Cosmic Defender

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muse™ the brain sensing headband

VIVE

Made with unity

CCRMA

Motivations & Objectives

1) Employ musical elements within a game environment to improve cognitive functions and task management through pattern matching and rhythmic training

2) Improve the effectiveness of multisensory and/or cross modal associative cues in short-term recollection of patterns and rhythms

3) Improve ability to localize and respond quickly to moving sounds

4) Create a fun and engaging VR game experience

Background

Chunking & Working Memory

Associative sequence processing relates to working memory processes and can improve performance and cognitive workload. [1]

Developing efficient chunking techniques for grouping sequence elements can result in decreased cognitive workload. [2]

Effects of Musical Training

Musical training refines a hierarchical network of brain structures that transfer to a broad range of cognitive mechanisms, facilitating both high and low level functions as well as coordination between auditory, visual, motor and memory related processes. [3]

Musical training involves exposure to complex auditory and visual stimuli, memorization of elaborate sequences, and extensive motor rehearsal.

Associations between multifaceted training and increased performance in basic cognitive functions have been the subject of many studies supporting the theory that musical training increases cognitive ability, for tasks ranging from unimodal and cross-prediction to working memory capacity and linguistic development [3, 4]

Neuroimaging studies show increased cortical activation in musicians versus non-musicians, for example during working memory tasks. [3]

Multi-Sensory Engagement

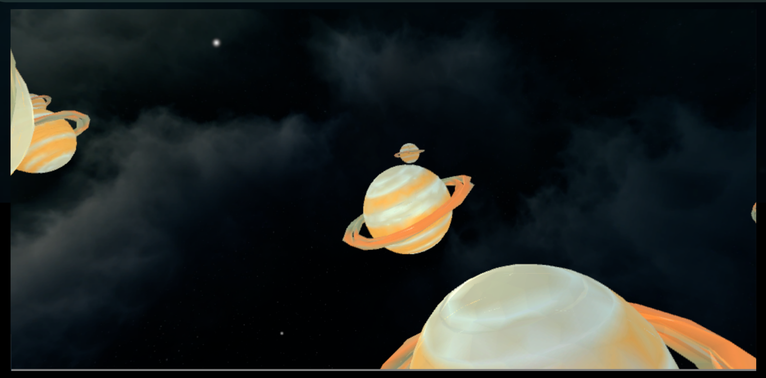
A study on motor acquisition and motor memory formation showed improvement on motor sequence and reaction time in both athletes and non-athletes after training. Findings suggest that differential formation and consolidation processes underlie motor tasks [5]

Musicians showed increase in predictive skills and sensitivity to statistical structure of various presented testing stimuli, supporting the theory that training with auditory and visual stimuli can transfer across modalities [4]

Single neurons in the pre-supplementary motor area have been shown to use identical representations for holding both tactile and auditory stimuli in working memory. [6]

Spatialization

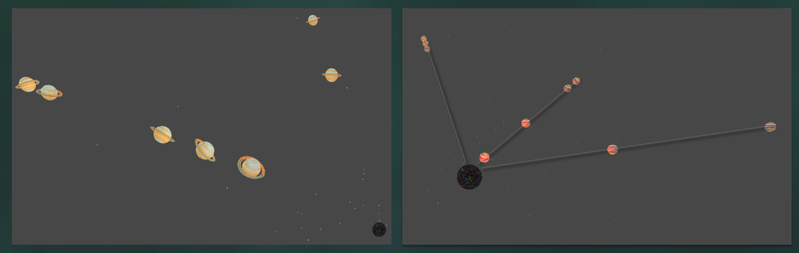
Many studies show evidence for spatialized auditory cues at effectively reducing search times in dynamic environments. Cues were most beneficial when the target appeared on the horizontal plan [7]



Gameplay & Game Design

You are the Cosmic Defender. A black hole at the center of the galaxy threatens to annihilate existence as it draws everything into its dark center. Only you can save the galaxy!

Planetary objects appear from eight directions surrounding the player and are drawn in toward the black hole, centered at and moving with the player's location. Your task is to free the planetary objects from the black hole's pull by hitting them with your anti-gravity spheres (representing the Vive controllers) at the right time as they approach.



Each of the nine types of planetary objects occurs in groups of the same type. Each group of planetary objects will always appear in the same pattern. The rhythmic or temporal sequence of these patterns remains consistent between different playthroughs of the game, while the spatial sequence varies from playthrough to playthrough. Thus the player is required to relearn the spatial component of each planetary object's pattern for consequent playings of the game while being able to rely on remembering each object's rhythmic pattern from previous game sessions.

At the beginning of the game, only one planetary object type can appear, with a relatively simple rhythmic pattern. As the game progresses, additional planetary types of increasing rhythmic complexity are introduced into the pool of possible types that randomly appear with increasing tempo and movement speed.

If the player misses a planetary object, it gets sucked into the black hole, increasing its mass and size (the black hole is visible if the player looks down). The game ends when the black hole reaches CRITICAL MASS!

The player's overall success is also indicated by the relative strength of colored lighting and background music (discussed below).

Sound Design

Each sound featured in the game serves a specific purpose in aiding associative training tasks; specifically, pattern matching & increased environmental awareness

Approaching Objects

Planets sucked towards the player emit their own unique click pattern and frequency range, linked to the temporal pattern in which they are triggered and must be hit. These clicks are spatialized on a horizontal plane to enhance player localization acuity.

Impact Sounds

Categorized by location and generated with temporal and timbre qualities mapped to strike velocity

Background Music

Generative music modulated by 3 factors:
1) Players movement (amplitude)
2) Performance in the game (detuning and harshness)
3) Outside influence from a spectator's brainwaves (tremolo and chord change)

Arm Movement

Arm movements are mapped to a continuous windy sound, giving speed and direction cues for increased feedback when hitting objects

References

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[3] Moreno, S., & Bidelman, G. M. (2014). Examining neural plasticity and cognitive benefit through the unique lens of musical training. Hearing Research, 308, 84-97.
[4] Vassena, E., Kochman, K., Latomme, J., Verguts, T. (2016) Unimodal and cross-modal prediction is enhanced in musicians. Department of Experimental Psychology, Ghent University, Belgium.
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[6] Constantinidis, C. (2016). A code for cross-modal working memory. Neuron, 89(1), 3-5. [7] McIntire, J. P., Havig, P. R., Watamaniuk, S. N. J., & Gilkey, R. H. (2010). Visual search performance with 3-D auditory cues: Effects of motion, target location, and practice. Human Factors, 52(1), 41-53.

Plasticity

Multi-modal rhythmic perception game designed to improve working memory, attention, concentration, reaction time, and flexible management of dealing with multiple tasks simultaneously

Player learns to associate relationships between many environmental features at once while ignoring others

Temporal pattern association enforces high level cognitive functioning and awareness of environment, leading to developing efficient environment navigation

Improved functioning in the VR environment develops strategic chunking abilities that can lead to reduced task demands

Detecting regular temporal patterns in the game, cued by auditory and visual stimuli, could enhance many areas of sensory perception including attention, working memory and executive control

Social / performance aspect of the game, involving direct spectator bio-feedback, can improve players abilities to act more efficiently under pressure

Working & Episodic Memory

Simple digit spam test could assess improvements in cross-modal working memory before and after gameplay [1]

Assess ability to recall written versus spoken digits could measure relative improved working memory capacity in response to visual versus auditory stimuli before and after gameplay

Attention

Stroop test where participants have task of reading the written color names of the words, independently of the color of text, can test whether game improves player focus [1]

Transcription task where participants transcribe as many given spoken or written symbols as possible, ie: repeating digits forwards and backwards [2]

Spectator EEG Influence

Motivation

Enhance social and performance element of the game by involving the spectator outside the VR game

Involvement

In order to increase difficulty for the player, the spectator has the challenging task of relaxing while being stimulated by player's movements and gameplay as well as generated music

An increase in the spectators alpha waves, measured by Muse 2016 EEG Headband, modulates the background music and introduces a fog while darkening incoming planets. This impairs the visibility of the player inside the cosmic VR world, forcing them to rely more on auditory cues.