PROJECT REPORT

Exploring the Perceptual Dynamics of Apparent Motion in Response to Vibrating Motors

Contents:

Description of the project

Title: Exploring the Perceptual Dynamics of Apparent Motion in Response to Vibrating Motors

Abstract:
This experiment investigates the participant-specific perception of apparent motion induced by changing stimuli in vibrating motors. The study focuses on understanding how participants perceive variations, analyzing the duration of the stimuli, the time between the stimuli, the frequency and amplitude of sine waves. Individual participants are identified by unique IDs and their responses are analyzed to unveil patterns in the perceptual dynamics of apparent motion.

Introduction:
The aim of this experiment is to gain insights into how participants perceive the apparent motion resulting from alterations in vibrating stimuli parameters. By manipulating the time of stimuli, the time between stimuli and the characteristics of the sine wave (frequency and amplitude), we seek to understand the individual variations in perceptual responses.

Methodology:

- Participants: A diverse group of participants, each assigned a unique Participant ID, took part in the experiment.
- Devices: Vibrating motors were used to create stimuli and participants were exposed to stimuli with sine wave properties.
- Procedure: Participants were exposed to different combinations of stimuli parameters. They were then asked to report their perception of apparent motion (vertical or horizontal), providing a subjective account of their experience.

Experimental Design:

- Time of stimuli manipulation: Participants experienced variations in the duration of stimuli presentation.
- Time between stimuli manipulation: The time interval between consecutive stimuli was manipulated to explore its impact on apparent motion perception.
- Sine wave characteristics: Frequency and amplitude of the sine wave were altered to observe their influence on perceived motion.

Results:

Data analysis revealed significant variations in participants' responses to the manipulated stimuli parameters. Some participants exhibited heightened sensitivity to changes in time of stimuli, while others were more influenced by alterations in time between stimuli. The frequency and amplitude of the sine wave also played a role in shaping individual perceptions of apparent motion.

Discussion:

The findings suggest that there is a participant-specific aspect to the perception of apparent motion induced by vibrating stimuli. Understanding these individual differences can have implications for designing personalized experiences in fields such as virtual reality, gaming, and human-computer interaction.

Conclusion:

This experiment provides valuable insights into the participant-specific dynamics of apparent motion perception in response to vibrating stimuli. Further research could delve deeper into the underlying cognitive and neurological processes to refine our understanding and potentially enhance personalized user experiences.

What is Apparent motion?

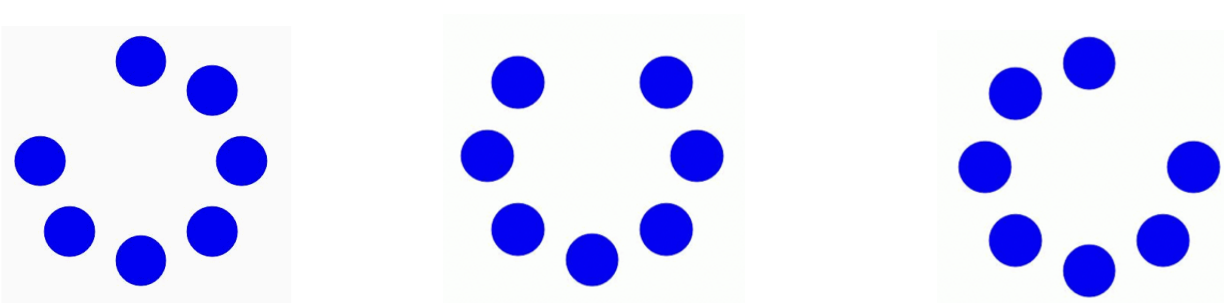
In psychology, apparent motion refers to a visual illusion where a sequence of discrete images or stimuli is perceived as continuous motion. This phenomenon is often studied to understand how the human brain processes visual information and constructs the perception of motion. There are several types of apparent motion, and they are often studied in the fields of psychology, neuroscience, and visual perception:

Types of Apparent Motion:

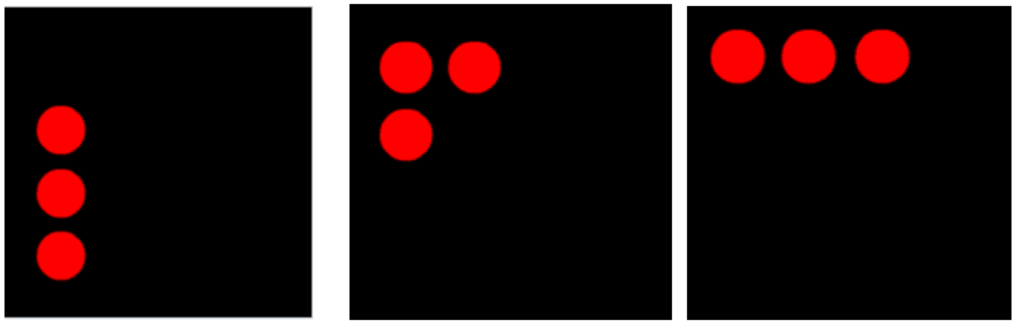
1. **Phi Phenomenon:** This is a type of apparent motion where an object is perceived as moving when, in reality, there is a rapid succession of still images. The classic example is a series of lights turned on and off quickly, creating the illusion of movement.
2. **Beta Movement:** Similar to phi phenomenon, beta movement involves perceiving motion in a sequence of static images, but it typically refers to motion between two distinct objects rather than a single object.
3. **Stroboscopic effect:** This type of apparent motion occurs when a rapid succession of still images or frames is presented to an observer. Even though each frame is static, the viewer perceives a smooth and continuous motion. An example of stroboscopic motion is the perception of motion in a series of rapidly displayed images, such as in a flipbook or the early days of film.
4. **Critical Flicker Fusion:** This phenomenon is related to the frequency of flickering lights. As the frequency of flickering increases, there is a point at which the flicker is perceived as a continuous light source. This threshold is known as the critical flicker fusion frequency.
5. **Autokinetic Effect:** Occurs when a stationary point of light in a dark environment appears to move due to the absence of visual reference points.

For this project the types of apparent motion of interest are:

Phi Phenomenon



Beta Movement



Creating effective vibrating signals

Creating effective vibrating signals (for blind individuals) involves consideration of apparent motion and how the brain processes tactile information. While vibrating signals can be a useful means of conveying information, there are challenges related to the perception of motion and the potential for confusion.
Addressing these challenges involves a multidisciplinary approach that includes insights from psychology, neuroscience, and human-computer interaction. Designing vibrating signals that account for the principles of perception and the potential for apparent motion can enhance the effectiveness of conveying information to (blind) individuals. Additionally, ongoing user feedback and iterative design processes can contribute to refining and optimizing these systems for better user experience.

Understanding the relationship between Apparent Motion and Perception

Understanding perception in psychology within the framework of apparent motion provides insights into how the brain processes visual stimuli to perceive motion and how factors such as sensory processing, perceptual organization, attention, and expectation influence this process. Studying perception in the context of apparent motion contributes to a deeper understanding of human cognition and the mechanisms underlying visual perception.

Perception in psychology refers to the process by which individuals organize and interpret sensory information to give meaning to their environment. It involves the selection, organization, and interpretation of sensory input to form a coherent representation of the world around us. Perception plays a crucial role in how we navigate and interact with our surroundings, influencing our thoughts, emotions, and behavior.

Perception begins with **sensory processing**, where sensory receptors detect stimuli from the environment such as light, sound, touch, taste, and smell. These sensory inputs are then transmitted to the brain for further processing.

Once sensory information reaches the brain, it undergoes **perceptual organization**, where it is structured and interpreted to create meaningful perceptions. This process involves principles such as figure-ground relationship, proximity, similarity, closure, and continuity, which help individuals organize sensory input into coherent perceptual units.

Perceptual constancies refer to the tendency to perceive objects as stable and unchanging despite variations in sensory input. Examples of perceptual constancies include size constancy (perceiving objects as having a constant size regardless of their distance from the observer), shape constancy, and color constancy.

Depth perception allows individuals to perceive the distance and spatial relationships between objects in their environment. It is influenced by cues such as binocular cues (which require both eyes) and monocular cues (which can be perceived with one eye), including relative size, overlap, texture gradient, motion parallax, and convergence.

Perceptual illusions occur when sensory input is misinterpreted or distorted, leading to discrepancies between perception and reality. These illusions highlight the role of cognitive processes, such as expectations, context, and past experiences, in shaping perception.

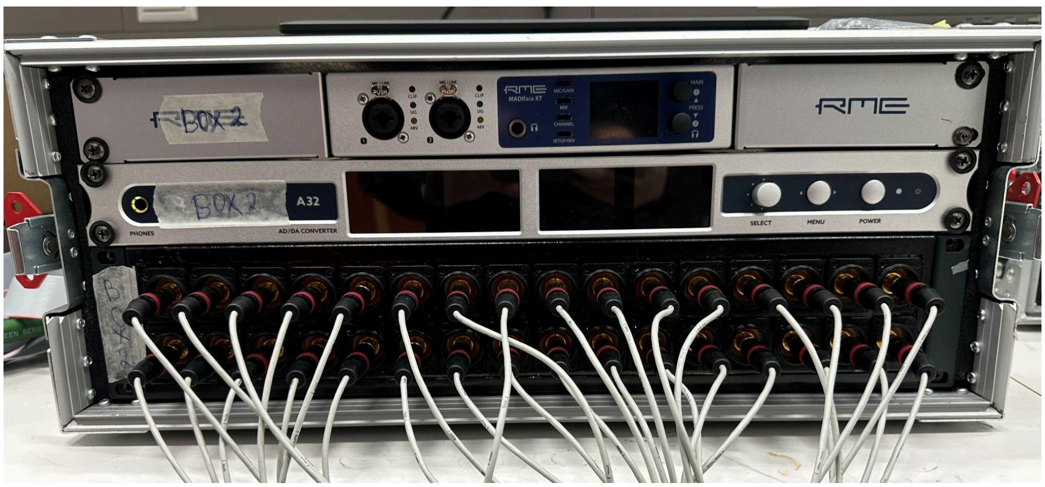
Perception is closely linked to attention, as attention directs and focuses cognitive resources on specific aspects of sensory input. Attention influences what stimuli are selected for further processing and how they are interpreted, ultimately shaping perceptual experiences.

Apparent motion, characterized by the illusion of movement created by successive presentation of static stimuli, is a phenomenon deeply intertwined with various principles of perception.

Prerequisites & getting started

In our research, we employed a range of advanced equipment to facilitate data acquisition, stimulus administration, and participant interaction. Key components of our experimental setup include:

- Access to working computer (preferably Windows)
- The "MADIface xt RME Audio" sound device:



The sound device is connected to the computer via a USB cable. The sound device is outfitted with 32 cables, each corresponding to an individual vibrating surface from the pads detailed below.

- Access to a tactile pad:

These 2 pads have 16 vibrating surfaces each, numbered from 0 to 15 on the left pad and from 16 to 31 on the right one. The sound device receives the signals from the computer with the help of the Python code created and then it forwards the signals to the pads.

One of the pads is intended to be positioned either on the participant's back or stomach. During the experiment, participants will communicate to the examiners the type of motion they perceive, distinguishing between vertical or horizontal movements induced by the vibrating pad.

In order to get started you first need to install Python on your computer. Python is the primary programming language we'll be using, so it's crucial to have it set up. Additionally, you'll want to install PyCharm, which is an integrated development environment (IDE) that streamlines the coding process.

For familiarizing yourself with Python there are plenty of online tutorials available to help you grasp the fundamentals of the language. These tutorials cover essential concepts such as variables, loops, functions, and more, providing a solid foundation for your coding endeavors.

Once Python and PyCharm are installed, it's time to equip yourself with the necessary packages. Packages like **numpy, sounddevice, soundfile, keyboard,** and **msvcrt** enhance Python's capabilities, allowing you to tackle a broader range of projects. Installing these packages is straightforward. Simply navigate to PyCharm's settings, select "Project: ProjectName," and then "Python Interpreter." From there, you can easily add the required packages to your environment.

Moreover, the hardware setup of the MADIface xt RME Audio Device is necessary. You will need to install the MADIface xt RME driver which you can find on their website, and it is the one called “MADIface XT”. You can find more information about this on the following link: https://github.com/Acute-hi-is/Acute-procedures. Then physically connect the "MADIface xt RME" to your computer, ensuring all connections are secure.

Step-by-step explanation of the Python code

```
import argparse
import sys
import numpy as np
import sounddevice as sd
import time
import msvcrt
import keyboard as kb
import threading
import random


# Function to change int variables into string variables
def int_or_str(text):
   """Helper function for argument parsing."""
   try:
       return int(text)
   except ValueError:
       return text

# This part of script is used to parse command-line arguments related to audio
devices
# It allows the user to list available devices and select a specific device for
output.
parser = argparse.ArgumentParser(add_help=False)
parser.add_argument(
   '-l', '--list-devices', action='store_true',
   help='show list of audio devices and exit')
args, remaining = parser.parse_known_args()
if args.list_devices:
   print(sd.query_devices())
   parser.exit(0)
parser = argparse.ArgumentParser(
   description=_doc_,
   formatter_class=argparse.RawDescriptionHelpFormatter,
   parents=[parser])
parser.add_argument(
   '-d', '--device', type=int_or_str,
   help='output device (numeric ID or substring)')
args = parser.parse_args(remaining)

start_idx = 0

# Playback function
def callback(outdata, frames, time, status):
   if status:
       print(status, file=sys.stderr)
```

```
    global start_idx
    t = (start_idx + np.arange(frames)) / samplerate
    t = t.reshape(-1, 1)  # Change from row vector to column vector

    # To play the same sine wave to both output channels use this:
    outdata[:] = a * np.sin(2 * np.pi * f * t)  # Compute the sine wave
    start_idx += frames


samplerate = sd.query_devices(args.device, 'output')['default_samplerate']

# Close the database connection

########## EXPERIMENT PARAMETERS #########

nTrials = 4  # Number of iterations per condition, should be divisible by 4
(the code assumes 4 blocks of trials, i.e. 3 breaks
nTestTrials = 1  # Number of iterations per condition
doStartupTest = 1  # Play a signal through all motors to make sure everything
is working
stimuliDuration = 0.2  # duration of stimuli (in secs)
delayBetweenStimuli = 0.05  # delay between stimuli 1 and stimuli 2
responseTimeWindow = 5  # time window for response
delayAfterResponse = 0.5  # time after response is given until the next is
played

# You can change the frequency and amplitude
f = 50
a = 0.1

# This part of the script  lets you choose the Participant ID (introduced using
the keyboard)
print("Choose Participant ID:")
try:
    # Read the input event (assuming it returns a string)
    participant_str = kb.read_event(suppress=True).name
    # Convert the input string to an integer
    participantID = int(participant_str)
    print(f"Participant ID: {participantID}\n")

except ValueError:
    print("Invalid input. Please enter a valid number.")

# Function for introducing new information to the text file
def write_to_file(file_path, content):
    with open(file_path, 'a') as file:  # Use 'a' for append mode to add content
to an existing file
        file.write(content)
```

```
# Figure out what your path to the file is and change it!
file_path = r"D:\Iceland Project\experiment_results.txt"

# These two line opens the file in write mode, effectively clearing its
contents, delete if you want all the information of all the participants in the
same file
with open(file_path, 'w'):
   pass

experiment_summary = f"""

Experiment Summary for Participant: {participantID}
Time of stimuli: {stimuliDuration}
Time between stimuli: {delayBetweenStimuli}
Frequency: {f}
Amplitude: {a}
"""

write_to_file(file_path, experiment_summary)

nCoils = 32
# Lets you choose how many times you want the actuators to vibrate (write the
number in the command window)
num_vibrations=int(input("Enter the number of vibrations you want to generate:
"))

# Define patterns
patterns = [
   [[0, 15], [3, 12]],
   [[1, 14], [2, 13]],
   [[4, 11], [7, 8]]
]
available_numbers = list(range(1, len(patterns) + 1))

# Startup test, change the number below, in parentheses into the number of
patterns you want to have in one test
for _ in range(3):

   if doStartupTest:
       print('Running startup test...')
       all_channels = list(range(nCoils))

       print("Available patterns:")
       for i, pattern_set in enumerate(patterns):
           print(f"Pattern {i + 1}. Motor set 1: {pattern_set[0]}, Motor set 2:
{pattern_set[1]}")

       # Generate random number for pattern selection
       while True:
```

```
            random_pattern = random.choice(available_numbers)
            print("Pattern number:", random_pattern)

            if 1 <= random_pattern <= len(patterns):
                selected_pattern_set = patterns[random_pattern - 1]
                available_numbers.remove(random_pattern)  # Remove selected
pattern from available patterns
                break



        motor_set_1 = selected_pattern_set[0]
        motor_set_2 = selected_pattern_set[1]

        print(f'Selected pattern: Motor set 1: {motor_set_1}, Motor set 2:
{motor_set_2}')
        write_to_file(file_path,
                      f"The participant was subjected to pattern
{random_pattern}: Motor set 1: {motor_set_1}, Motor set 2: {motor_set_2} \n")
        # Generate vibrations of the actuators
        asio_ch1 = sd.AsioSettings(channel_selectors=motor_set_1)
        asio_ch2 = sd.AsioSettings(channel_selectors=motor_set_2)
        start_idx = 0
        # Check what number the port of the Madiface XT RME audio device was
connected to and change it in the "device=" parts
        for _ in range(num_vibrations):
            with sd.OutputStream(device=8, channels=2, callback=callback,
                                 samplerate=samplerate, extra_settings=asio_ch1):
                time.sleep(1)
                sd.stop()

            with sd.OutputStream(device=8, channels=2, callback=callback,
                                 samplerate=samplerate, extra_settings=asio_ch2):
                time.sleep(1)
                sd.stop()



    print("Choose orientation: V for VERTICAL, H for HORIZONTAL. Press Q to
quit.")

    # Introduce the answer of the participant using the keyboard and store the
information in the text file
    while True:
        response = kb.read_event(suppress=True).name.lower()

        if response == 'v':
            print("You selected: VERTICAL")
```

```
            write_to_file(file_path, "The participant felt a vertical
motion.\n")
            break  # Exit the loop after writing to the file
        elif response == 'h':
            print("You selected: HORIZONTAL")
            write_to_file(file_path, "The participant felt a horizontal
motion.\n")
            break  # Exit the loop after writing to the file
        elif response == 'q':
            print("Exiting the program.")
            break  # Exit the loop if 'q' is pressed
        else:
            print("Invalid input. Please choose V, H, or Q to quit.")

    print("Remaining available numbers:", available_numbers)

print(f"Results for Participant {participantID} saved to {file_path}")
```

Problems encountered in the process & future improvements

1. The error message indicates that the code is attempting to use the keyboard library, and it requires administrator privileges to run. On macOS, this is a common restriction for applications that capture keyboard events.

2. The challenge of connecting the Madiface XT RME audio device to Mac OS devices, potentially due to port differences, presents a notable issue warranting exploration. his problem can hinder users, especially those relying on audio equipment for professional purposes, from effectively utilizing their hardware on Mac OS platforms.

3. The difficulty of effectively documenting comprehensive project information, including parameters such as frequency, amplitude, vibration count, and any additional variables introduced by the experimenter during test execution, within a text file format.

4. Solving indentation issues in Python can sometimes be challenging, especially for beginners or when working with complex codebases. Python is highly sensitive to indentation because it uses it as part of its syntax. Even small deviations in indentation can lead to syntax errors or alter the logical flow of the code, potentially resulting in unexpected behavior or bugs.

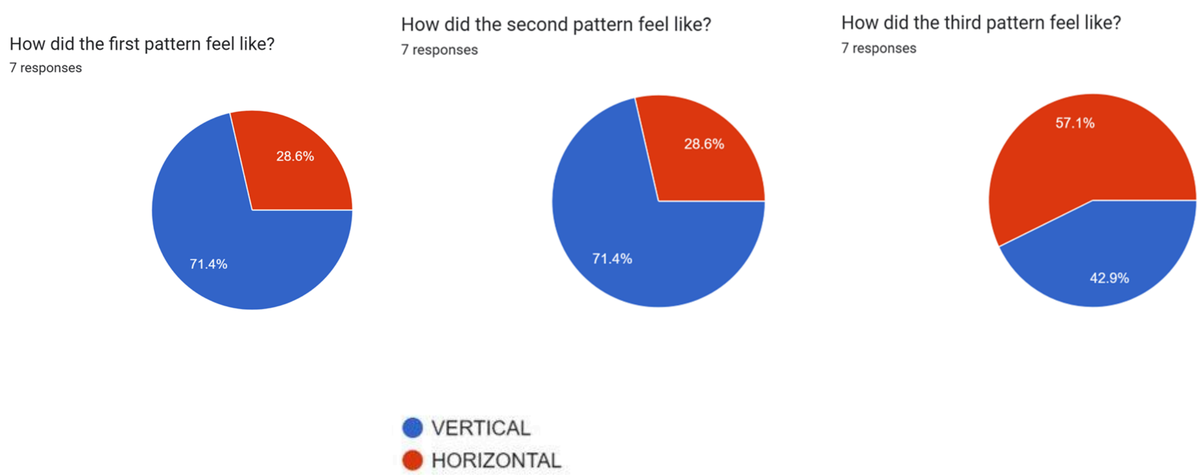
5. A prospective enhancement to this project entails a refined focus on prolonged patterns with specific characteristics, thereby delving deeper into the temporal intricacies of perceptual phenomena. Furthermore, future iterations could prioritize investigating the significance of stimulus sequence order and its influence on perceptual processes and cognitive mechanisms.

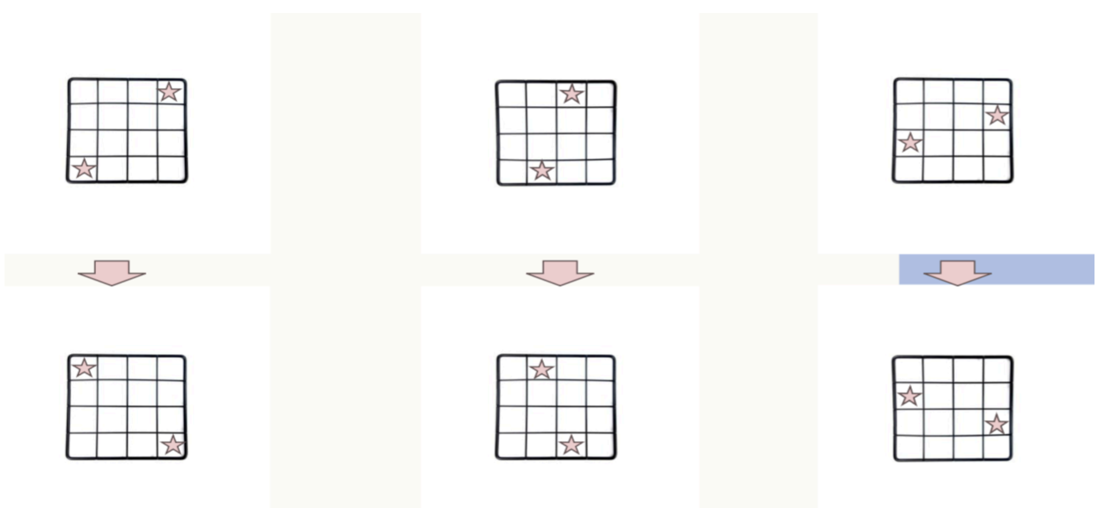
6. The experimental apparatus is positioned either on the dorsal or ventral aspect of the participant's body, specifically on the back or stomach region. By varying the location of the device, researchers can discern potential differences in perceptual experiences and elucidate the role of bodily positioning in modulating the perception of dynamic stimuli.

Such enhancements promise to enrich our understanding of apparent motion perception and its underlying determinants, thereby advancing the broader discourse within perceptual psychology and sensory neuroscience.

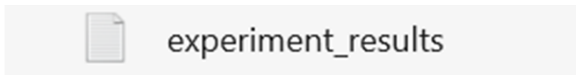
Testing & outcome

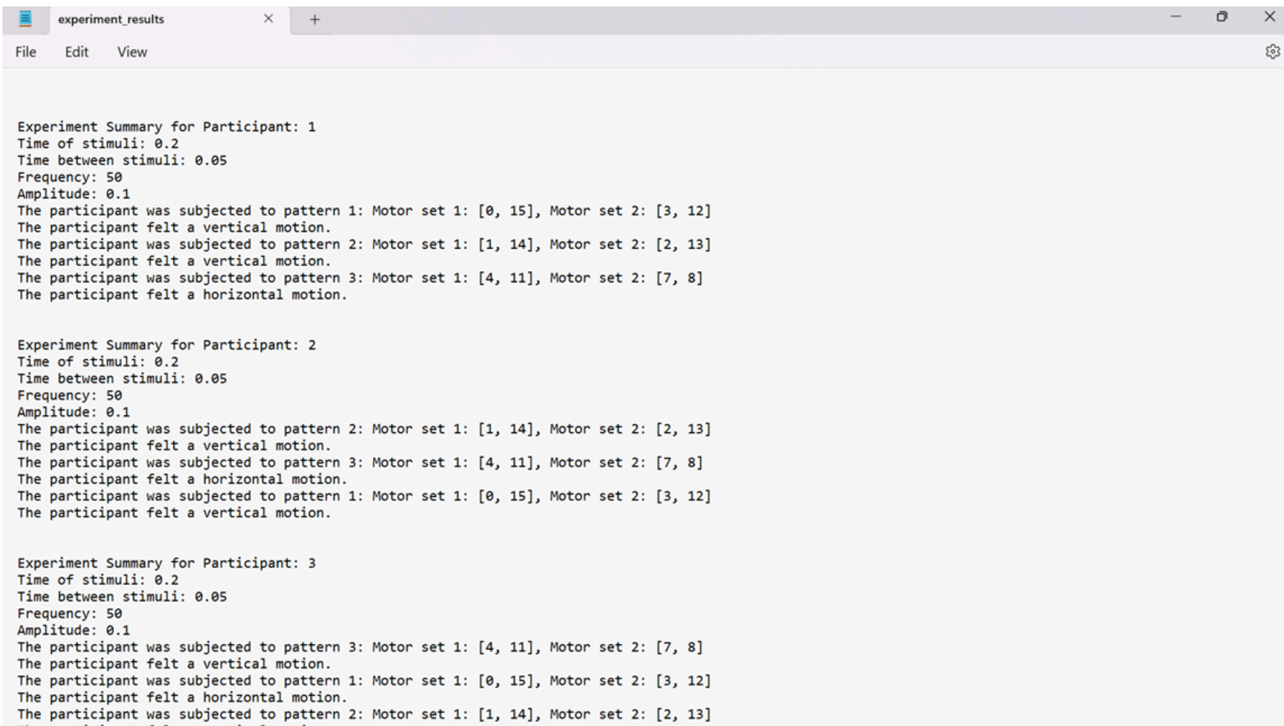
We conducted an experiment involving seven participants aged between 19 and 25. Each participant was exposed to three distinct patterns of vibration presented in a randomized sequence. Subsequently, participants were requested to say their perception of motion after each pattern, indicating whether they perceived it as vertical or horizontal. The diverse interpretations of apparent motion among individuals are discernible within the depicted images:





All the data resulted from the experiment is stored in a file called "experiment_results":






```
Experiment Summary for Participant: 1
Time of stimuli: 0.2
Time between stimuli: 0.05
Frequency: 50
Amplitude: 0.1
The participant was subjected to pattern 1: Motor set 1: [0, 15], Motor set 2: [3, 12]
The participant felt a vertical motion.
The participant was subjected to pattern 2: Motor set 1: [1, 14], Motor set 2: [2, 13]
The participant felt a vertical motion.
The participant was subjected to pattern 3: Motor set 1: [4, 11], Motor set 2: [7, 8]
The participant felt a horizontal motion.

Experiment Summary for Participant: 2
Time of stimuli: 0.2
Time between stimuli: 0.05
Frequency: 50
Amplitude: 0.1
The participant was subjected to pattern 2: Motor set 1: [1, 14], Motor set 2: [2, 13]
The participant felt a vertical motion.
The participant was subjected to pattern 3: Motor set 1: [4, 11], Motor set 2: [7, 8]
The participant felt a horizontal motion.
The participant was subjected to pattern 1: Motor set 1: [0, 15], Motor set 2: [3, 12]
The participant felt a vertical motion.

Experiment Summary for Participant: 3
Time of stimuli: 0.2
Time between stimuli: 0.05
Frequency: 50
Amplitude: 0.1
The participant was subjected to pattern 3: Motor set 1: [4, 11], Motor set 2: [7, 8]
The participant felt a vertical motion.
The participant was subjected to pattern 1: Motor set 1: [0, 15], Motor set 2: [3, 12]
The participant felt a horizontal motion.
The participant was subjected to pattern 2: Motor set 1: [1, 14], Motor set 2: [2, 13]
```

Conclusions

The project explores the perception of apparent motion through the use of vibration patterns. Apparent motion refers to the illusion of movement perceived by the brain when static stimuli are presented sequentially. By utilizing vibration motors, we aim to simulate this illusion and investigate how individuals perceive motion orientations, such as vertical or horizontal. Through a series of controlled trials, we examine participant responses to different vibration patterns and explore factors influencing apparent motion perception.

- The startup test successfully verifies the functionality of the vibration motors by playing predefined patterns through them. The randomized selection of patterns ensures variability and accuracy in testing, contributing to the reliability of subsequent participant trials.
- The participant responses to the apparent motion stimuli (vertical or horizontal) demonstrate variability across trials. This variability could be influenced by factors such as individual differences in perception, sensitivity to vibrations, or subjective interpretation of motion orientation.
- The project highlights the ability to induce the perception of apparent motion through vibration patterns. By alternating vibrations between different motor sets, the project simulates the illusion of motion, providing insights into how the brain interprets sensory stimuli to perceive motion.
- The project incorporates key experimental design elements, such as stimuli duration, delay between stimuli, and response time window, to ensure controlled presentation and measurement of apparent motion perception. These parameters contribute to the standardization and reproducibility of the experimental procedure.
- The project effectively collects participant responses and experimental data, storing them in a structured format for further analysis. Analyzing the collected data could reveal patterns or trends in participant responses, shedding light on the mechanisms underlying apparent motion perception.
- Future iterations of the project could explore additional variables, such as varying the frequency or amplitude of vibration patterns, to investigate their effects on apparent motion perception. Moreover, incorporating larger sample sizes and diverse participant demographics could enhance the generalizability of findings.
- The project's findings contribute to our understanding of perceptual phenomena, with potential applications in fields such as human-computer interaction, virtual reality, and assistive technology. Understanding how vibrations can evoke the perception of motion has implications for designing more immersive experiences and enhancing sensory feedback systems.