 02 | 04 | 15 | 02 | 00 | 15 |
| 41 | 02 | 09 | 15 | 01 | 01 | 15 | 01 | 05 | 15 | 01 | 05 | 15 | 01 | 04 | 15 | 02 | 01 | 15 |
| 42 | 01 | 09 | 20 | 02 | 04 | 15 | 02 | 09 | 15 | 02 | 04 | 15 | 02 | 05 | 20 | 02 | 18 | 15 |
| 43 | 02 | 09 | 20 | 01 | 04 | 15 | 02 | 10 | 15 | 01 | 04 | 15 | 01 | 05 | 20 | 01 | 01 | 15 |
| 44 | 02 | 18 | 99 | 02 | 09 | 15 | 02 | 05 | 15 | 02 | 00 | 15 | 02 | 05 | 15 | 02 | 00 | 15 |
| 45 | 01 | 18 | 99 | 01 | 09 | 15 | 01 | 00 | 15 | 01 | 00 | 15 | 01 | 05 | 15 | 02 | 00 | 15 |
| 46 | 02 | 18 | 20 | 02 | 05 | 15 | 02 | 10 | 15 | 02 | 18 | 15 | 02 | 09 | 15 | 02 | 05 | 15 |
| 47 | 01 | 18 | 20 | 01 | 05 | 15 | 02 | 00 | 15 | 01 | 18 | 15 | 01 | 09 | 15 | 01 | 01 | 15 |
| 48 | 02 | 18 | 15 | 02 | 11 | 15 | 01 | 05 | 15 | 02 | 00 | 15 | 02 | 04 | 15 | 01 | 10 | 15 |
| 49 | 01 | 18 | 15 | 01 | 11 | 15 | 02 | 18 | 15 | 01 | 00 | 15 | 01 | 04 | 15 | 02 | 05 | 15 |
| 50 | 01 | 18 | 15 | 02 | 00 | 15 | 01 | 09 | 15 | 02 | 05 | 15 | 02 | 09 | 15 | 01 | 18 | 15 |
| 51 | 01 | 18 | 20 | 01 | 00 | 15 | 02 | 09 | 15 | 01 | 05 | 15 | 01 | 09 | 15 | 01 | 00 | 15 |
| 52 | 02 | 18 | 15 | 02 | 10 | 15 | 01 | 01 | 15 | 02 | 04 | 15 | 02 | 18 | 15 | 01 | 09 | 15 |
| 53 | 02 | 10 | 15 | 01 | 10 | 15 | 02 | 18 | 15 | 01 | 04 | 15 | 01 | 18 | 15 | 02 | 04 | 15 |
| 54 | 01 | 01 | 15 | 02 | 18 | 15 | 01 | 11 | 15 | 02 | 05 | 15 | 02 | 00 | 15 | 02 | 10 | 15 |
| 55 | 02 | 04 | 15 | 01 | 18 | 15 | 02 | 04 | 15 | 01 | 05 | 15 | 01 | 00 | 15 | 01 | 04 | 15 |
| 56 | 01 | 09 | 15 | 02 | 10 | 15 | 02 | 01 | 15 | 02 | 04 | 15 | 02 | 11 | 15 | 01 | 18 | 15 |
| 57 | 02 | 10 | 15 | 01 | 10 | 15 | 02 | 01 | 15 | 01 | 04 | 15 | 01 | 11 | 15 | 01 | 00 | 15 |
| 58 | 01 | 18 | 15 | 02 | 00 | 15 | 02 | 09 | 15 | 02 | 09 | 15 | 02 | 11 | 15 | 01 | 05 | 15 |
| 59 | 02 | 00 | 15 | 01 | 00 | 15 | 02 | 01 | 15 | 01 | 09 | 15 | 01 | 11 | 15 | 01 | 05 | 15 |

| | day13 | | | | | | | | | day14 | | | | | | | | | day15 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | set I | | | set II | | | set III | | | set I | | | set II | | | set III | | | set I | | | set II | | |
| 0 | 02 | 00 | 99 | 02 | 18 | 65 | 02 | 00 | 15 | 02 | 00 | 20 | 01 | 10 | 65 | 02 | 05 | 15 | 02 | 00 | 20 | 02 | 00 | 15 |
| 1 | 01 | 00 | 20 | 01 | 05 | 65 | 02 | 05 | 15 | 01 | 00 | 20 | 01 | 00 | 65 | 02 | 04 | 15 | 01 | 00 | 20 | 02 | 00 | 15 |
| 2 | 02 | 00 | 15 | 02 | 10 | 65 | 01 | 04 | 15 | 02 | 00 | 15 | 02 | 18 | 65 | 02 | 04 | 15 | 02 | 00 | 15 | 01 | 00 | 15 |
| 3 | 01 | 00 | 15 | 02 | 01 | 65 | 02 | 00 | 15 | 02 | 00 | 15 | 01 | 10 | 65 | 01 | 05 | 15 | 02 | 00 | 15 | 01 | 00 | 15 |
| 4 | 02 | 00 | 15 | 01 | 10 | 65 | 02 | 00 | 15 | 01 | 00 | 15 | 02 | 00 | 65 | 01 | 10 | 15 | 01 | 00 | 15 | 02 | 01 | 15 |
| 5 | 01 | 00 | 15 | 02 | 11 | 65 | 02 | 18 | 15 | 01 | 00 | 15 | 01 | 11 | 65 | 02 | 00 | 15 | 01 | 00 | 15 | 02 | 01 | 15 |
| 6 | 02 | 18 | 15 | 01 | 00 | 65 | 01 | 18 | 15 | 02 | 01 | 20 | 01 | 09 | 65 | 01 | 01 | 15 | 02 | 01 | 20 | 01 | 01 | 15 |
| 7 | 01 | 18 | 15 | 01 | 11 | 65 | 02 | 00 | 15 | 01 | 01 | 20 | 02 | 10 | 65 | 02 | 05 | 15 | 01 | 01 | 20 | 01 | 01 | 15 |
| 8 | 02 | 00 | 15 | 01 | 18 | 65 | 01 | 01 | 15 | 02 | 01 | 15 | 02 | 05 | 65 | 01 | 00 | 15 | 02 | 01 | 15 | 02 | 00 | 15 |
| 9 | 01 | 00 | 15 | 01 | 04 | 65 | 01 | 00 | 15 | 02 | 01 | 15 | 01 | 18 | 65 | 02 | 04 | 15 | 02 | 01 | 15 | 01 | 00 | 15 |
| 10 | 02 | 00 | 15 | 01 | 01 | 65 | 02 | 11 | 15 | 01 | 01 | 15 | 01 | 18 | 65 | 02 | 18 | 15 | 01 | 01 | 15 | 02 | 10 | 15 |
| 11 | 01 | 00 | 15 | 02 | 09 | 65 | 01 | 00 | 15 | 01 | 01 | 15 | 01 | 04 | 65 | 01 | 11 | 15 | 01 | 01 | 15 | 02 | 10 | 15 |
| 12 | 02 | 01 | 15 | 01 | 11 | 65 | 02 | 04 | 15 | 02 | 00 | 15 | 01 | 01 | 65 | 01 | 04 | 15 | 02 | 00 | 15 | 01 | 10 | 15 |
| 13 | 01 | 01 | 15 | 01 | 01 | 65 | 01 | 05 | 15 | 01 | 00 | 15 | 02 | 00 | 65 | 02 | 11 | 15 | 01 | 00 | 15 | 01 | 10 | 15 |
| 14 | 02 | 01 | 20 | 02 | 04 | 65 | 01 | 01 | 15 | 02 | 18 | 20 | 02 | 09 | 65 | 02 | 01 | 15 | 02 | 18 | 20 | 02 | 01 | 15 |
| 15 | 01 | 01 | 20 | 02 | 05 | 65 | 02 | 01 | 15 | 01 | 18 | 20 | 02 | 18 | 65 | 01 | 09 | 15 | 01 | 18 | 20 | 01 | 01 | 15 |
| 16 | 02 | 01 | 99 | 02 | 11 | 65 | 01 | 04 | 15 | 02 | 18 | 15 | 02 | 05 | 65 | 01 | 18 | 15 | 02 | 18 | 15 | 02 | 18 | 15 |
| 17 | 01 | 01 | 99 | 01 | 04 | 65 | 01 | 10 | 15 | 02 | 18 | 15 | 01 | 01 | 65 | 01 | 00 | 15 | 02 | 18 | 15 | 02 | 18 | 15 |
| 18 | 02 | 10 | 99 | 02 | 09 | 65 | 01 | 18 | 15 | 01 | 18 | 15 | 02 | 09 | 65 | 02 | 11 | 15 | 01 | 18 | 15 | 01 | 18 | 15 |
| 19 | 01 | 10 | 99 | 02 | 00 | 65 | 01 | 01 | 15 | 01 | 18 | 15 | 01 | 00 | 65 | 02 | 10 | 15 | 01 | 18 | 15 | 01 | 18 | 15 |
| 20 | 02 | 10 | 20 | 01 | 10 | 65 | 01 | 10 | 15 | 02 | 00 | 15 | 02 | 11 | 65 | 01 | 11 | 15 | 02 | 00 | 15 | 02 | 10 | 15 |
| 21 | 01 | 10 | 20 | 01 | 05 | 65 | 02 | 10 | 15 | 01 | 00 | 15 | 02 | 01 | 65 | 02 | 00 | 15 | 01 | 00 | 15 | 01 | 10 | 15 |
| 22 | 02 | 10 | 15 | 02 | 01 | 65 | 01 | 05 | 15 | 02 | 01 | 15 | 01 | 09 | 65 | 01 | 00 | 15 | 02 | 01 | 15 | 02 | 00 | 15 |
| 23 | 01 | 10 | 15 | 02 | 04 | 65 | 02 | 11 | 15 | 01 | 01 | 15 | 02 | 04 | 65 | 02 | 05 | 15 | 01 | 01 | 15 | 01 | 00 | 15 |
| 24 | 02 | 18 | 15 | 01 | 00 | 65 | 01 | 09 | 15 | 02 | 18 | 15 | 02 | 10 | 65 | 02 | 10 | 15 | 02 | 18 | 15 | 02 | 18 | 15 |
| 25 | 01 | 18 | 15 | 01 | 18 | 65 | 02 | 04 | 15 | 01 | 18 | 15 | 02 | 11 | 65 | 02 | 01 | 15 | 01 | 18 | 15 | 01 | 18 | 15 |
| 26 | 02 | 18 | 20 | 01 | 09 | 65 | 02 | 01 | 15 | 02 | 01 | 15 | 01 | 05 | 65 | 01 | 01 | 15 | 02 | 01 | 15 | 02 | 01 | 15 |
| 27 | 01 | 18 | 20 | 02 | 10 | 65 | 02 | 04 | 15 | 01 | 01 | 15 | 01 | 05 | 65 | 01 | 18 | 15 | 01 | 01 | 15 | 01 | 01 | 15 |
| 28 | 02 | 18 | 99 | 02 | 00 | 65 | 01 | 10 | 15 | 02 | 10 | 20 | 02 | 04 | 65 | 02 | 10 | 15 | 02 | 10 | 20 | 02 | 04 | 15 |
| 29 | 01 | 18 | 99 | 01 | 09 | 65 | 02 | 09 | 15 | 01 | 10 | 20 | 01 | 11 | 65 | 01 | 09 | 15 | 01 | 10 | 20 | 02 | 04 | 15 |
| 30 | 02 | 18 | 20 | 02 | 05 | 65 | 02 | 01 | 15 | 02 | 10 | 15 | 01 | 04 | 65 | 02 | 11 | 15 | 02 | 10 | 15 | 01 | 04 | 15 |
| 31 | 01 | 18 | 20 | 02 | 18 | 65 | 02 | 09 | 15 | 02 | 10 | 15 | 02 | 01 | 65 | 02 | 09 | 15 | 02 | 10 | 15 | 01 | 04 | 15 |
| 32 | 02 | 10 | 15 | 02 | 00 | 13 | 02 | 09 | 15 | 01 | 10 | 15 | 02 | 00 | 15 | 01 | 10 | 15 | 01 | 10 | 15 | 02 | 05 | 15 |
| 33 | 01 | 10 | 15 | 01 | 00 | 13 | 01 | 00 | 15 | 01 | 10 | 15 | 01 | 00 | 15 | 01 | 01 | 15 | 01 | 10 | 15 | 02 | 05 | 15 |
| 34 | 02 | 18 | 15 | 02 | 00 | 13 | 01 | 01 | 15 | 02 | 00 | 15 | 02 | 01 | 15 | 02 | 18 | 15 | 02 | 00 | 15 | 01 | 05 | 15 |
| 35 | 01 | 18 | 15 | 01 | 00 | 13 | 02 | 11 | 15 | 01 | 00 | 15 | 01 | 01 | 15 | 01 | 04 | 15 | 01 | 00 | 15 | 01 | 05 | 15 |
| 36 | 02 | 04 | 15 | 02 | 18 | 13 | 01 | 10 | 15 | 02 | 04 | 20 | 02 | 00 | 15 | 01 | 09 | 15 | 02 | 04 | 20 | 02 | 04 | 15 |
| 37 | 01 | 04 | 15 | 01 | 18 | 13 | 01 | 11 | 15 | 01 | 04 | 20 | 01 | 00 | 15 | 01 | 01 | 15 | 01 | 04 | 20 | 01 | 04 | 15 |
| 38 | 02 | 04 | 20 | 02 | 10 | 13 | 02 | 04 | 15 | 02 | 04 | 15 | 02 | 18 | 15 | 02 | 04 | 15 | 02 | 04 | 15 | 02 | 05 | 15 |
| 39 | 01 | 04 | 20 | 02 | 10 | 13 | 02 | 18 | 15 | 02 | 04 | 15 | 01 | 18 | 15 | 01 | 05 | 15 | 02 | 04 | 15 | 01 | 05 | 15 |
| 40 | 02 | 04 | 99 | 01 | 10 | 13 | 01 | 11 | 15 | 01 | 04 | 15 | 02 | 00 | 15 | 01 | 05 | 15 | 01 | 04 | 15 | 02 | 09 | 15 |
| 41 | 01 | 04 | 99 | 01 | 10 | 13 | 01 | 18 | 15 | 01 | 04 | 15 | 01 | 00 | 15 | 01 | 11 | 15 | 01 | 04 | 15 | 02 | 09 | 15 |
| 42 | 02 | 05 | 20 | 02 | 01 | 13 | 01 | 09 | 15 | 02 | 09 | 20 | 02 | 01 | 15 | 01 | 05 | 15 | 02 | 09 | 20 | 01 | 09 | 15 |
| 43 | 01 | 05 | 20 | 02 | 01 | 13 | 02 | 05 | 15 | 01 | 09 | 20 | 01 | 01 | 15 | 01 | 18 | 15 | 01 | 09 | 20 | 01 | 09 | 15 |
| 44 | 02 | 05 | 15 | 01 | 01 | 13 | 02 | 10 | 15 | 02 | 09 | 15 | 02 | 10 | 15 | 02 | 18 | 15 | 02 | 09 | 15 | 02 | 11 | 15 |
| 45 | 01 | 05 | 15 | 01 | 01 | 13 | 01 | 18 | 15 | 02 | 09 | 15 | 01 | 10 | 15 | 02 | 11 | 15 | 02 | 09 | 15 | 02 | 11 | 15 |
| 46 | 02 | 04 | 15 | 02 | 18 | 13 | 02 | 11 | 15 | 01 | 09 | 15 | 02 | 18 | 15 | 02 | 00 | 15 | 01 | 09 | 15 | 01 | 11 | 15 |
| 47 | 01 | 04 | 15 | 02 | 18 | 13 | 02 | 09 | 15 | 01 | 09 | 15 | 01 | 18 | 15 | 01 | 10 | 15 | 01 | 09 | 15 | 01 | 11 | 15 |
| 48 | 02 | 00 | 15 | 01 | 18 | 13 | 01 | 11 | 15 | 02 | 04 | 15 | 02 | 04 | 15 | 02 | 09 | 15 | 02 | 04 | 15 | 02 | 00 | 15 |
| 49 | 01 | 00 | 15 | 01 | 18 | 13 | 01 | 05 | 15 | 01 | 04 | 15 | 01 | 04 | 15 | 01 | 10 | 15 | 01 | 04 | 15 | 01 | 00 | 15 |
| 50 | 02 | 18 | 15 | 02 | 05 | 13 | 01 | 09 | 15 | 02 | 05 | 20 | 02 | 05 | 15 | 02 | 00 | 15 | 02 | 05 | 20 | 02 | 01 | 15 |
| 51 | 01 | 18 | 15 | 02 | 05 | 13 | 02 | 00 | 15 | 01 | 05 | 20 | 01 | 05 | 15 | 02 | 09 | 15 | 01 | 05 | 20 | 01 | 01 | 15 |
| 52 | 02 | 05 | 15 | 01 | 05 | 13 | 01 | 04 | 15 | 02 | 05 | 15 | 02 | 04 | 15 | 02 | 09 | 15 | 02 | 05 | 15 | 02 | 18 | 15 |
| 53 | 01 | 05 | 15 | 01 | 05 | 13 | 01 | 18 | 15 | 02 | 05 | 15 | 01 | 04 | 15 | 01 | 10 | 15 | 02 | 05 | 15 | 01 | 18 | 15 |
| 54 | 02 | 05 | 20 | 02 | 04 | 13 | 01 | 01 | 15 | 01 | 05 | 15 | 02 | 09 | 15 | 01 | 00 | 15 | 01 | 05 | 15 | 02 | 10 | 15 |
| 55 | 01 | 05 | 20 | 02 | 04 | 13 | 02 | 10 | 15 | 01 | 05 | 15 | 01 | 09 | 15 | 02 | 18 | 15 | 01 | 05 | 15 | 01 | 10 | 15 |
| 56 | 02 | 04 | 15 | 01 | 04 | 13 | 01 | 05 | 15 | 02 | 11 | 15 | 02 | 05 | 15 | 02 | 01 | 15 | 02 | 11 | 15 | 02 | 04 | 15 |
| 57 | 01 | 04 | 15 | 01 | 04 | 13 | 02 | 04 | 15 | 02 | 11 | 15 | 01 | 05 | 15 | 01 | 18 | 15 | 02 | 11 | 15 | 01 | 04 | 15 |
| 58 | 02 | 09 | 15 | 02 | 05 | 13 | 02 | 05 | 15 | 01 | 11 | 15 | 02 | 11 | 15 | 02 | 01 | 15 | 01 | 11 | 15 | 02 | 05 | 15 |
| 59 | 01 | 09 | 15 | 01 | 05 | 13 | 02 | 18 | 15 | 01 | 11 | 15 | 01 | 11 | 15 | 01 | 04 | 15 | 01 | 11 | 15 | 01 | 05 | 15 |

Figure A.3: Training schedule for the second half duration for Subject 0

| | day09 set I | | | day09 set II | | | day09 set III | | | day10 set I | | | day10 set II | | | day10 set III | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 02 | 01 | 99 | 02 | 21 | 99 | 02 | 10 | 15 | 02 | 01 | 99 | 02 | 04 | 15 | 02 | 18 | 15 |
| 1 | 02 | 01 | 99 | 01 | 21 | 99 | 01 | 04 | 15 | 02 | 01 | 99 | 02 | 04 | 15 | 01 | 04 | 15 |
| 2 | 02 | 01 | 99 | 01 | 21 | 99 | 02 | 21 | 15 | 01 | 01 | 99 | 01 | 04 | 15 | 01 | 11 | 15 |
| 3 | 01 | 01 | 99 | 02 | 01 | 15 | 01 | 11 | 15 | 02 | 04 | 99 | 02 | 09 | 15 | 02 | 11 | 15 |
| 4 | 01 | 01 | 99 | 01 | 01 | 15 | 02 | 21 | 15 | 02 | 04 | 99 | 02 | 09 | 15 | 02 | 09 | 15 |
| 5 | 02 | 04 | 99 | 02 | 04 | 15 | 01 | 04 | 15 | 01 | 04 | 99 | 01 | 09 | 15 | 01 | 05 | 15 |
| 6 | 02 | 04 | 99 | 01 | 04 | 15 | 01 | 01 | 15 | 02 | 05 | 99 | 02 | 01 | 15 | 02 | 10 | 15 |
| 7 | 02 | 04 | 99 | 02 | 05 | 15 | 01 | 09 | 15 | 02 | 05 | 99 | 02 | 01 | 15 | 01 | 01 | 15 |
| 8 | 01 | 04 | 99 | 01 | 05 | 15 | 02 | 18 | 15 | 01 | 05 | 99 | 01 | 01 | 15 | 02 | 21 | 15 |
| 9 | 01 | 04 | 99 | 02 | 09 | 15 | 01 | 11 | 15 | 02 | 09 | 99 | 02 | 11 | 15 | 01 | 21 | 15 |
| 10 | 02 | 05 | 99 | 01 | 09 | 15 | 01 | 10 | 15 | 02 | 09 | 99 | 02 | 11 | 15 | 01 | 04 | 15 |
| 11 | 02 | 05 | 99 | 02 | 10 | 15 | 02 | 21 | 15 | 01 | 09 | 99 | 01 | 11 | 15 | 02 | 09 | 15 |
| 12 | 02 | 05 | 99 | 01 | 10 | 15 | 01 | 05 | 15 | 02 | 10 | 99 | 02 | 05 | 15 | 01 | 01 | 15 |
| 13 | 01 | 05 | 99 | 02 | 11 | 15 | 02 | 01 | 15 | 02 | 10 | 99 | 02 | 05 | 15 | 02 | 18 | 15 |
| 14 | 01 | 05 | 99 | 01 | 11 | 15 | 02 | 18 | 15 | 01 | 10 | 99 | 01 | 05 | 15 | 01 | 01 | 15 |
| 15 | 02 | 09 | 99 | 02 | 18 | 15 | 01 | 04 | 15 | 02 | 11 | 99 | 02 | 10 | 15 | 01 | 11 | 15 |
| 16 | 02 | 09 | 99 | 01 | 18 | 15 | 02 | 11 | 15 | 02 | 11 | 99 | 02 | 10 | 15 | 01 | 11 | 15 |
| 17 | 02 | 09 | 99 | 02 | 21 | 15 | 01 | 01 | 15 | 01 | 11 | 99 | 01 | 10 | 15 | 02 | 01 | 15 |
| 18 | 01 | 09 | 99 | 01 | 21 | 15 | 02 | 05 | 15 | 02 | 18 | 99 | 02 | 21 | 15 | 02 | 11 | 15 |
| 19 | 01 | 09 | 99 | 02 | 09 | 15 | 01 | 21 | 15 | 02 | 18 | 99 | 02 | 21 | 15 | 01 | 09 | 15 |
| 20 | 02 | 10 | 99 | 01 | 09 | 15 | 02 | 18 | 15 | 01 | 18 | 99 | 01 | 21 | 15 | 02 | 01 | 15 |
| 21 | 02 | 10 | 99 | 02 | 01 | 15 | 01 | 04 | 15 | 02 | 21 | 99 | 02 | 18 | 15 | 02 | 18 | 15 |
| 22 | 02 | 10 | 99 | 01 | 01 | 15 | 01 | 09 | 15 | 02 | 21 | 99 | 02 | 18 | 15 | 01 | 11 | 15 |
| 23 | 01 | 10 | 99 | 02 | 10 | 15 | 02 | 04 | 15 | 01 | 21 | 99 | 01 | 18 | 15 | 02 | 01 | 15 |
| 24 | 01 | 10 | 99 | 01 | 10 | 15 | 01 | 18 | 15 | 02 | 01 | 99 | 02 | 01 | 15 | 01 | 21 | 15 |
| 25 | 02 | 11 | 99 | 02 | 21 | 15 | 02 | 05 | 15 | 01 | 01 | 99 | 02 | 01 | 15 | 02 | 11 | 15 |
| 26 | 02 | 11 | 99 | 01 | 21 | 15 | 02 | 01 | 15 | 02 | 04 | 99 | 02 | 04 | 15 | 01 | 04 | 15 |
| 27 | 02 | 11 | 99 | 02 | 04 | 15 | 01 | 05 | 15 | 02 | 01 | 99 | 02 | 04 | 15 | 01 | 09 | 15 |
| 28 | 01 | 11 | 99 | 01 | 04 | 15 | 02 | 18 | 15 | 02 | 04 | 99 | 02 | 05 | 15 | 01 | 21 | 15 |
| 29 | 01 | 11 | 99 | 02 | 11 | 15 | 01 | 05 | 15 | 01 | 04 | 99 | 02 | 05 | 15 | 02 | 10 | 15 |
| 30 | 02 | 18 | 99 | 01 | 11 | 15 | 01 | 21 | 15 | 02 | 05 | 99 | 02 | 09 | 15 | 01 | 05 | 15 |
| 31 | 02 | 18 | 99 | 02 | 18 | 15 | 01 | 09 | 15 | 02 | 04 | 99 | 02 | 09 | 15 | 02 | 04 | 15 |
| 32 | 02 | 18 | 99 | 01 | 18 | 15 | 02 | 10 | 15 | 02 | 05 | 99 | 02 | 10 | 15 | 02 | 04 | 15 |
| 33 | 01 | 18 | 99 | 01 | 01 | 15 | 02 | 21 | 15 | 01 | 05 | 99 | 02 | 10 | 15 | 02 | 05 | 15 |
| 34 | 01 | 18 | 99 | 02 | 01 | 15 | 02 | 09 | 15 | 02 | 09 | 99 | 02 | 11 | 15 | 01 | 18 | 15 |
| 35 | 02 | 21 | 99 | 01 | 01 | 15 | 01 | 11 | 15 | 02 | 05 | 99 | 02 | 11 | 15 | 01 | 21 | 15 |
| 36 | 02 | 21 | 99 | 02 | 04 | 15 | 01 | 09 | 15 | 02 | 09 | 99 | 02 | 18 | 15 | 01 | 18 | 15 |
| 37 | 02 | 21 | 99 | 01 | 04 | 15 | 02 | 04 | 15 | 01 | 09 | 99 | 02 | 18 | 15 | 01 | 18 | 15 |
| 38 | 01 | 21 | 99 | 02 | 04 | 15 | 02 | 01 | 15 | 02 | 10 | 99 | 02 | 21 | 15 | 02 | 21 | 15 |
| 39 | 01 | 21 | 99 | 01 | 05 | 15 | 01 | 11 | 15 | 02 | 09 | 99 | 02 | 21 | 15 | 02 | 18 | 15 |
| 40 | 02 | 01 | 99 | 02 | 05 | 15 | 01 | 10 | 15 | 02 | 10 | 99 | 02 | 01 | 15 | 01 | 10 | 15 |
| 41 | 01 | 01 | 99 | 01 | 05 | 15 | 02 | 11 | 15 | 01 | 10 | 99 | 01 | 01 | 15 | 02 | 10 | 15 |
| 42 | 01 | 01 | 99 | 02 | 09 | 15 | 01 | 01 | 15 | 02 | 11 | 99 | 02 | 04 | 15 | 02 | 01 | 15 |
| 43 | 02 | 04 | 99 | 01 | 09 | 15 | 02 | 01 | 15 | 02 | 10 | 99 | 01 | 04 | 15 | 02 | 10 | 15 |
| 44 | 01 | 04 | 99 | 02 | 09 | 15 | 02 | 04 | 15 | 02 | 11 | 99 | 02 | 05 | 15 | 01 | 10 | 15 |
| 45 | 01 | 04 | 99 | 01 | 10 | 15 | 02 | 10 | 15 | 01 | 11 | 99 | 01 | 05 | 15 | 02 | 05 | 15 |
| 46 | 02 | 05 | 99 | 02 | 10 | 15 | 01 | 01 | 15 | 02 | 18 | 99 | 02 | 09 | 15 | 02 | 05 | 15 |
| 47 | 01 | 05 | 99 | 01 | 10 | 15 | 01 | 05 | 15 | 02 | 11 | 99 | 01 | 09 | 15 | 02 | 05 | 15 |
| 48 | 01 | 05 | 99 | 02 | 11 | 15 | 01 | 18 | 15 | 02 | 18 | 99 | 02 | 10 | 15 | 02 | 21 | 15 |
| 49 | 02 | 09 | 99 | 01 | 11 | 15 | 02 | 21 | 15 | 01 | 18 | 99 | 01 | 10 | 15 | 01 | 10 | 15 |
| 50 | 01 | 09 | 99 | 02 | 11 | 15 | 02 | 05 | 15 | 02 | 21 | 99 | 02 | 11 | 15 | 01 | 09 | 15 |
| 51 | 01 | 09 | 99 | 01 | 18 | 15 | 02 | 10 | 15 | 02 | 18 | 99 | 01 | 11 | 15 | 01 | 05 | 15 |
| 52 | 02 | 10 | 99 | 02 | 18 | 15 | 02 | 09 | 15 | 02 | 21 | 99 | 02 | 18 | 15 | 01 | 09 | 15 |
| 53 | 01 | 10 | 99 | 01 | 18 | 15 | 01 | 21 | 15 | 01 | 21 | 99 | 01 | 18 | 15 | 02 | 04 | 15 |
| 54 | 01 | 10 | 99 | 02 | 21 | 15 | 01 | 11 | 15 | 02 | 01 | 99 | 02 | 21 | 15 | 02 | 09 | 15 |
| 55 | 02 | 11 | 99 | 01 | 21 | 15 | 01 | 04 | 15 | 02 | 21 | 99 | 01 | 21 | 15 | 01 | 04 | 15 |
| 56 | 01 | 11 | 99 | 02 | 21 | 15 | 02 | 09 | 15 | 02 | 01 | 99 | 02 | 05 | 15 | 02 | 01 | 15 |
| 57 | 01 | 11 | 99 | 01 | 04 | 15 | 02 | 18 | 15 | 02 | 01 | 99 | 02 | 05 | 15 | 01 | 04 | 15 |
| 58 | 02 | 18 | 99 | 02 | 04 | 15 | 01 | 01 | 15 | 01 | 01 | 99 | 01 | 05 | 15 | 02 | 05 | 15 |
| 59 | 01 | 18 | 99 | 02 | 04 | 15 | 02 | 05 | 15 | 01 | 01 | 99 | 01 | 05 | 15 | 01 | 11 | 15 |

| | day11 set I | | | day11 set II | | | day11 set III | | | day12 set I | | | day12 set II | | | day12 set III | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 02 | 04 | 99 | 01 | 21 | 65 | 01 | 09 | 13 | 02 | 09 | 99 | 01 | 09 | 60 | 01 | 01 | 10 |
| 1 | 01 | 04 | 99 | 01 | 18 | 65 | 01 | 05 | 13 | 01 | 09 | 99 | 01 | 04 | 60 | 02 | 09 | 10 |
| 2 | 02 | 04 | 20 | 01 | 09 | 65 | 01 | 21 | 13 | 02 | 09 | 20 | 02 | 10 | 60 | 01 | 01 | 10 |
| 3 | 01 | 04 | 20 | 02 | 10 | 65 | 02 | 18 | 13 | 01 | 09 | 20 | 01 | 05 | 60 | 02 | 09 | 10 |
| 4 | 02 | 04 | 15 | 01 | 11 | 65 | 01 | 09 | 13 | 02 | 09 | 15 | 01 | 21 | 60 | 01 | 09 | 10 |
| 5 | 01 | 04 | 15 | 02 | 01 | 65 | 02 | 18 | 13 | 01 | 09 | 15 | 02 | 21 | 60 | 02 | 04 | 10 |
| 6 | 01 | 04 | 15 | 02 | 09 | 65 | 01 | 11 | 13 | 02 | 09 | 10 | 02 | 05 | 60 | 01 | 04 | 10 |
| 7 | 02 | 04 | 15 | 01 | 04 | 65 | 01 | 01 | 13 | 01 | 09 | 10 | 01 | 11 | 60 | 01 | 21 | 10 |
| 8 | 02 | 10 | 99 | 02 | 05 | 65 | 02 | 05 | 13 | 02 | 21 | 15 | 01 | 10 | 60 | 01 | 01 | 10 |
| 9 | 01 | 10 | 99 | 01 | 01 | 65 | 02 | 10 | 13 | 01 | 21 | 15 | 02 | 18 | 60 | 01 | 21 | 10 |
| 10 | 02 | 10 | 20 | 02 | 18 | 65 | 01 | 10 | 13 | 02 | 21 | 10 | 01 | 18 | 60 | 01 | 05 | 10 |
| 11 | 01 | 10 | 20 | 02 | 21 | 65 | 01 | 01 | 13 | 01 | 21 | 10 | 02 | 04 | 60 | 02 | 11 | 10 |
| 12 | 02 | 10 | 15 | 01 | 05 | 65 | 02 | 01 | 13 | 02 | 09 | 10 | 02 | 01 | 60 | 02 | 18 | 10 |
| 13 | 01 | 10 | 15 | 01 | 10 | 65 | 02 | 01 | 13 | 01 | 09 | 10 | 01 | 01 | 60 | 01 | 11 | 10 |
| 14 | 02 | 01 | 99 | 02 | 04 | 65 | 02 | 05 | 13 | 02 | 21 | 10 | 02 | 11 | 60 | 01 | 11 | 10 |
| 15 | 01 | 01 | 99 | 02 | 11 | 65 | 02 | 04 | 13 | 01 | 21 | 10 | 02 | 09 | 60 | 01 | 10 | 10 |
| 16 | 02 | 01 | 20 | 02 | 11 | 20 | 02 | 09 | 13 | 02 | 04 | 15 | 02 | 01 | 15 | 02 | 04 | 10 |
| 17 | 01 | 01 | 20 | 01 | 18 | 20 | 01 | 05 | 13 | 01 | 04 | 15 | 02 | 01 | 15 | 01 | 18 | 10 |
| 18 | 02 | 01 | 15 | 01 | 04 | 20 | 02 | 18 | 13 | 02 | 04 | 10 | 01 | 01 | 15 | 01 | 05 | 10 |
| 19 | 01 | 01 | 15 | 02 | 04 | 20 | 02 | 05 | 13 | 02 | 04 | 10 | 01 | 01 | 15 | 02 | 04 | 10 |
| 20 | 02 | 05 | 99 | 02 | 10 | 20 | 02 | 21 | 13 | 01 | 04 | 10 | 02 | 10 | 15 | 02 | 01 | 10 |
| 21 | 01 | 05 | 99 | 02 | 18 | 20 | 02 | 21 | 13 | 01 | 04 | 10 | 02 | 10 | 15 | 02 | 21 | 10 |
| 22 | 02 | 05 | 20 | 02 | 05 | 20 | 02 | 11 | 13 | 02 | 21 | 10 | 01 | 10 | 15 | 01 | 04 | 10 |
| 23 | 01 | 05 | 20 | 01 | 11 | 20 | 01 | 21 | 13 | 01 | 21 | 10 | 01 | 10 | 15 | 02 | 05 | 10 |
| 24 | 02 | 05 | 15 | 02 | 01 | 20 | 01 | 04 | 13 | 02 | 04 | 10 | 02 | 01 | 15 | 02 | 21 | 10 |
| 25 | 01 | 05 | 15 | 02 | 09 | 20 | 01 | 11 | 13 | 01 | 04 | 10 | 01 | 01 | 15 | 01 | 09 | 10 |
| 26 | 02 | 09 | 99 | 01 | 01 | 20 | 02 | 11 | 13 | 02 | 05 | 15 | 02 | 21 | 13 | 01 | 05 | 10 |
| 27 | 01 | 09 | 99 | 02 | 21 | 20 | 01 | 10 | 13 | 02 | 05 | 15 | 02 | 21 | 13 | 02 | 05 | 10 |
| 28 | 02 | 09 | 20 | 01 | 05 | 20 | 01 | 04 | 13 | 01 | 05 | 15 | 01 | 21 | 13 | 01 | 11 | 10 |
| 29 | 01 | 09 | 20 | 01 | 09 | 20 | 02 | 09 | 13 | 01 | 05 | 15 | 01 | 21 | 13 | 02 | 18 | 10 |
| 30 | 02 | 09 | 15 | 01 | 21 | 20 | 02 | 10 | 13 | 02 | 05 | 10 | 02 | 04 | 13 | 02 | 05 | 10 |
| 31 | 01 | 09 | 15 | 01 | 10 | 20 | 02 | 10 | 13 | 02 | 05 | 10 | 02 | 04 | 13 | 02 | 21 | 10 |
| 32 | 02 | 11 | 30 | 01 | 21 | 15 | 01 | 09 | 13 | 01 | 05 | 10 | 01 | 04 | 13 | 02 | 04 | 10 |
| 33 | 01 | 11 | 30 | 01 | 04 | 15 | 02 | 18 | 13 | 01 | 05 | 10 | 01 | 04 | 13 | 01 | 18 | 10 |
| 34 | 02 | 11 | 15 | 01 | 21 | 15 | 01 | 21 | 13 | 02 | 21 | 10 | 02 | 21 | 13 | 02 | 09 | 10 |
| 35 | 01 | 11 | 15 | 02 | 01 | 15 | 02 | 21 | 13 | 01 | 21 | 10 | 01 | 21 | 13 | 02 | 11 | 10 |
| 36 | 02 | 18 | 30 | 02 | 10 | 15 | 02 | 21 | 13 | 02 | 05 | 10 | 02 | 09 | 13 | 02 | 21 | 10 |
| 37 | 01 | 18 | 30 | 01 | 10 | 15 | 01 | 18 | 13 | 01 | 05 | 10 | 02 | 09 | 13 | 02 | 09 | 10 |
| 38 | 02 | 18 | 15 | 01 | 11 | 15 | 01 | 18 | 13 | 02 | 09 | 10 | 01 | 09 | 13 | 02 | 18 | 10 |
| 39 | 01 | 18 | 15 | 01 | 05 | 15 | 01 | 04 | 13 | 02 | 09 | 10 | 01 | 09 | 13 | 02 | 10 | 10 |
| 40 | 02 | 21 | 30 | 01 | 01 | 15 | 01 | 11 | 13 | 01 | 09 | 10 | 02 | 21 | 13 | 01 | 18 | 10 |
| 41 | 01 | 21 | 30 | 02 | 18 | 15 | 02 | 04 | 13 | 01 | 09 | 10 | 01 | 21 | 13 | 02 | 11 | 10 |
| 42 | 02 | 21 | 15 | 01 | 18 | 15 | 01 | 09 | 13 | 02 | 10 | 15 | 02 | 05 | 13 | 02 | 10 | 10 |
| 43 | 01 | 21 | 15 | 02 | 10 | 15 | 02 | 09 | 13 | 01 | 10 | 15 | 02 | 05 | 13 | 01 | 21 | 10 |
| 44 | 02 | 01 | 13 | 02 | 18 | 15 | 02 | 04 | 13 | 02 | 10 | 20 | 01 | 05 | 13 | 01 | 10 | 10 |
| 45 | 01 | 01 | 13 | 01 | 11 | 15 | 02 | 09 | 13 | 01 | 10 | 20 | 01 | 05 | 13 | 02 | 01 | 10 |
| 46 | 02 | 04 | 13 | 01 | 09 | 15 | 02 | 11 | 13 | 02 | 10 | 99 | 02 | 04 | 13 | 01 | 01 | 10 |
| 47 | 01 | 04 | 13 | 02 | 05 | 15 | 02 | 10 | 13 | 01 | 10 | 99 | 01 | 04 | 13 | 02 | 05 | 10 |
| 48 | 02 | 05 | 13 | 02 | 09 | 15 | 01 | 10 | 13 | 02 | 01 | 99 | 02 | 04 | 13 | 02 | 21 | 10 |
| 49 | 01 | 05 | 13 | 01 | 04 | 15 | 02 | 11 | 13 | 01 | 01 | 99 | 02 | 05 | 13 | 01 | 18 | 10 |
| 50 | 02 | 09 | 13 | 02 | 05 | 15 | 01 | 05 | 13 | 02 | 01 | 15 | 02 | 05 | 13 | 01 | 05 | 10 |
| 51 | 01 | 09 | 13 | 01 | 09 | 15 | 02 | 04 | 13 | 01 | 01 | 15 | 01 | 05 | 13 | 01 | 10 | 10 |
| 52 | 02 | 10 | 13 | 01 | 04 | 15 | 02 | 05 | 13 | 02 | 01 | 10 | 01 | 05 | 13 | 01 | 04 | 10 |
| 53 | 01 | 10 | 13 | 02 | 05 | 15 | 02 | 01 | 13 | 01 | 01 | 10 | 02 | 21 | 13 | 01 | 09 | 10 |
| 54 | 02 | 11 | 13 | 02 | 01 | 15 | 02 | 05 | 13 | 02 | 10 | 10 | 01 | 21 | 13 | 02 | 10 | 10 |
| 55 | 01 | 11 | 13 | 01 | 09 | 15 | 01 | 01 | 13 | 02 | 10 | 10 | 02 | 21 | 13 | 02 | 11 | 10 |
| 56 | 02 | 18 | 13 | 02 | 11 | 15 | 01 | 04 | 13 | 01 | 10 | 10 | 02 | 01 | 13 | 01 | 09 | 10 |
| 57 | 01 | 18 | 13 | 02 | 21 | 15 | 01 | 18 | 13 | 01 | 10 | 10 | 02 | 01 | 13 | 01 | 10 | 10 |
| 58 | 02 | 21 | 13 | 02 | 04 | 15 | 02 | 01 | 13 | 02 | 01 | 10 | 01 | 01 | 13 | 02 | 01 | 10 |
| 59 | 01 | 21 | 13 | 02 | 01 | 15 | 02 | 01 | 13 | 01 | 01 | 10 | 01 | 01 | 13 | 01 | 04 | 10 |

| | day13 set I | | | day13 set II | | | day13 set III | | | day14 set I | | | day14 set II | | | day14 set III | | | day15 set I | | | day15 set II | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 02 | 21 | 20 | 02 | 21 | 60 | 01 | 18 | 10 | 02 | 05 | 20 | 02 | 01 | 15 | 01 | 04 | 55 | 02 | 05 | 20 | 02 | 01 | 15 |
| 1 | 01 | 21 | 20 | 01 | 09 | 60 | 01 | 18 | 10 | 01 | 05 | 20 | 02 | 01 | 15 | 02 | 10 | 05 | 01 | 05 | 20 | 02 | 01 | 15 |
| 2 | 02 | 21 | 15 | 02 | 05 | 60 | 01 | 11 | 10 | 02 | 05 | 15 | 01 | 01 | 15 | 01 | 11 | 05 | 02 | 05 | 15 | 01 | 01 | 15 |
| 3 | 01 | 21 | 15 | 02 | 05 | 60 | 01 | 10 | 10 | 02 | 05 | 15 | 01 | 01 | 15 | 02 | 01 | 05 | 02 | 05 | 15 | 01 | 01 | 15 |
| 4 | 02 | 21 | 10 | 01 | 01 | 60 | 01 | 18 | 10 | 01 | 05 | 15 | 02 | 04 | 15 | 01 | 04 | 05 | 01 | 05 | 15 | 02 | 04 | 15 |
| 5 | 01 | 21 | 10 | 01 | 21 | 60 | 01 | 09 | 10 | 01 | 05 | 15 | 02 | 04 | 15 | 02 | 05 | 55 | 01 | 05 | 15 | 02 | 04 | 15 |
| 6 | 02 | 05 | 10 | 02 | 18 | 60 | 02 | 01 | 10 | 02 | 04 | 20 | 01 | 04 | 15 | 02 | 09 | 55 | 02 | 04 | 20 | 01 | 04 | 15 |
| 7 | 01 | 05 | 10 | 01 | 11 | 60 | 02 | 10 | 10 | 01 | 04 | 20 | 01 | 04 | 15 | 01 | 11 | 05 | 01 | 04 | 20 | 01 | 04 | 15 |
| 8 | 02 | 05 | 15 | 01 | 04 | 60 | 02 | 05 | 10 | 02 | 04 | 15 | 02 | 05 | 15 | 02 | 11 | 55 | 02 | 04 | 15 | 02 | 05 | 15 |
| 9 | 01 | 05 | 15 | 01 | 10 | 60 | 02 | 04 | 10 | 02 | 04 | 15 | 02 | 05 | 15 | 01 | 11 | 55 | 02 | 04 | 15 | 02 | 05 | 15 |
| 10 | 02 | 05 | 20 | 02 | 09 | 60 | 01 | 10 | 10 | 01 | 04 | 15 | 01 | 05 | 15 | 01 | 09 | 05 | 01 | 04 | 15 | 01 | 05 | 15 |
| 11 | 01 | 05 | 20 | 01 | 04 | 60 | 01 | 21 | 10 | 01 | 04 | 15 | 01 | 05 | 15 | 02 | 21 | 05 | 01 | 04 | 15 | 01 | 05 | 15 |
| 12 | 02 | 21 | 15 | 01 | 18 | 60 | 01 | 18 | 10 | 02 | 05 | 15 | 02 | 09 | 15 | 01 | 18 | 55 | 02 | 05 | 15 | 02 | 09 | 15 |
| 13 | 01 | 21 | 15 | 02 | 01 | 60 | 01 | 01 | 10 | 01 | 05 | 15 | 02 | 09 | 15 | 01 | 01 | 05 | 01 | 05 | 15 | 02 | 09 | 15 |
| 14 | 02 | 21 | 10 | 02 | 21 | 60 | 01 | 05 | 10 | 02 | 01 | 20 | 01 | 09 | 15 | 01 | 09 | 55 | 02 | 01 | 20 | 01 | 09 | 15 |
| 15 | 01 | 21 | 10 | 01 | 21 | 60 | 01 | 05 | 10 | 01 | 01 | 20 | 01 | 09 | 15 | 01 | 09 | 05 | 01 | 01 | 20 | 01 | 09 | 15 |
| 16 | 02 | 04 | 10 | 01 | 11 | 60 | 01 | 04 | 10 | 02 | 01 | 15 | 02 | 10 | 15 | 02 | 21 | 55 | 02 | 01 | 15 | 02 | 10 | 15 |
| 17 | 01 | 04 | 10 | 01 | 09 | 60 | 02 | 18 | 10 | 02 | 01 | 15 | 02 | 10 | 15 | 01 | 18 | 05 | 02 | 01 | 15 | 02 | 10 | 15 |
| 18 | 02 | 04 | 15 | 02 | 04 | 60 | 01 | 01 | 10 | 01 | 01 | 15 | 01 | 10 | 15 | 01 | 01 | 55 | 01 | 01 | 15 | 01 | 10 | 15 |
| 19 | 01 | 04 | 15 | 01 | 10 | 60 | 02 | 04 | 10 | 01 | 01 | 15 | 01 | 10 | 15 | 01 | 01 | 55 | 01 | 01 | 15 | 01 | 10 | 15 |
| 20 | 02 | 04 | 20 | 02 | 04 | 60 | 01 | 21 | 10 | 02 | 04 | 15 | 02 | 11 | 15 | 01 | 09 | 55 | 02 | 04 | 15 | 02 | 11 | 15 |
| 21 | 01 | 04 | 20 | 02 | 10 | 60 | 01 | 04 | 10 | 01 | 04 | 15 | 02 | 11 | 15 | 02 | 18 | 05 | 01 | 04 | 15 | 02 | 11 | 15 |
| 22 | 02 | 05 | 15 | 02 | 18 | 60 | 02 | 09 | 10 | 02 | 18 | 20 | 01 | 11 | 15 | 01 | 10 | 55 | 02 | 18 | 20 | 01 | 11 | 15 |
| 23 | 02 | 05 | 15 | 01 | 05 | 60 | 01 | 11 | 10 | 01 | 18 | 20 | 01 | 11 | 15 | 02 | 01 | 55 | 01 | 18 | 20 | 01 | 11 | 15 |
| 24 | 01 | 05 | 15 | 02 | 09 | 60 | 01 | 04 | 10 | 02 | 18 | 15 | 02 | 18 | 15 | 01 | 05 | 55 | 02 | 18 | 15 | 02 | 18 | 15 |
| 25 | 01 | 05 | 15 | 02 | 11 | 60 | 02 | 21 | 10 | 02 | 18 | 15 | 02 | 18 | 15 | 02 | 04 | 55 | 02 | 18 | 15 | 02 | 18 | 15 |
| 26 | 02 | 21 | 10 | 02 | 10 | 60 | 02 | 18 | 10 | 01 | 18 | 15 | 01 | 18 | 15 | 02 | 18 | 55 | 01 | 18 | 15 | 01 | 18 | 15 |
| 27 | 01 | 21 | 10 | 02 | 11 | 60 | 02 | 05 | 10 | 01 | 18 | 15 | 01 | 18 | 15 | 02 | 09 | 55 | 01 | 18 | 15 | 01 | 18 | 15 |
| 28 | 02 | 04 | 10 | 01 | 18 | 60 | 01 | 10 | 10 | 02 | 01 | 15 | 02 | 21 | 15 | 01 | 10 | 05 | 02 | 01 | 15 | 02 | 21 | 15 |
| 29 | 01 | 04 | 10 | 01 | 05 | 60 | 02 | 09 | 10 | 01 | 01 | 15 | 02 | 21 | 15 | 01 | 04 | 05 | 01 | 01 | 15 | 02 | 21 | 15 |
| 30 | 02 | 05 | 15 | 01 | 01 | 60 | 01 | 09 | 10 | 02 | 09 | 20 | 01 | 21 | 15 | 02 | 09 | 05 | 02 | 09 | 20 | 01 | 21 | 15 |
| 31 | 01 | 05 | 15 | 02 | 01 | 60 | 01 | 05 | 10 | 01 | 09 | 20 | 01 | 21 | 15 | 02 | 04 | 55 | 01 | 09 | 20 | 01 | 21 | 15 |
| 32 | 02 | 09 | 15 | 02 | 04 | 13 | 02 | 09 | 10 | 02 | 09 | 15 | 02 | 01 | 15 | 01 | 05 | 05 | 02 | 09 | 15 | 02 | 01 | 15 |
| 33 | 01 | 09 | 15 | 02 | 04 | 13 | 02 | 01 | 10 | 02 | 09 | 15 | 01 | 01 | 15 | 02 | 04 | 05 | 02 | 09 | 15 | 01 | 01 | 15 |
| 34 | 02 | 09 | 10 | 01 | 04 | 13 | 01 | 11 | 10 | 01 | 09 | 15 | 02 | 04 | 15 | 02 | 09 | 05 | 01 | 09 | 15 | 02 | 04 | 15 |
| 35 | 02 | 09 | 10 | 01 | 04 | 13 | 02 | 04 | 10 | 01 | 09 | 15 | 01 | 04 | 15 | 02 | 10 | 05 | 01 | 09 | 15 | 01 | 04 | 15 |
| 36 | 01 | 09 | 10 | 02 | 21 | 13 | 01 | 09 | 10 | 02 | 21 | 20 | 02 | 05 | 15 | 01 | 01 | 05 | 02 | 21 | 20 | 02 | 05 | 15 |
| 37 | 01 | 09 | 10 | 01 | 21 | 13 | 02 | 11 | 10 | 01 | 21 | 20 | 01 | 05 | 15 | 01 | 10 | 05 | 01 | 21 | 20 | 01 | 05 | 15 |
| 38 | 02 | 05 | 15 | 02 | 05 | 13 | 02 | 09 | 10 | 02 | 21 | 15 | 02 | 21 | 15 | 02 | 05 | 05 | 02 | 21 | 15 | 02 | 21 | 15 |
| 39 | 02 | 05 | 15 | 02 | 05 | 13 | 01 | 05 | 10 | 02 | 21 | 15 | 01 | 21 | 15 | 01 | 21 | 55 | 02 | 21 | 15 | 01 | 21 | 15 |
| 40 | 01 | 05 | 15 | 01 | 05 | 13 | 02 | 18 | 10 | 01 | 21 | 15 | 02 | 09 | 15 | 02 | 18 | 05 | 01 | 21 | 15 | 02 | 09 | 15 |
| 41 | 01 | 05 | 15 | 01 | 05 | 13 | 02 | 10 | 10 | 01 | 21 | 15 | 01 | 09 | 15 | 01 | 18 | 05 | 01 | 21 | 15 | 01 | 09 | 15 |
| 42 | 02 | 21 | 15 | 02 | 21 | 13 | 02 | 11 | 10 | 02 | 09 | 15 | 02 | 21 | 15 | 02 | 01 | 05 | 02 | 09 | 15 | 02 | 21 | 15 |
| 43 | 01 | 21 | 15 | 01 | 21 | 13 | 02 | 05 | 10 | 01 | 09 | 15 | 01 | 21 | 15 | 02 | 11 | 05 | 01 | 09 | 15 | 01 | 21 | 15 |
| 44 | 02 | 18 | 15 | 02 | 01 | 13 | 02 | 01 | 10 | 02 | 21 | 15 | 02 | 18 | 15 | 01 | 05 | 05 | 02 | 21 | 15 | 02 | 18 | 15 |
| 45 | 01 | 18 | 15 | 01 | 01 | 13 | 02 | 04 | 10 | 01 | 21 | 15 | 01 | 18 | 15 | 02 | 10 | 55 | 01 | 21 | 15 | 01 | 18 | 15 |
| 46 | 02 | 18 | 10 | 02 | 05 | 13 | 02 | 11 | 10 | 02 | 18 | 20 | 02 | 01 | 15 | 02 | 05 | 55 | 02 | 18 | 20 | 02 | 01 | 15 |
| 47 | 01 | 18 | 10 | 01 | 05 | 13 | 01 | 01 | 10 | 01 | 18 | 20 | 01 | 01 | 15 | 02 | 01 | 55 | 01 | 18 | 20 | 01 | 01 | 15 |
| 48 | 02 | 21 | 15 | 02 | 09 | 13 | 02 | 21 | 10 | 02 | 18 | 15 | 02 | 10 | 15 | 02 | 21 | 05 | 02 | 18 | 15 | 02 | 10 | 15 |
| 49 | 01 | 21 | 15 | 01 | 09 | 13 | 02 | 10 | 10 | 02 | 18 | 15 | 01 | 10 | 15 | 02 | 05 | 05 | 02 | 18 | 15 | 01 | 10 | 15 |
| 50 | 02 | 21 | 10 | 02 | 21 | 13 | 01 | 21 | 10 | 01 | 18 | 15 | 02 | 09 | 15 | 01 | 04 | 55 | 01 | 18 | 15 | 02 | 09 | 15 |
| 51 | 01 | 21 | 10 | 01 | 21 | 13 | 02 | 21 | 10 | 01 | 18 | 15 | 01 | 09 | 15 | 01 | 21 | 05 | 01 | 18 | 15 | 01 | 09 | 15 |
| 52 | 02 | 01 | 15 | 02 | 10 | 13 | 01 | 01 | 10 | 02 | 21 | 15 | 02 | 05 | 15 | 01 | 05 | 55 | 02 | 21 | 15 | 02 | 05 | 15 |
| 53 | 01 | 01 | 15 | 02 | 10 | 13 | 02 | 11 | 10 | 01 | 21 | 15 | 01 | 05 | 15 | 02 | 11 | 55 | 01 | 21 | 15 | 01 | 05 | 15 |
| 54 | 02 | 01 | 10 | 01 | 10 | 13 | 01 | 09 | 10 | 02 | 04 | 15 | 02 | 04 | 15 | 02 | 11 | 05 | 02 | 04 | 15 | 02 | 04 | 15 |
| 55 | 01 | 01 | 10 | 01 | 10 | 13 | 02 | 21 | 10 | 01 | 04 | 15 | 01 | 04 | 15 | 02 | 10 | 55 | 01 | 04 | 15 | 01 | 04 | 15 |
| 56 | 02 | 11 | 15 | 02 | 18 | 13 | 01 | 10 | 10 | 02 | 05 | 15 | 02 | 21 | 15 | 02 | 04 | 05 | 02 | 05 | 15 | 02 | 21 | 15 |
| 57 | 01 | 11 | 15 | 01 | 18 | 13 | 02 | 19 | 10 | 01 | 05 | 15 | 01 | 21 | 15 | 01 | 21 | 05 | 01 | 05 | 15 | 01 | 21 | 15 |
| 58 | 02 | 11 | 10 | 02 | 11 | 13 | 01 | 04 | 10 | 02 | 18 | 15 | 02 | 11 | 15 | 02 | 21 | 55 | 02 | 18 | 15 | 02 | 11 | 15 |
| 59 | 01 | 11 | 10 | 01 | 11 | 13 | 02 | 05 | 10 | 01 | 18 | 15 | 01 | 11 | 15 | 02 | 18 | 55 | 01 | 18 | 15 | 01 | 11 | 15 |

Figure A.4: Training schedule for the second half duration for Subject 1

| | day08 | | | | | | | | | day09 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | set I | | | set II | | | set III | | | set I | | | set II | | | set III | | |
| 0 | 02 | 02 | 99 | 02 | 02 | 99 | 02 | 20 | 15 | 02 | 02 | 99 | 02 | 19 | 15 | 02 | 12 | 15 |
| 1 | 02 | 02 | 99 | 02 | 02 | 99 | 02 | 10 | 15 | 02 | 02 | 99 | 02 | 19 | 15 | 01 | 04 | 15 |
| 2 | 02 | 02 | 99 | 02 | 02 | 99 | 01 | 20 | 15 | 01 | 02 | 99 | 01 | 19 | 15 | 02 | 20 | 15 |
| 3 | 01 | 02 | 99 | 01 | 02 | 99 | 02 | 20 | 15 | 01 | 02 | 99 | 01 | 19 | 15 | 02 | 04 | 15 |
| 4 | 01 | 02 | 99 | 01 | 02 | 99 | 01 | 04 | 15 | 02 | 04 | 99 | 02 | 20 | 15 | 01 | 02 | 15 |
| 5 | 02 | 04 | 99 | 02 | 04 | 99 | 01 | 19 | 15 | 02 | 04 | 99 | 02 | 20 | 15 | 01 | 10 | 15 |
| 6 | 02 | 04 | 99 | 02 | 04 | 99 | 01 | 19 | 15 | 01 | 04 | 99 | 01 | 20 | 15 | 01 | 19 | 15 |
| 7 | 02 | 04 | 99 | 02 | 04 | 99 | 02 | 04 | 15 | 01 | 04 | 99 | 01 | 20 | 15 | 01 | 20 | 15 |
| 8 | 01 | 04 | 99 | 01 | 04 | 99 | 01 | 19 | 15 | 02 | 10 | 99 | 02 | 10 | 15 | 02 | 12 | 15 |
| 9 | 01 | 04 | 99 | 01 | 04 | 99 | 01 | 12 | 15 | 02 | 10 | 99 | 02 | 10 | 15 | 02 | 02 | 15 |
| 10 | 02 | 10 | 99 | 02 | 10 | 99 | 02 | 10 | 15 | 01 | 10 | 99 | 01 | 10 | 15 | 01 | 04 | 15 |
| 11 | 02 | 10 | 99 | 02 | 10 | 99 | 02 | 12 | 15 | 01 | 10 | 99 | 01 | 10 | 15 | 01 | 10 | 15 |
| 12 | 02 | 10 | 99 | 02 | 10 | 99 | 02 | 04 | 15 | 02 | 12 | 99 | 02 | 12 | 15 | 02 | 02 | 15 |
| 13 | 01 | 10 | 99 | 01 | 10 | 99 | 01 | 20 | 15 | 02 | 12 | 99 | 02 | 12 | 15 | 01 | 04 | 15 |
| 14 | 01 | 10 | 99 | 01 | 10 | 99 | 01 | 10 | 15 | 01 | 12 | 99 | 01 | 12 | 15 | 02 | 02 | 15 |
| 15 | 02 | 12 | 99 | 02 | 12 | 99 | 01 | 04 | 15 | 01 | 12 | 99 | 01 | 12 | 15 | 01 | 04 | 15 |
| 16 | 02 | 12 | 99 | 02 | 12 | 99 | 01 | 12 | 15 | 02 | 19 | 99 | 02 | 02 | 15 | 02 | 12 | 15 |
| 17 | 02 | 12 | 99 | 02 | 12 | 99 | 01 | 02 | 15 | 02 | 19 | 99 | 01 | 02 | 15 | 01 | 20 | 15 |
| 18 | 01 | 12 | 99 | 01 | 12 | 99 | 01 | 02 | 15 | 01 | 19 | 99 | 02 | 02 | 15 | 01 | 12 | 15 |
| 19 | 01 | 12 | 99 | 01 | 12 | 99 | 02 | 20 | 15 | 01 | 19 | 99 | 01 | 02 | 15 | 01 | 02 | 15 |
| 20 | 02 | 19 | 99 | 02 | 19 | 99 | 01 | 02 | 15 | 02 | 20 | 99 | 02 | 04 | 15 | 02 | 04 | 15 |
| 21 | 02 | 19 | 99 | 02 | 19 | 99 | 01 | 10 | 15 | 02 | 20 | 99 | 01 | 04 | 15 | 02 | 20 | 15 |
| 22 | 02 | 19 | 99 | 02 | 19 | 99 | 02 | 19 | 15 | 01 | 20 | 99 | 02 | 04 | 15 | 01 | 20 | 15 |
| 23 | 01 | 19 | 99 | 01 | 19 | 99 | 02 | 04 | 15 | 01 | 20 | 99 | 01 | 04 | 15 | 01 | 04 | 15 |
| 24 | 01 | 19 | 99 | 01 | 19 | 99 | 02 | 19 | 15 | 02 | 04 | 99 | 02 | 02 | 15 | 02 | 12 | 15 |
| 25 | 02 | 20 | 99 | 02 | 20 | 99 | 02 | 10 | 15 | 02 | 04 | 99 | 01 | 02 | 15 | 01 | 20 | 15 |
| 26 | 02 | 20 | 99 | 02 | 20 | 99 | 02 | 10 | 15 | 01 | 04 | 99 | 02 | 02 | 15 | 01 | 10 | 15 |
| 27 | 02 | 20 | 99 | 02 | 20 | 99 | 02 | 04 | 15 | 01 | 04 | 99 | 01 | 02 | 15 | 02 | 20 | 15 |
| 28 | 01 | 20 | 99 | 01 | 20 | 99 | 02 | 12 | 15 | 02 | 10 | 99 | 02 | 04 | 15 | 01 | 10 | 15 |
| 29 | 01 | 20 | 99 | 01 | 20 | 99 | 02 | 20 | 15 | 02 | 10 | 99 | 01 | 04 | 15 | 01 | 02 | 15 |
| 30 | 02 | 02 | 99 | 02 | 02 | 99 | 01 | 10 | 15 | 01 | 10 | 99 | 02 | 04 | 15 | 02 | 19 | 15 |
| 31 | 01 | 02 | 99 | 01 | 02 | 99 | 02 | 02 | 15 | 01 | 10 | 99 | 01 | 04 | 15 | 01 | 12 | 15 |
| 32 | 01 | 02 | 99 | 01 | 02 | 99 | 02 | 02 | 15 | 02 | 19 | 99 | 02 | 10 | 15 | 01 | 12 | 15 |
| 33 | 02 | 04 | 99 | 02 | 04 | 99 | 02 | 12 | 15 | 02 | 19 | 99 | 01 | 10 | 15 | 02 | 12 | 15 |
| 34 | 01 | 04 | 99 | 01 | 04 | 99 | 02 | 19 | 15 | 01 | 19 | 99 | 02 | 10 | 15 | 02 | 02 | 15 |
| 35 | 01 | 04 | 99 | 01 | 04 | 99 | 01 | 02 | 15 | 01 | 19 | 99 | 01 | 10 | 15 | 02 | 04 | 15 |
| 36 | 02 | 10 | 99 | 02 | 10 | 99 | 01 | 20 | 15 | 02 | 02 | 99 | 02 | 12 | 15 | 02 | 19 | 15 |
| 37 | 01 | 10 | 99 | 01 | 10 | 99 | 02 | 12 | 15 | 01 | 02 | 99 | 01 | 12 | 15 | 01 | 10 | 15 |
| 38 | 01 | 10 | 99 | 01 | 10 | 99 | 01 | 12 | 15 | 02 | 04 | 99 | 02 | 12 | 15 | 02 | 04 | 15 |
| 39 | 02 | 12 | 99 | 02 | 12 | 99 | 01 | 12 | 15 | 01 | 04 | 99 | 01 | 12 | 15 | 01 | 12 | 15 |
| 40 | 01 | 12 | 99 | 01 | 12 | 99 | 02 | 12 | 15 | 02 | 10 | 99 | 02 | 19 | 15 | 02 | 19 | 15 |
| 41 | 01 | 12 | 99 | 01 | 12 | 99 | 01 | 04 | 15 | 01 | 10 | 99 | 01 | 19 | 15 | 01 | 19 | 15 |
| 42 | 02 | 19 | 99 | 02 | 19 | 99 | 02 | 20 | 15 | 02 | 12 | 99 | 02 | 19 | 15 | 02 | 10 | 15 |
| 43 | 01 | 19 | 99 | 01 | 19 | 99 | 02 | 10 | 15 | 01 | 12 | 99 | 01 | 19 | 15 | 02 | 20 | 15 |
| 44 | 01 | 19 | 99 | 01 | 19 | 99 | 01 | 04 | 15 | 02 | 19 | 99 | 02 | 20 | 15 | 01 | 02 | 15 |
| 45 | 02 | 02 | 99 | 02 | 02 | 99 | 02 | 19 | 15 | 01 | 19 | 99 | 01 | 20 | 15 | 02 | 19 | 15 |
| 46 | 01 | 02 | 99 | 01 | 02 | 99 | 01 | 12 | 15 | 02 | 20 | 99 | 02 | 20 | 15 | 02 | 10 | 15 |
| 47 | 02 | 04 | 99 | 02 | 04 | 99 | 02 | 02 | 15 | 01 | 20 | 99 | 01 | 20 | 15 | 01 | 19 | 15 |
| 48 | 01 | 04 | 99 | 01 | 04 | 99 | 01 | 19 | 15 | 02 | 02 | 99 | 02 | 02 | 15 | 02 | 02 | 15 |
| 49 | 02 | 10 | 99 | 02 | 10 | 99 | 01 | 19 | 15 | 01 | 04 | 99 | 01 | 02 | 15 | 02 | 19 | 15 |
| 50 | 01 | 10 | 99 | 01 | 10 | 99 | 01 | 02 | 15 | 02 | 10 | 99 | 02 | 04 | 15 | 02 | 10 | 15 |
| 51 | 02 | 12 | 99 | 02 | 12 | 99 | 01 | 10 | 15 | 01 | 12 | 99 | 01 | 04 | 15 | 01 | 20 | 15 |
| 52 | 01 | 12 | 99 | 01 | 12 | 99 | 01 | 04 | 15 | 02 | 19 | 99 | 02 | 10 | 15 | 01 | 19 | 15 |
| 53 | 02 | 19 | 99 | 02 | 19 | 99 | 02 | 02 | 15 | 01 | 20 | 99 | 01 | 10 | 15 | 02 | 20 | 15 |
| 54 | 01 | 19 | 99 | 01 | 19 | 99 | 01 | 10 | 15 | 02 | 04 | 99 | 02 | 12 | 15 | 01 | 02 | 15 |
| 55 | 02 | 20 | 99 | 02 | 20 | 99 | 02 | 19 | 15 | 02 | 04 | 99 | 01 | 12 | 15 | 01 | 19 | 15 |
| 56 | 01 | 20 | 99 | 01 | 20 | 99 | 02 | 04 | 15 | 01 | 04 | 99 | 02 | 19 | 15 | 02 | 10 | 15 |
| 57 | 02 | 10 | 99 | 02 | 10 | 99 | 01 | 20 | 15 | 02 | 19 | 99 | 01 | 19 | 15 | 01 | 12 | 15 |
| 58 | 01 | 10 | 99 | 01 | 10 | 99 | 01 | 20 | 15 | 02 | 19 | 99 | 02 | 20 | 15 | 02 | 04 | 15 |
| 59 | 01 | 10 | 99 | 01 | 10 | 99 | 02 | 02 | 15 | 01 | 19 | 99 | 01 | 20 | 15 | 02 | 10 | 15 |

| | day10 | | | | | | | | | day11 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | set I | | | set II | | | set III | | | set I | | | set II | | | set III | | |
| 0 | 02 | 04 | 99 | 01 | 12 | 65 | 01 | 09 | 13 | 02 | 02 | 30 | 02 | 02 | 15 | 02 | 10 | 15 |
| 1 | 01 | 04 | 99 | 01 | 10 | 65 | 01 | 05 | 13 | 01 | 02 | 30 | 01 | 02 | 15 | 02 | 10 | 15 |
| 2 | 02 | 04 | 20 | 01 | 04 | 65 | 01 | 21 | 13 | 02 | 02 | 20 | 02 | 02 | 15 | 02 | 04 | 15 |
| 3 | 01 | 04 | 20 | 02 | 04 | 65 | 02 | 18 | 13 | 01 | 02 | 20 | 02 | 04 | 15 | 02 | 12 | 15 |
| 4 | 02 | 04 | 15 | 01 | 20 | 65 | 01 | 09 | 13 | 02 | 02 | 15 | 01 | 04 | 15 | 01 | 20 | 15 |
| 5 | 01 | 04 | 15 | 02 | 04 | 65 | 02 | 18 | 13 | 02 | 02 | 15 | 02 | 04 | 15 | 02 | 10 | 15 |
| 6 | 02 | 04 | 15 | 01 | 19 | 65 | 01 | 11 | 13 | 01 | 02 | 15 | 01 | 02 | 15 | 01 | 10 | 15 |
| 7 | 01 | 04 | 15 | 02 | 10 | 65 | 01 | 01 | 13 | 01 | 02 | 15 | 02 | 02 | 15 | 02 | 02 | 15 |
| 8 | 02 | 19 | 99 | 02 | 02 | 65 | 02 | 05 | 13 | 02 | 04 | 20 | 01 | 02 | 15 | 01 | 10 | 15 |
| 9 | 01 | 19 | 99 | 01 | 02 | 65 | 02 | 10 | 13 | 01 | 04 | 20 | 02 | 10 | 15 | 01 | 20 | 15 |
| 10 | 02 | 19 | 20 | 02 | 20 | 65 | 01 | 10 | 13 | 02 | 04 | 15 | 01 | 10 | 15 | 02 | 20 | 15 |
| 11 | 01 | 19 | 20 | 01 | 10 | 65 | 01 | 01 | 13 | 02 | 04 | 15 | 02 | 10 | 15 | 01 | 19 | 15 |
| 12 | 02 | 19 | 15 | 01 | 19 | 65 | 02 | 01 | 13 | 01 | 04 | 15 | 01 | 04 | 15 | 01 | 12 | 15 |
| 13 | 01 | 19 | 15 | 02 | 02 | 65 | 02 | 01 | 13 | 01 | 04 | 15 | 02 | 04 | 15 | 01 | 04 | 15 |
| 14 | 02 | 19 | 15 | 02 | 19 | 65 | 02 | 05 | 13 | 02 | 10 | 20 | 01 | 04 | 15 | 01 | 12 | 15 |
| 15 | 01 | 19 | 15 | 02 | 12 | 65 | 02 | 04 | 13 | 01 | 10 | 20 | 02 | 12 | 15 | 01 | 04 | 15 |
| 16 | 02 | 02 | 99 | 02 | 20 | 20 | 02 | 09 | 13 | 02 | 10 | 15 | 01 | 12 | 15 | 02 | 20 | 15 |
| 17 | 01 | 02 | 99 | 02 | 19 | 20 | 01 | 05 | 13 | 02 | 10 | 15 | 02 | 12 | 15 | 02 | 04 | 15 |
| 18 | 02 | 02 | 20 | 02 | 12 | 20 | 02 | 18 | 13 | 01 | 10 | 15 | 01 | 10 | 15 | 02 | 12 | 15 |
| 19 | 01 | 02 | 20 | 01 | 10 | 20 | 02 | 05 | 13 | 01 | 10 | 15 | 02 | 10 | 15 | 01 | 19 | 15 |
| 20 | 02 | 02 | 15 | 01 | 19 | 20 | 02 | 21 | 13 | 02 | 12 | 20 | 01 | 10 | 15 | 02 | 19 | 15 |
| 21 | 01 | 02 | 15 | 02 | 02 | 20 | 02 | 21 | 13 | 01 | 12 | 20 | 02 | 04 | 15 | 01 | 12 | 15 |
| 22 | 02 | 02 | 15 | 01 | 02 | 20 | 02 | 11 | 13 | 02 | 12 | 15 | 01 | 04 | 15 | 01 | 20 | 15 |
| 23 | 01 | 02 | 15 | 02 | 04 | 20 | 01 | 21 | 13 | 02 | 12 | 15 | 02 | 04 | 15 | 02 | 10 | 15 |
| 24 | 02 | 10 | 99 | 02 | 10 | 20 | 01 | 04 | 13 | 01 | 12 | 15 | 01 | 12 | 15 | 01 | 10 | 15 |
| 25 | 01 | 10 | 99 | 01 | 04 | 20 | 01 | 11 | 13 | 01 | 12 | 15 | 02 | 12 | 15 | 02 | 20 | 15 |
| 26 | 02 | 10 | 20 | 01 | 12 | 20 | 02 | 11 | 13 | 02 | 19 | 20 | 01 | 12 | 15 | 01 | 10 | 15 |
| 27 | 01 | 10 | 20 | 01 | 20 | 20 | 01 | 10 | 13 | 01 | 19 | 20 | 02 | 10 | 15 | 02 | 04 | 15 |
| 28 | 02 | 10 | 15 | 01 | 10 | 15 | 01 | 04 | 13 | 02 | 19 | 15 | 01 | 10 | 15 | 01 | 20 | 15 |
| 29 | 01 | 10 | 15 | 02 | 10 | 15 | 02 | 09 | 13 | 02 | 19 | 15 | 02 | 10 | 15 | 02 | 12 | 15 |
| 30 | 02 | 10 | 15 | 01 | 10 | 15 | 02 | 10 | 13 | 01 | 19 | 15 | 02 | 19 | 15 | 01 | 02 | 15 |
| 31 | 01 | 10 | 15 | 01 | 12 | 15 | 02 | 10 | 13 | 01 | 19 | 15 | 01 | 19 | 15 | 02 | 04 | 15 |
| 32 | 02 | 12 | 99 | 02 | 04 | 15 | 01 | 09 | 13 | 02 | 20 | 20 | 02 | 19 | 15 | 01 | 12 | 15 |
| 33 | 01 | 12 | 99 | 02 | 02 | 15 | 02 | 18 | 13 | 01 | 20 | 20 | 02 | 12 | 15 | 01 | 19 | 15 |
| 34 | 02 | 12 | 20 | 02 | 19 | 15 | 01 | 21 | 13 | 02 | 20 | 15 | 01 | 12 | 15 | 02 | 19 | 15 |
| 35 | 01 | 12 | 20 | 02 | 20 | 15 | 02 | 21 | 13 | 02 | 20 | 15 | 02 | 12 | 15 | 01 | 02 | 15 |
| 36 | 02 | 12 | 15 | 02 | 04 | 15 | 02 | 21 | 13 | 01 | 20 | 15 | 02 | 02 | 15 | 01 | 02 | 15 |
| 37 | 01 | 12 | 15 | 01 | 19 | 15 | 01 | 18 | 13 | 01 | 20 | 15 | 01 | 02 | 15 | 01 | 20 | 15 |
| 38 | 02 | 12 | 15 | 01 | 19 | 15 | 01 | 18 | 13 | 02 | 02 | 15 | 02 | 02 | 15 | 02 | 02 | 15 |
| 39 | 01 | 12 | 15 | 02 | 20 | 15 | 01 | 04 | 13 | 02 | 02 | 15 | 01 | 19 | 15 | 01 | 19 | 15 |
| 40 | 02 | 20 | 99 | 01 | 20 | 15 | 01 | 11 | 13 | 01 | 02 | 15 | 02 | 19 | 15 | 01 | 12 | 15 |
| 41 | 01 | 20 | 99 | 02 | 04 | 15 | 02 | 04 | 13 | 01 | 02 | 15 | 01 | 19 | 15 | 01 | 19 | 15 |
| 42 | 02 | 20 | 20 | 01 | 02 | 15 | 01 | 09 | 13 | 02 | 04 | 15 | 02 | 20 | 15 | 01 | 04 | 15 |
| 43 | 01 | 20 | 20 | 02 | 04 | 15 | 02 | 09 | 13 | 02 | 04 | 15 | 01 | 20 | 15 | 01 | 02 | 15 |
| 44 | 02 | 20 | 15 | 02 | 12 | 15 | 02 | 04 | 13 | 01 | 04 | 15 | 02 | 20 | 15 | 02 | 02 | 15 |
| 45 | 01 | 20 | 15 | 01 | 20 | 15 | 02 | 09 | 13 | 01 | 04 | 15 | 02 | 19 | 15 | 02 | 04 | 15 |
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| 47 | 01 | 20 | 15 | 02 | 02 | 15 | 02 | 10 | 13 | 02 | 10 | 15 | 02 | 19 | 15 | 02 | 02 | 15 |
| 48 | 02 | 04 | 15 | 01 | 04 | 15 | 01 | 10 | 13 | 01 | 10 | 15 | 01 | 20 | 15 | 02 | 20 | 15 |
| 49 | 01 | 04 | 15 | 01 | 04 | 15 | 02 | 11 | 13 | 01 | 10 | 15 | 02 | 20 | 15 | 01 | 04 | 15 |
| 50 | 02 | 04 | 15 | 02 | 10 | 15 | 01 | 05 | 13 | 02 | 12 | 15 | 01 | 20 | 15 | 02 | 10 | 15 |
| 51 | 01 | 19 | 15 | 02 | 10 | 15 | 02 | 04 | 13 | 02 | 12 | 15 | 02 | 02 | 15 | 02 | 12 | 15 |
| 52 | 02 | 19 | 15 | 02 | 12 | 15 | 02 | 05 | 13 | 01 | 12 | 15 | 01 | 04 | 15 | 02 | 12 | 15 |
| 53 | 01 | 19 | 15 | 02 | 02 | 15 | 02 | 01 | 13 | 01 | 12 | 15 | 02 | 20 | 15 | 02 | 19 | 15 |
| 54 | 02 | 20 | 15 | 01 | 19 | 15 | 02 | 05 | 13 | 02 | 19 | 15 | 01 | 20 | 15 | 01 | 02 | 15 |
| 55 | 01 | 20 | 15 | 01 | 02 | 15 | 01 | 01 | 13 | 02 | 19 | 15 | 02 | 10 | 15 | 02 | 02 | 15 |
| 56 | 02 | 20 | 15 | 02 | 20 | 15 | 01 | 04 | 13 | 01 | 19 | 15 | 01 | 12 | 15 | 02 | 19 | 15 |
| 57 | 01 | 10 | 15 | 01 | 12 | 15 | 01 | 18 | 13 | 01 | 19 | 15 | 02 | 19 | 15 | 02 | 20 | 15 |
| 58 | 02 | 12 | 15 | 02 | 19 | 15 | 02 | 01 | 13 | 02 | 20 | 15 | 01 | 10 | 15 | 02 | 19 | 15 |
| 59 | 01 | 20 | 15 | 02 | 19 | 15 | 02 | 01 | 13 | 01 | 20 | 15 | 02 | 19 | 15 | 01 | 04 | 15 |

| | day12 | | | | | | | | | day13 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | set I | | | set II | | | set III | | | set I | | | set II | | | set III | | |
| 0 | 02 | 02 | 20 | 02 | 02 | 15 | 01 | 01 | 10 | 02 | 02 | 20 | 02 | 02 | 15 | 01 | 19 | 15 |
| 1 | 01 | 02 | 20 | 02 | 02 | 15 | 02 | 09 | 10 | 01 | 02 | 20 | 02 | 02 | 15 | 02 | 02 | 15 |
| 2 | 02 | 02 | 15 | 01 | 02 | 15 | 01 | 01 | 10 | 02 | 02 | 15 | 01 | 02 | 15 | 02 | 04 | 15 |
| 3 | 02 | 02 | 15 | 01 | 02 | 15 | 02 | 09 | 10 | 02 | 02 | 15 | 01 | 02 | 15 | 01 | 10 | 15 |
| 4 | 01 | 02 | 15 | 02 | 04 | 15 | 01 | 09 | 10 | 01 | 02 | 15 | 02 | 04 | 15 | 01 | 10 | 15 |
| 5 | 01 | 02 | 15 | 02 | 04 | 15 | 02 | 04 | 10 | 01 | 02 | 15 | 02 | 04 | 15 | 02 | 12 | 15 |
| 6 | 02 | 04 | 20 | 01 | 04 | 15 | 01 | 04 | 10 | 02 | 04 | 20 | 01 | 04 | 15 | 01 | 20 | 15 |
| 7 | 01 | 04 | 20 | 01 | 04 | 15 | 01 | 21 | 10 | 01 | 04 | 20 | 01 | 04 | 15 | 01 | 04 | 15 |
| 8 | 02 | 04 | 15 | 02 | 10 | 15 | 01 | 01 | 10 | 02 | 04 | 15 | 02 | 10 | 15 | 01 | 10 | 15 |
| 9 | 02 | 04 | 15 | 02 | 10 | 15 | 01 | 21 | 10 | 02 | 04 | 15 | 02 | 10 | 15 | 02 | 10 | 15 |
| 10 | 01 | 04 | 15 | 01 | 10 | 15 | 01 | 05 | 10 | 01 | 04 | 15 | 01 | 10 | 15 | 01 | 12 | 15 |
| 11 | 01 | 04 | 15 | 01 | 10 | 15 | 02 | 11 | 10 | 01 | 04 | 15 | 01 | 10 | 15 | 02 | 12 | 15 |
| 12 | 02 | 02 | 15 | 02 | 12 | 15 | 02 | 18 | 10 | 02 | 02 | 15 | 02 | 12 | 15 | 01 | 12 | 15 |
| 13 | 01 | 02 | 15 | 02 | 12 | 15 | 01 | 11 | 10 | 01 | 02 | 15 | 02 | 12 | 15 | 01 | 12 | 15 |
| 14 | 02 | 10 | 20 | 01 | 12 | 15 | 01 | 11 | 10 | 02 | 10 | 20 | 01 | 12 | 15 | 01 | 19 | 15 |
| 15 | 01 | 10 | 20 | 01 | 12 | 15 | 01 | 10 | 10 | 01 | 10 | 20 | 01 | 12 | 15 | 01 | 02 | 15 |
| 16 | 02 | 10 | 15 | 02 | 19 | 15 | 02 | 04 | 10 | 02 | 10 | 15 | 02 | 19 | 15 | 02 | 20 | 15 |
| 17 | 02 | 10 | 15 | 02 | 19 | 15 | 01 | 18 | 10 | 02 | 10 | 15 | 02 | 19 | 15 | 01 | 04 | 15 |
| 18 | 01 | 10 | 15 | 01 | 19 | 15 | 01 | 05 | 10 | 01 | 10 | 15 | 01 | 19 | 15 | 01 | 19 | 15 |
| 19 | 01 | 10 | 15 | 01 | 19 | 15 | 02 | 04 | 10 | 01 | 10 | 15 | 01 | 19 | 15 | 01 | 10 | 15 |
| 20 | 02 | 04 | 15 | 02 | 20 | 15 | 02 | 01 | 10 | 02 | 04 | 15 | 02 | 20 | 15 | 02 | 20 | 15 |
| 21 | 01 | 04 | 15 | 02 | 20 | 15 | 02 | 21 | 10 | 01 | 04 | 15 | 02 | 20 | 15 | 02 | 19 | 15 |
| 22 | 02 | 12 | 20 | 01 | 20 | 15 | 01 | 04 | 10 | 02 | 12 | 20 | 01 | 20 | 15 | 02 | 02 | 15 |
| 23 | 01 | 12 | 20 | 01 | 20 | 15 | 02 | 05 | 10 | 01 | 12 | 20 | 01 | 20 | 15 | 02 | 04 | 15 |
| 24 | 02 | 12 | 15 | 02 | 02 | 15 | 02 | 21 | 10 | 02 | 12 | 15 | 02 | 02 | 15 | 01 | 12 | 15 |
| 25 | 02 | 12 | 15 | 02 | 02 | 15 | 01 | 09 | 10 | 02 | 12 | 15 | 02 | 02 | 15 | 01 | 04 | 15 |
| 26 | 01 | 12 | 15 | 01 | 02 | 15 | 01 | 05 | 10 | 01 | 12 | 15 | 01 | 02 | 15 | 02 | 20 | 15 |
| 27 | 01 | 12 | 15 | 01 | 02 | 15 | 02 | 05 | 10 | 01 | 12 | 15 | 01 | 02 | 15 | 02 | 10 | 15 |
| 28 | 02 | 10 | 15 | 02 | 04 | 15 | 01 | 11 | 10 | 02 | 10 | 15 | 02 | 04 | 15 | 02 | 04 | 15 |
| 29 | 01 | 10 | 15 | 02 | 04 | 15 | 02 | 18 | 10 | 01 | 10 | 15 | 02 | 04 | 15 | 02 | 02 | 15 |
| 30 | 02 | 19 | 20 | 01 | 04 | 15 | 02 | 05 | 10 | 02 | 19 | 20 | 01 | 04 | 15 | 02 | 12 | 15 |
| 31 | 01 | 19 | 20 | 01 | 04 | 15 | 02 | 21 | 10 | 01 | 19 | 20 | 01 | 04 | 15 | 02 | 10 | 15 |
| 32 | 02 | 19 | 15 | 02 | 10 | 15 | 02 | 04 | 10 | 02 | 19 | 15 | 02 | 10 | 15 | 02 | 19 | 15 |
| 33 | 02 | 19 | 15 | 02 | 10 | 15 | 01 | 18 | 10 | 02 | 19 | 15 | 02 | 10 | 15 | 02 | 10 | 15 |
| 34 | 01 | 19 | 15 | 01 | 10 | 15 | 02 | 09 | 10 | 01 | 19 | 15 | 01 | 10 | 15 | 01 | 02 | 15 |
| 35 | 01 | 19 | 15 | 01 | 10 | 15 | 02 | 11 | 10 | 01 | 19 | 15 | 01 | 10 | 15 | 02 | 02 | 15 |
| 36 | 02 | 12 | 15 | 02 | 12 | 15 | 02 | 21 | 10 | 02 | 12 | 15 | 02 | 12 | 15 | 02 | 20 | 15 |
| 37 | 01 | 12 | 15 | 02 | 12 | 15 | 02 | 09 | 10 | 01 | 12 | 15 | 02 | 12 | 15 | 02 | 12 | 15 |
| 38 | 02 | 20 | 20 | 01 | 12 | 15 | 02 | 18 | 10 | 02 | 20 | 20 | 01 | 12 | 15 | 01 | 10 | 15 |
| 39 | 01 | 20 | 20 | 01 | 12 | 15 | 02 | 10 | 10 | 01 | 20 | 20 | 01 | 12 | 15 | 01 | 02 | 15 |
| 40 | 02 | 20 | 15 | 02 | 19 | 15 | 01 | 18 | 10 | 02 | 20 | 15 | 02 | 19 | 15 | 02 | 19 | 15 |
| 41 | 02 | 20 | 15 | 02 | 19 | 15 | 02 | 11 | 10 | 02 | 20 | 15 | 02 | 19 | 15 | 01 | 20 | 15 |
| 42 | 01 | 20 | 15 | 01 | 19 | 15 | 02 | 10 | 10 | 01 | 20 | 15 | 01 | 19 | 15 | 02 | 02 | 15 |
| 43 | 01 | 20 | 15 | 01 | 19 | 15 | 01 | 21 | 10 | 01 | 20 | 15 | 01 | 19 | 15 | 02 | 19 | 15 |
| 44 | 02 | 19 | 15 | 02 | 20 | 15 | 01 | 10 | 10 | 02 | 19 | 15 | 02 | 20 | 15 | 02 | 19 | 15 |
| 45 | 01 | 19 | 15 | 02 | 20 | 15 | 02 | 01 | 10 | 01 | 19 | 15 | 02 | 20 | 15 | 02 | 04 | 15 |
| 46 | 02 | 02 | 15 | 01 | 20 | 15 | 01 | 01 | 10 | 02 | 02 | 15 | 01 | 20 | 15 | 01 | 02 | 15 |
| 47 | 01 | 02 | 15 | 01 | 20 | 15 | 02 | 05 | 10 | 01 | 02 | 15 | 01 | 20 | 15 | 01 | 02 | 15 |
| 48 | 02 | 04 | 15 | 02 | 02 | 15 | 02 | 21 | 10 | 02 | 04 | 15 | 02 | 02 | 15 | 02 | 20 | 15 |
| 49 | 01 | 04 | 15 | 01 | 02 | 15 | 01 | 18 | 10 | 01 | 04 | 15 | 01 | 02 | 15 | 01 | 04 | 15 |
| 50 | 02 | 10 | 15 | 02 | 04 | 15 | 01 | 05 | 10 | 02 | 10 | 15 | 02 | 04 | 15 | 01 | 20 | 15 |
| 51 | 01 | 10 | 15 | 01 | 04 | 15 | 01 | 10 | 10 | 01 | 10 | 15 | 01 | 04 | 15 | 01 | 20 | 15 |
| 52 | 02 | 12 | 15 | 02 | 10 | 15 | 01 | 04 | 10 | 02 | 12 | 15 | 02 | 10 | 15 | 01 | 12 | 15 |
| 53 | 01 | 12 | 15 | 01 | 10 | 15 | 01 | 09 | 10 | 01 | 12 | 15 | 01 | 10 | 15 | 02 | 12 | 15 |
| 54 | 02 | 19 | 15 | 02 | 12 | 15 | 02 | 10 | 10 | 02 | 19 | 15 | 02 | 12 | 15 | 02 | 04 | 15 |
| 55 | 01 | 19 | 15 | 01 | 12 | 15 | 02 | 11 | 10 | 01 | 19 | 15 | 01 | 12 | 15 | 02 | 10 | 15 |
| 56 | 02 | 20 | 15 | 02 | 19 | 15 | 01 | 09 | 10 | 02 | 20 | 15 | 02 | 19 | 15 | 01 | 20 | 15 |
| 57 | 01 | 20 | 15 | 01 | 19 | 15 | 01 | 10 | 10 | 01 | 20 | 15 | 01 | 19 | 15 | 01 | 19 | 15 |
| 58 | 02 | 19 | 15 | 02 | 20 | 15 | 02 | 01 | 10 | 02 | 19 | 15 | 02 | 20 | 15 | 01 | 19 | 15 |
| 59 | 01 | 19 | 15 | 01 | 20 | 15 | 01 | 04 | 10 | 01 | 19 | 15 | 01 | 20 | 15 | 01 | 04 | 15 |

| | day14 | | | | | | | | | day15 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | set I | | | set II | | | set III | | | set I | | | set II | | |
| 0 | 02 | 04 | 15 | 02 | 19 | 65 | 02 | 04 | 15 | 02 | 19 | 20 | 02 | 02 | 15 |
| 1 | 01 | 04 | 15 | 01 | 19 | 65 | 01 | 04 | 15 | 01 | 19 | 20 | 01 | 02 | 15 |
| 2 | 02 | 04 | 10 | 01 | 20 | 65 | 01 | 04 | 15 | 02 | 19 | 15 | 02 | 04 | 15 |
| 3 | 02 | 04 | 10 | 02 | 02 | 65 | 02 | 02 | 15 | 02 | 19 | 15 | 01 | 04 | 15 |
| 4 | 01 | 04 | 10 | 01 | 19 | 65 | 02 | 19 | 15 | 01 | 19 | 15 | 02 | 10 | 15 |
| 5 | 01 | 04 | 10 | 01 | 20 | 65 | 01 | 20 | 15 | 01 | 19 | 15 | 01 | 10 | 15 |
| 6 | 02 | 19 | 15 | 02 | 20 | 65 | 01 | 19 | 15 | 02 | 20 | 20 | 02 | 12 | 15 |
| 7 | 02 | 19 | 15 | 01 | 02 | 65 | 02 | 02 | 15 | 01 | 20 | 20 | 01 | 12 | 15 |
| 8 | 01 | 19 | 15 | 02 | 20 | 65 | 01 | 10 | 15 | 02 | 20 | 15 | 02 | 19 | 15 |
| 9 | 01 | 19 | 15 | 01 | 10 | 65 | 02 | 19 | 15 | 02 | 20 | 15 | 01 | 19 | 15 |
| 10 | 02 | 19 | 10 | 02 | 12 | 65 | 02 | 04 | 15 | 01 | 20 | 15 | 02 | 20 | 15 |
| 11 | 01 | 19 | 10 | 02 | 04 | 65 | 01 | 10 | 15 | 01 | 20 | 15 | 01 | 20 | 15 |
| 12 | 02 | 20 | 15 | 01 | 04 | 65 | 02 | 04 | 15 | 02 | 19 | 15 | 02 | 02 | 15 |
| 13 | 02 | 20 | 15 | 01 | 10 | 65 | 02 | 20 | 15 | 01 | 19 | 15 | 02 | 02 | 15 |
| 14 | 01 | 20 | 15 | 01 | 12 | 65 | 02 | 04 | 15 | 02 | 20 | 15 | 01 | 02 | 15 |
| 15 | 01 | 20 | 15 | 01 | 04 | 65 | 02 | 02 | 15 | 01 | 20 | 15 | 01 | 02 | 15 |
| 16 | 02 | 20 | 10 | 02 | 19 | 65 | 02 | 10 | 15 | 02 | 04 | 20 | 02 | 04 | 15 |
| 17 | 01 | 20 | 10 | 02 | 10 | 65 | 01 | 10 | 15 | 01 | 04 | 20 | 02 | 04 | 15 |
| 18 | 02 | 19 | 15 | 01 | 02 | 65 | 01 | 04 | 15 | 02 | 04 | 15 | 01 | 04 | 15 |
| 19 | 01 | 19 | 15 | 02 | 12 | 65 | 02 | 12 | 15 | 02 | 04 | 15 | 01 | 04 | 15 |
| 20 | 02 | 04 | 15 | 02 | 10 | 65 | 01 | 02 | 15 | 01 | 04 | 15 | 02 | 10 | 15 |
| 21 | 01 | 04 | 15 | 02 | 02 | 65 | 02 | 19 | 15 | 01 | 04 | 15 | 02 | 10 | 15 |
| 22 | 02 | 20 | 15 | 01 | 12 | 65 | 01 | 04 | 15 | 02 | 02 | 20 | 01 | 10 | 15 |
| 23 | 01 | 20 | 15 | 02 | 04 | 65 | 01 | 20 | 15 | 01 | 02 | 20 | 01 | 10 | 15 |
| 24 | 02 | 10 | 15 | 02 | 02 | 10 | 01 | 20 | 15 | 02 | 02 | 15 | 02 | 12 | 15 |
| 25 | 01 | 10 | 15 | 02 | 04 | 10 | 01 | 02 | 15 | 02 | 02 | 15 | 02 | 12 | 15 |
| 26 | 02 | 10 | 10 | 02 | 10 | 10 | 02 | 10 | 15 | 01 | 02 | 15 | 01 | 12 | 15 |
| 27 | 02 | 10 | 10 | 02 | 12 | 10 | 01 | 20 | 15 | 01 | 02 | 15 | 01 | 12 | 15 |
| 28 | 01 | 10 | 10 | 02 | 19 | 10 | 02 | 20 | 15 | 02 | 10 | 20 | 02 | 19 | 15 |
| 29 | 01 | 10 | 10 | 02 | 20 | 10 | 02 | 02 | 15 | 01 | 10 | 20 | 02 | 19 | 15 |
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| 32 | 02 | 12 | 10 | 01 | 10 | 10 | 01 | 02 | 15 | 01 | 10 | 15 | 02 | 20 | 15 |
| 33 | 02 | 12 | 10 | 01 | 12 | 10 | 02 | 12 | 15 | 01 | 10 | 15 | 02 | 20 | 15 |
| 34 | 01 | 12 | 10 | 01 | 19 | 10 | 01 | 19 | 15 | 02 | 12 | 20 | 01 | 20 | 15 |
| 35 | 01 | 12 | 10 | 01 | 20 | 10 | 01 | 10 | 15 | 01 | 12 | 20 | 01 | 20 | 15 |
| 36 | 02 | 02 | 15 | 02 | 02 | 10 | 02 | 12 | 15 | 02 | 12 | 15 | 02 | 19 | 15 |
| 37 | 01 | 02 | 15 | 02 | 04 | 10 | 01 | 04 | 15 | 02 | 12 | 15 | 01 | 19 | 15 |
| 38 | 02 | 02 | 10 | 02 | 10 | 10 | 01 | 12 | 15 | 01 | 12 | 15 | 02 | 20 | 15 |
| 39 | 02 | 02 | 10 | 02 | 12 | 10 | 02 | 10 | 15 | 01 | 12 | 15 | 01 | 20 | 15 |
| 40 | 01 | 02 | 10 | 02 | 19 | 10 | 01 | 19 | 15 | 02 | 19 | 20 | 02 | 19 | 15 |
| 41 | 01 | 02 | 10 | 02 | 20 | 10 | 01 | 10 | 15 | 01 | 19 | 20 | 01 | 19 | 15 |
| 42 | 02 | 12 | 15 | 01 | 02 | 10 | 01 | 12 | 15 | 02 | 19 | 15 | 02 | 02 | 15 |
| 43 | 01 | 12 | 15 | 01 | 04 | 10 | 02 | 20 | 15 | 02 | 19 | 15 | 01 | 02 | 15 |
| 44 | 02 | 12 | 10 | 01 | 10 | 10 | 02 | 19 | 15 | 01 | 19 | 15 | 02 | 04 | 15 |
| 45 | 02 | 12 | 10 | 01 | 12 | 10 | 02 | 10 | 15 | 01 | 19 | 15 | 01 | 04 | 15 |
| 46 | 01 | 12 | 10 | 01 | 19 | 10 | 02 | 04 | 15 | 02 | 20 | 20 | 02 | 10 | 15 |
| 47 | 01 | 12 | 10 | 01 | 20 | 10 | 01 | 12 | 15 | 01 | 20 | 20 | 01 | 10 | 15 |
| 48 | 02 | 02 | 10 | 02 | 02 | 10 | 01 | 02 | 15 | 02 | 20 | 15 | 02 | 12 | 15 |
| 49 | 01 | 02 | 10 | 02 | 04 | 10 | 02 | 19 | 15 | 02 | 20 | 15 | 01 | 12 | 15 |
| 50 | 02 | 04 | 10 | 02 | 10 | 10 | 01 | 19 | 15 | 01 | 20 | 15 | 02 | 19 | 15 |
| 51 | 01 | 04 | 10 | 02 | 12 | 10 | 01 | 19 | 15 | 01 | 20 | 15 | 01 | 19 | 15 |
| 52 | 02 | 10 | 10 | 02 | 19 | 10 | 01 | 12 | 15 | 02 | 02 | 15 | 02 | 20 | 15 |
| 53 | 01 | 10 | 10 | 02 | 20 | 10 | 01 | 12 | 15 | 01 | 04 | 15 | 01 | 20 | 15 |
| 54 | 02 | 12 | 10 | 01 | 02 | 10 | 02 | 20 | 15 | 02 | 10 | 15 | 01 | 02 | 15 |
| 55 | 01 | 12 | 10 | 01 | 04 | 10 | 02 | 12 | 15 | 01 | 12 | 15 | 02 | 04 | 15 |
| 56 | 02 | 19 | 10 | 01 | 10 | 10 | 02 | 10 | 15 | 02 | 19 | 15 | 01 | 10 | 15 |
| 57 | 01 | 19 | 10 | 01 | 12 | 10 | 02 | 12 | 15 | 01 | 20 | 15 | 02 | 12 | 15 |
| 58 | 02 | 20 | 10 | 01 | 19 | 10 | 02 | 20 | 15 | 01 | 19 | 15 | 01 | 19 | 15 |
| 59 | 01 | 20 | 10 | 01 | 20 | 10 | 01 | 20 | 15 | 02 | 20 | 15 | 02 | 20 | 15 |

Figure A.5: Training schedule for the second half duration for Subject 2

| | Final Examination Set | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 15dB | | | 10dB | | | 5dB | | | 0dB | | |
| **0** | 01 | 05 | 15 | 01 | 05 | 10 | 02 | 00 | 05 | 02 | 09 | 00 |
| **1** | 01 | 18 | 15 | 01 | 11 | 10 | 02 | 04 | 05 | 01 | 01 | 00 |
| **2** | 02 | 10 | 15 | 01 | 01 | 10 | 01 | 04 | 05 | 01 | 11 | 00 |
| **3** | 02 | 11 | 15 | 02 | 01 | 10 | 02 | 10 | 05 | 01 | 11 | 00 |
| **4** | 01 | 01 | 15 | 02 | 09 | 10 | 01 | 04 | 05 | 01 | 04 | 00 |
| **5** | 02 | 04 | 15 | 02 | 18 | 10 | 02 | 00 | 05 | 02 | 05 | 00 |
| **6** | 02 | 09 | 15 | 02 | 04 | 10 | 01 | 01 | 05 | 01 | 10 | 00 |
| **7** | 02 | 01 | 15 | 01 | 11 | 10 | 01 | 00 | 05 | 01 | 04 | 00 |
| **8** | 01 | 05 | 15 | 01 | 10 | 10 | 01 | 18 | 05 | 01 | 18 | 00 |
| **9** | 01 | 00 | 15 | 02 | 00 | 10 | 01 | 18 | 05 | 02 | 05 | 00 |
| **10** | 01 | 04 | 15 | 02 | 09 | 10 | 01 | 10 | 05 | 01 | 05 | 00 |
| **11** | 02 | 05 | 15 | 01 | 01 | 10 | 02 | 11 | 05 | 02 | 01 | 00 |
| **12** | 01 | 01 | 15 | 02 | 10 | 10 | 01 | 01 | 05 | 01 | 09 | 00 |
| **13** | 01 | 00 | 15 | 02 | 05 | 10 | 01 | 01 | 05 | 01 | 11 | 00 |
| **14** | 01 | 10 | 15 | 01 | 10 | 10 | 01 | 11 | 05 | 02 | 09 | 00 |
| **15** | 02 | 00 | 15 | 01 | 05 | 10 | 02 | 18 | 05 | 01 | 00 | 00 |
| **16** | 01 | 10 | 15 | 01 | 05 | 10 | 01 | 04 | 05 | 02 | 10 | 00 |
| **17** | 02 | 04 | 15 | 02 | 05 | 10 | 02 | 09 | 05 | 02 | 04 | 00 |
| **18** | 02 | 09 | 15 | 02 | 00 | 10 | 01 | 00 | 05 | 01 | 18 | 00 |
| **19** | 02 | 09 | 15 | 02 | 04 | 10 | 02 | 11 | 05 | 01 | 10 | 00 |
| **20** | 01 | 18 | 15 | 01 | 00 | 10 | 01 | 09 | 05 | 01 | 04 | 00 |
| **21** | 01 | 10 | 15 | 01 | 09 | 10 | 01 | 10 | 05 | 01 | 05 | 00 |
| **22** | 02 | 04 | 15 | 01 | 09 | 10 | 02 | 01 | 05 | 01 | 01 | 00 |
| **23** | 01 | 04 | 15 | 01 | 11 | 10 | 02 | 09 | 05 | 02 | 11 | 00 |
| **24** | 02 | 00 | 15 | 01 | 09 | 10 | 02 | 04 | 05 | 01 | 00 | 00 |
| **25** | 01 | 11 | 15 | 01 | 10 | 10 | 01 | 01 | 05 | 02 | 18 | 00 |
| **26** | 01 | 11 | 15 | 01 | 00 | 10 | 02 | 18 | 05 | 01 | 00 | 00 |
| **27** | 01 | 10 | 15 | 01 | 04 | 10 | 02 | 11 | 05 | 02 | 18 | 00 |
| **28** | 02 | 04 | 15 | 02 | 00 | 10 | 02 | 00 | 05 | 02 | 10 | 00 |
| **29** | 02 | 05 | 15 | 01 | 18 | 10 | 02 | 18 | 05 | 01 | 00 | 00 |
| **30** | 02 | 00 | 15 | 01 | 09 | 10 | 01 | 11 | 05 | 01 | 18 | 00 |
| **31** | 01 | 01 | 15 | 01 | 11 | 10 | 01 | 04 | 05 | 02 | 00 | 00 |
| **32** | 02 | 11 | 15 | 02 | 05 | 10 | 02 | 09 | 05 | 01 | 10 | 00 |
| **33** | 01 | 18 | 15 | 02 | 11 | 10 | 01 | 11 | 05 | 02 | 01 | 00 |
| **34** | 02 | 05 | 15 | 01 | 00 | 10 | 01 | 00 | 05 | 01 | 09 | 00 |
| **35** | 02 | 01 | 15 | 02 | 11 | 10 | 01 | 10 | 05 | 01 | 18 | 00 |
| **36** | 01 | 01 | 15 | 02 | 01 | 10 | 01 | 10 | 05 | 02 | 09 | 00 |
| **37** | 01 | 00 | 15 | 01 | 01 | 10 | 01 | 18 | 05 | 02 | 09 | 00 |
| **38** | 01 | 09 | 15 | 02 | 09 | 10 | 02 | 04 | 05 | 02 | 04 | 00 |
| **39** | 01 | 11 | 15 | 02 | 01 | 10 | 02 | 01 | 05 | 02 | 05 | 00 |
| **40** | 01 | 05 | 15 | 01 | 09 | 10 | 02 | 04 | 05 | 02 | 18 | 00 |
| **41** | 01 | 18 | 15 | 02 | 01 | 10 | 01 | 18 | 05 | 01 | 01 | 00 |
| **42** | 02 | 18 | 15 | 02 | 10 | 10 | 02 | 01 | 05 | 01 | 10 | 00 |
| **43** | 02 | 04 | 15 | 02 | 10 | 10 | 02 | 09 | 05 | 02 | 18 | 00 |
| **44** | 01 | 04 | 15 | 02 | 18 | 10 | 02 | 05 | 05 | 02 | 01 | 00 |
| **45** | 02 | 18 | 15 | 01 | 04 | 10 | 02 | 11 | 05 | 02 | 00 | 00 |
| **46** | 02 | 00 | 15 | 02 | 04 | 10 | 02 | 00 | 05 | 02 | 10 | 00 |
| **47** | 01 | 05 | 15 | 01 | 00 | 10 | 01 | 05 | 05 | 02 | 05 | 00 |
| **48** | 02 | 00 | 15 | 02 | 10 | 10 | 01 | 00 | 05 | 02 | 11 | 00 |
| **49** | 01 | 09 | 15 | 02 | 18 | 10 | 02 | 05 | 05 | 02 | 11 | 00 |
| **50** | 01 | 05 | 15 | 01 | 18 | 10 | 01 | 09 | 05 | 02 | 04 | 00 |
| **51** | 02 | 10 | 15 | 01 | 04 | 10 | 02 | 10 | 05 | 02 | 10 | 00 |
| **52** | 02 | 01 | 15 | 02 | 18 | 10 | 01 | 05 | 05 | 01 | 09 | 00 |
| **53** | 01 | 09 | 15 | 01 | 04 | 10 | 02 | 05 | 05 | 02 | 01 | 00 |
| **54** | 02 | 10 | 15 | 02 | 11 | 10 | 02 | 01 | 05 | 01 | 05 | 00 |
| **55** | 02 | 11 | 15 | 02 | 10 | 10 | 01 | 05 | 05 | 01 | 09 | 00 |
| **56** | 02 | 09 | 15 | 02 | 18 | 10 | 01 | 05 | 05 | 01 | 04 | 00 |
| **57** | 01 | 01 | 15 | 02 | 05 | 10 | 01 | 09 | 05 | 02 | 11 | 00 |
| **58** | 02 | 18 | 15 | 01 | 18 | 10 | 02 | 05 | 05 | 02 | 00 | 00 |
| **59** | 02 | 11 | 15 | 01 | 11 | 10 | 02 | 10 | 05 | 01 | 11 | 00 |

Figure A.6: Final test schedule for Subject 0. Darker cells indicates non-stimuli sample.

| | Final Examination Set | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 15dB | | | 10dB | | | 5dB | | | 0dB | | |
| **0** | 01 | 05 | 15 | 01 | 05 | 10 | 02 | 21 | 05 | 02 | 09 | 00 |
| **1** | 01 | 18 | 15 | 01 | 11 | 10 | 02 | 04 | 05 | 01 | 01 | 00 |
| **2** | 02 | 10 | 15 | 01 | 01 | 10 | 01 | 04 | 05 | 01 | 11 | 00 |
| **3** | 02 | 11 | 15 | 02 | 01 | 10 | 02 | 10 | 05 | 01 | 11 | 00 |
| **4** | 01 | 01 | 15 | 02 | 09 | 10 | 01 | 04 | 05 | 01 | 04 | 00 |
| **5** | 02 | 04 | 15 | 02 | 18 | 10 | 02 | 21 | 05 | 02 | 05 | 00 |
| **6** | 02 | 09 | 15 | 02 | 04 | 10 | 01 | 01 | 05 | 01 | 10 | 00 |
| **7** | 02 | 01 | 15 | 01 | 11 | 10 | 01 | 21 | 05 | 01 | 04 | 00 |
| **8** | 01 | 05 | 15 | 01 | 10 | 10 | 01 | 18 | 05 | 01 | 18 | 00 |
| **9** | 01 | 21 | 15 | 02 | 21 | 10 | 01 | 18 | 05 | 02 | 05 | 00 |
| **10** | 01 | 04 | 15 | 02 | 09 | 10 | 01 | 10 | 05 | 01 | 05 | 00 |
| **11** | 02 | 05 | 15 | 01 | 01 | 10 | 02 | 11 | 05 | 02 | 01 | 00 |
| **12** | 01 | 01 | 15 | 02 | 10 | 10 | 01 | 01 | 05 | 01 | 09 | 00 |
| **13** | 01 | 21 | 15 | 02 | 05 | 10 | 01 | 01 | 05 | 01 | 11 | 00 |
| **14** | 01 | 10 | 15 | 01 | 10 | 10 | 01 | 11 | 05 | 02 | 09 | 00 |
| **15** | 02 | 21 | 15 | 01 | 05 | 10 | 02 | 18 | 05 | 01 | 21 | 00 |
| **16** | 01 | 10 | 15 | 01 | 05 | 10 | 01 | 04 | 05 | 02 | 10 | 00 |
| **17** | 02 | 04 | 15 | 02 | 05 | 10 | 02 | 09 | 05 | 02 | 04 | 00 |
| **18** | 02 | 09 | 15 | 02 | 21 | 10 | 01 | 21 | 05 | 01 | 18 | 00 |
| **19** | 02 | 09 | 15 | 02 | 04 | 10 | 02 | 11 | 05 | 01 | 10 | 00 |
| **20** | 01 | 18 | 15 | 01 | 21 | 10 | 01 | 09 | 05 | 01 | 04 | 00 |
| **21** | 01 | 10 | 15 | 01 | 09 | 10 | 01 | 10 | 05 | 01 | 05 | 00 |
| **22** | 02 | 04 | 15 | 01 | 09 | 10 | 02 | 01 | 05 | 01 | 01 | 00 |
| **23** | 01 | 04 | 15 | 01 | 11 | 10 | 02 | 09 | 05 | 02 | 11 | 00 |
| **24** | 02 | 21 | 15 | 01 | 09 | 10 | 02 | 04 | 05 | 01 | 21 | 00 |
| **25** | 01 | 11 | 15 | 01 | 10 | 10 | 01 | 01 | 05 | 02 | 18 | 00 |
| **26** | 01 | 11 | 15 | 01 | 21 | 10 | 02 | 18 | 05 | 01 | 21 | 00 |
| **27** | 01 | 10 | 15 | 01 | 04 | 10 | 02 | 11 | 05 | 02 | 18 | 00 |
| **28** | 02 | 04 | 15 | 02 | 21 | 10 | 02 | 21 | 05 | 02 | 10 | 00 |
| **29** | 02 | 05 | 15 | 01 | 18 | 10 | 02 | 18 | 05 | 01 | 21 | 00 |
| **30** | 02 | 21 | 15 | 01 | 09 | 10 | 01 | 11 | 05 | 01 | 18 | 00 |
| **31** | 01 | 01 | 15 | 01 | 11 | 10 | 01 | 04 | 05 | 02 | 21 | 00 |
| **32** | 02 | 11 | 15 | 02 | 05 | 10 | 02 | 09 | 05 | 01 | 10 | 00 |
| **33** | 01 | 18 | 15 | 02 | 11 | 10 | 01 | 11 | 05 | 02 | 01 | 00 |
| **34** | 02 | 05 | 15 | 01 | 21 | 10 | 01 | 21 | 05 | 01 | 09 | 00 |
| **35** | 02 | 01 | 15 | 02 | 11 | 10 | 01 | 10 | 05 | 01 | 18 | 00 |
| **36** | 01 | 01 | 15 | 02 | 01 | 10 | 01 | 10 | 05 | 02 | 09 | 00 |
| **37** | 01 | 21 | 15 | 01 | 01 | 10 | 01 | 18 | 05 | 02 | 09 | 00 |
| **38** | 01 | 09 | 15 | 02 | 09 | 10 | 02 | 04 | 05 | 02 | 04 | 00 |
| **39** | 01 | 11 | 15 | 02 | 01 | 10 | 02 | 01 | 05 | 02 | 05 | 00 |
| **40** | 01 | 05 | 15 | 01 | 09 | 10 | 02 | 04 | 05 | 02 | 18 | 00 |
| **41** | 01 | 18 | 15 | 02 | 01 | 10 | 01 | 18 | 05 | 01 | 01 | 00 |
| **42** | 02 | 18 | 15 | 02 | 10 | 10 | 02 | 01 | 05 | 01 | 10 | 00 |
| **43** | 02 | 04 | 15 | 02 | 10 | 10 | 02 | 09 | 05 | 02 | 18 | 00 |
| **44** | 01 | 04 | 15 | 02 | 18 | 10 | 02 | 05 | 05 | 02 | 01 | 00 |
| **45** | 02 | 18 | 15 | 01 | 04 | 10 | 02 | 11 | 05 | 02 | 21 | 00 |
| **46** | 02 | 21 | 15 | 02 | 04 | 10 | 02 | 21 | 05 | 02 | 10 | 00 |
| **47** | 01 | 05 | 15 | 01 | 21 | 10 | 01 | 05 | 05 | 02 | 05 | 00 |
| **48** | 02 | 21 | 15 | 02 | 10 | 10 | 01 | 21 | 05 | 02 | 11 | 00 |
| **49** | 01 | 09 | 15 | 02 | 18 | 10 | 02 | 05 | 05 | 02 | 11 | 00 |
| **50** | 01 | 05 | 15 | 01 | 18 | 10 | 01 | 09 | 05 | 02 | 04 | 00 |
| **51** | 02 | 10 | 15 | 01 | 04 | 10 | 02 | 10 | 05 | 02 | 10 | 00 |
| **52** | 02 | 01 | 15 | 02 | 18 | 10 | 01 | 05 | 05 | 01 | 09 | 00 |
| **53** | 01 | 09 | 15 | 01 | 04 | 10 | 02 | 05 | 05 | 02 | 01 | 00 |
| **54** | 02 | 10 | 15 | 02 | 11 | 10 | 02 | 01 | 05 | 01 | 05 | 00 |
| **55** | 02 | 11 | 15 | 02 | 10 | 10 | 01 | 05 | 05 | 01 | 09 | 00 |
| **56** | 02 | 09 | 15 | 02 | 18 | 10 | 01 | 05 | 05 | 01 | 04 | 00 |
| **57** | 01 | 01 | 15 | 02 | 05 | 10 | 01 | 09 | 05 | 02 | 11 | 00 |
| **58** | 02 | 18 | 15 | 01 | 18 | 10 | 02 | 05 | 05 | 02 | 21 | 00 |
| **59** | 02 | 11 | 15 | 01 | 11 | 10 | 02 | 10 | 05 | 01 | 11 | 00 |

Figure A.7: Final test schedule for Subject 1. Darker cells indicates non-stimuli sample.

| | Final Examination Set | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 15dB | | | 10dB | | | 5dB | | | 0dB | | |
| 0 | 01 | 19 | 15 | 01 | 04 | 10 | 02 | 19 | 05 | 01 | 02 | 00 |
| 1 | 02 | 10 | 15 | 02 | 04 | 10 | 01 | 20 | 05 | 02 | 04 | 00 |
| 2 | 02 | 10 | 15 | 01 | 12 | 10 | 01 | 12 | 05 | 01 | 19 | 00 |
| 3 | 02 | 02 | 15 | 01 | 12 | 10 | 02 | 10 | 05 | 01 | 04 | 00 |
| 4 | 01 | 12 | 15 | 01 | 12 | 10 | 02 | 19 | 05 | 01 | 12 | 00 |
| 5 | 02 | 20 | 15 | 01 | 02 | 10 | 02 | 02 | 05 | 01 | 04 | 00 |
| 6 | 02 | 02 | 15 | 01 | 02 | 10 | 01 | 02 | 05 | 02 | 04 | 00 |
| 7 | 02 | 04 | 15 | 02 | 20 | 10 | 02 | 20 | 05 | 01 | 10 | 00 |
| 8 | 01 | 12 | 15 | 02 | 19 | 10 | 02 | 12 | 05 | 02 | 20 | 00 |
| 9 | 02 | 10 | 15 | 02 | 20 | 10 | 01 | 20 | 05 | 02 | 20 | 00 |
| 10 | 01 | 10 | 15 | 01 | 10 | 10 | 01 | 02 | 05 | 01 | 20 | 00 |
| 11 | 02 | 20 | 15 | 02 | 20 | 10 | 01 | 19 | 05 | 01 | 02 | 00 |
| 12 | 01 | 02 | 15 | 02 | 20 | 10 | 02 | 04 | 05 | 02 | 20 | 00 |
| 13 | 02 | 04 | 15 | 02 | 12 | 10 | 02 | 04 | 05 | 01 | 12 | 00 |
| 14 | 01 | 20 | 15 | 01 | 10 | 10 | 01 | 04 | 05 | 01 | 12 | 00 |
| 15 | 02 | 19 | 15 | 01 | 19 | 10 | 01 | 12 | 05 | 01 | 10 | 00 |
| 16 | 01 | 20 | 15 | 02 | 02 | 10 | 02 | 20 | 05 | 02 | 20 | 00 |
| 17 | 01 | 10 | 15 | 01 | 12 | 10 | 02 | 10 | 05 | 01 | 10 | 00 |
| 18 | 01 | 10 | 15 | 01 | 10 | 10 | 02 | 12 | 05 | 02 | 20 | 00 |
| 19 | 02 | 12 | 15 | 02 | 04 | 10 | 02 | 19 | 05 | 01 | 10 | 00 |
| 20 | 01 | 04 | 15 | 01 | 20 | 10 | 01 | 04 | 05 | 02 | 12 | 00 |
| 21 | 01 | 20 | 15 | 02 | 02 | 10 | 02 | 02 | 05 | 01 | 20 | 00 |
| 22 | 01 | 04 | 15 | 01 | 19 | 10 | 01 | 04 | 05 | 01 | 19 | 00 |
| 23 | 01 | 20 | 15 | 02 | 20 | 10 | 01 | 19 | 05 | 02 | 10 | 00 |
| 24 | 02 | 19 | 15 | 02 | 10 | 10 | 02 | 02 | 05 | 01 | 10 | 00 |
| 25 | 02 | 19 | 15 | 02 | 19 | 10 | 02 | 19 | 05 | 02 | 19 | 00 |
| 26 | 01 | 19 | 15 | 01 | 10 | 10 | 02 | 04 | 05 | 02 | 02 | 00 |
| 27 | 01 | 20 | 15 | 01 | 02 | 10 | 02 | 20 | 05 | 01 | 19 | 00 |
| 28 | 02 | 10 | 15 | 01 | 04 | 10 | 01 | 04 | 05 | 02 | 04 | 00 |
| 29 | 02 | 12 | 15 | 01 | 04 | 10 | 02 | 19 | 05 | 01 | 10 | 00 |
| 30 | 01 | 02 | 15 | 02 | 12 | 10 | 01 | 12 | 05 | 01 | 04 | 00 |
| 31 | 02 | 04 | 15 | 02 | 10 | 10 | 02 | 10 | 05 | 02 | 10 | 00 |
| 32 | 02 | 10 | 15 | 02 | 12 | 10 | 02 | 02 | 05 | 02 | 12 | 00 |
| 33 | 01 | 04 | 15 | 02 | 12 | 10 | 01 | 19 | 05 | 01 | 02 | 00 |
| 34 | 01 | 12 | 15 | 02 | 02 | 10 | 01 | 20 | 05 | 01 | 19 | 00 |
| 35 | 02 | 02 | 15 | 02 | 10 | 10 | 02 | 10 | 05 | 02 | 12 | 00 |
| 36 | 02 | 19 | 15 | 02 | 12 | 10 | 01 | 02 | 05 | 02 | 02 | 00 |
| 37 | 01 | 04 | 15 | 01 | 19 | 10 | 01 | 19 | 05 | 02 | 02 | 00 |
| 38 | 01 | 20 | 15 | 02 | 02 | 10 | 02 | 12 | 05 | 01 | 02 | 00 |
| 39 | 02 | 02 | 15 | 02 | 19 | 10 | 01 | 10 | 05 | 02 | 10 | 00 |
| 40 | 01 | 12 | 15 | 01 | 02 | 10 | 02 | 20 | 05 | 02 | 12 | 00 |
| 41 | 01 | 02 | 15 | 01 | 02 | 10 | 01 | 02 | 05 | 02 | 04 | 00 |
| 42 | 02 | 19 | 15 | 01 | 10 | 10 | 01 | 10 | 05 | 02 | 19 | 00 |
| 43 | 01 | 10 | 15 | 02 | 04 | 10 | 02 | 10 | 05 | 02 | 20 | 00 |
| 44 | 01 | 19 | 15 | 02 | 19 | 10 | 01 | 20 | 05 | 02 | 04 | 00 |
| 45 | 01 | 19 | 15 | 02 | 04 | 10 | 01 | 04 | 05 | 02 | 12 | 00 |
| 46 | 02 | 19 | 15 | 02 | 04 | 10 | 02 | 02 | 05 | 01 | 02 | 00 |
| 47 | 01 | 04 | 15 | 01 | 20 | 10 | 01 | 20 | 05 | 01 | 19 | 00 |
| 48 | 02 | 12 | 15 | 01 | 19 | 10 | 02 | 12 | 05 | 02 | 19 | 00 |
| 49 | 02 | 20 | 15 | 01 | 02 | 10 | 01 | 04 | 05 | 02 | 10 | 00 |
| 50 | 01 | 12 | 15 | 01 | 19 | 10 | 02 | 10 | 05 | 02 | 04 | 00 |
| 51 | 02 | 10 | 15 | 01 | 19 | 10 | 01 | 12 | 05 | 01 | 20 | 00 |
| 52 | 02 | 12 | 15 | 01 | 20 | 10 | 01 | 20 | 05 | 02 | 02 | 00 |
| 53 | 01 | 02 | 15 | 02 | 10 | 10 | 01 | 10 | 05 | 01 | 20 | 00 |
| 54 | 02 | 02 | 15 | 02 | 12 | 10 | 01 | 10 | 05 | 01 | 12 | 00 |
| 55 | 02 | 02 | 15 | 01 | 04 | 10 | 02 | 04 | 05 | 02 | 19 | 00 |
| 56 | 02 | 20 | 15 | 02 | 04 | 10 | 01 | 12 | 05 | 02 | 12 | 00 |
| 57 | 01 | 04 | 15 | 01 | 20 | 10 | 02 | 19 | 05 | 01 | 02 | 00 |
| 58 | 02 | 04 | 15 | 02 | 20 | 10 | 01 | 12 | 05 | 01 | 04 | 00 |
| 59 | 01 | 12 | 15 | 01 | 10 | 10 | 02 | 02 | 05 | 01 | 19 | 00 |

Figure A.8: Final test schedule for Subject 2. Darker cells indicates non-stimuli sample.

# Bibliography


Andrassy, B. and Hoege, H. (2006). Human and machine recognition as a function of snr. In *Proc. LREC*.

Bach-Y-Rita, P. (2005). Emerging concepts of brain function. *J Integr Neurosci*, 4(2):183–205.

Bach-y Rita, P., Collins, C. C., Saunders, F. A., White, B., and Scadden, L. (1969). Vision substitution by tactile image projection. *Nature*, 221(5184):963–4.

Calvert, G. A., Bullmore, E. T., Brammer, M. J., Campbell, R., Williams, S. C., McGuire, P. K., Woodruff, P. W., Iversen, S. D., and David, A. S. (1997). Activation of auditory cortex during silent lipreading. *science*, 276(5312):593–596.

Cousineau, D. (2005). Confidence intervals in within-subject designs: A simpler solution to loftus and masson's method. *Tutorials in quantitative methods for psychology*, 1(1):42–45.

Daniel, E. (2007). *Noise and hearing loss: a review*, volume 77, pages 225–31. Department of Health Science, SUNY College at Brockport, Brockport, NY 14420, USA. edaniel@brockport.edu.

Deller, J. R., Hansen, J. H. L., and Proakis, J. G. (2000). *Discrete-time processing of speech signals*. Institute of Electrical and Electronics Engineers, New York.

Fant, G., Lindblom, B., and de Serpa-Leitão, A. (1966). Consonant confusions in english and swedish. a pilot study. *STL-QPSR*, 4(1966):31.

HEAR-IT-AISBL (2015). *Sensorineural hearing loss from http://www.hear-it.org/Sensorineural-hearing-loss*. HEAR-IT-AISBL.

James, W. (2011). *The Principles of Psychology (Volume 2 of 2)*. Digireads. com Publishing.

JOJA, D. O. (2002). Learning experience and neuroplasticity–a shifting paradigm. *Nature Reviews Neuroscience*, 3(1):65–71.

Kubo, T., Matsuura, S., and Iwaki, T. (2005). Complications of cochlear implant surgery. *Operative Techniques in Otolaryngology-Head and Neck Surgery*, 16:154–158.

Loizou, P. C. (1999). Signal-processing techniques for cochlear implants. *Engineering in Medicine and Biology Magazine, IEEE*, 18:34–46.

Loizou, P. C., Dorman, M., and Tu, Z. (1999). On the number of channels needed to understand speech. *Journal of the Acoustical Society of America*, 106:2097–2103.

Lynch, M. P., Eilers, R. E., and Pero, P. J. (1992). Open-set word identification by an adult with profound hearing impairmentintegration of touch, aided hearing, and speechreading. *Journal of Speech, Language, and Hearing Research*, 35(2):443–449.

Meijer, P. B. (1992). An experimental system for auditory image representations. *IEEE Trans Biomed Eng*, 39(2):112–21.

Miller, G. A. and Nicely, P. E. (1955). An analysis of perceptual confusions among some english consonants. *Journal of the Acoustical Society of America*, 27:338–352.

NIDCD (2013). Cochlear implants. *U.S. National Institute on Deafness and Other Communication Disorders Fact Sheet*, (11-4798).

Novich, S. D. and Eagleman, D. M. (2014). A vibrotactile sensory substitution device for the deaf and profoundly hearing impaired. *Haptics Symposium (HAPTICS), IEEE*, pages 1–1.

Oishi, N. and Schacht, J. (2011). Emerging treatments for noise-induced hearing loss. *Expert Opinion on Emerging Drugs*, 16(2):235–245.

Owren, M. J. and Cardillo, G. C. (2006). The relative roles of vowels and consonants in discriminating talker identity versus word meaning. *J Acoust Soc Am*, 119(3):1727–39.

Sadato, N., Pascual-Leone, A., Grafmani, J., Ibanez, V., Deiber, M.-P., Dold, G., and Hallett, M. (1996). Activation of the primary visual cortex by braille reading in blind subjects. *Nature*, 380(6574):526–528.

Schürmann, M., Caetano, G., Hlushchuk, Y., Jousmäki, V., and Hari, R. (2006). Touch activates human auditory cortex. *Neuroimage*, 30(4):1325–31.

Stevens, S. S., Volkmann, J., and Newman, E. B. (1937). A scale for the measurement of the psychological magnitude pitch. *The Journal of the Acoustical Society of America*, 8(3):185–190.

Tierney, J., Zissman, M. A., and Eddington, D. K. (1994). Digital signal processing applications in cochlea-implant research. *The Lincoln Laboratory Journal*, 7:31–62.

Tyler, M., Danilov, Y., and Bach-Y-Rita, P. (2003). Closing an open-loop control system: vestibular substitution through the tongue. *Journal of integrative neuroscience*, 2(2):159–64.

Van Boven, R. W. and Johnson, K. O. (1994). The limit of tactile spatial resolution in humans grating orientation discrimination at the lip, tongue, and finger. *Neurology*, 44(12):2361–2361.

Von Bekesy, G. (1960). *Experiments in hearing*. McGraw-Hill.

WHO (2015). Deafness and hearing loss. *Fact sheet N°300*.

Wiki-commons (2015). Lobes of the brain.