# Software Requirements Specification

**for**

# Binocular Rivalry in VR

**Version 1.0 approved**

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**February 7, 2025**

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# Revision History

| Name | Date | Reason For Changes | Version |
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# 1. Introduction

## 1.1 Purpose

The purpose of this document is to detail the creation and structure of the Multi-Perception VR System designed for Binocular Rivalry experiments. This system will utilize a VR headset to project two different images simultaneously—one to each eye—allowing researchers to study perceptual dominance shifts.

This document will outline the system's interface, purpose, and structure. It will cover key functionalities, such as the ability to control displayed images, implement quick flashing effects at adjustable intervals, and integrate with an EEG headset to track brain activity. Additionally, it will describe the hardware and software requirements, potential constraints, and challenges associated with inter-device communication.

This document is intended for both developers and researchers to ensure a clear understanding of the project scope. It will be proposed to our project sponsor, Dr. David Van Den Heever, for approval.

## 1.2 Document Conventions

The highlighted words are the software tools that will be used. All fonts are Times New Roman 12pt. Each subsection is Times New Roman 14pt. Headers are bolded. Each section is divided by numbers.

## 1.3 Intended Audience and Reading Suggestions

This Software Requirements Specification (SRS) document is intended for developers, the project sponsor, researchers, and testers involved in the Multi-Perception VR System. Developers will use this document to implement key functionalities such as image projection, flashing controls, and EEG integration while ensuring smooth inter-device communication. The project sponsor, Dr. David Van Den Heever, and researchers will refer to it to verify that the system meets experimental needs, particularly in conducting Binocular Rivalry experiments. Testers will rely on this document to validate system functionality, ensuring that image presentation, timing, and EEG synchronization work as expected.

To facilitate a structured understanding, readers should begin with the Introduction & Overview, which provides background information on Binocular Rivalry experiments and the motivation behind the project. The System Description follows, detailing the core functionalities, hardware and software dependencies, and constraints, making it essential for developers, testers, and researchers. Next, the Functional Requirements section outlines key features such as image control, flashing intervals, and EEG synchronization, which are particularly relevant to developers and testers. The

Non-Functional Requirements section covers performance, reliability, and usability considerations, which are critical for developers and researchers to ensure the system's effectiveness in a research environment. The System Interaction & Interfaces section explains how the VR headset, EEG device, and user input mechanisms interact, making it crucial for developers and testers. Lastly, the Use Cases & User Scenarios section presents real-world experiment execution, helping researchers and testers understand how the system will function in practice

### 1.4 Product Scope

The scope of this product is to provide the customer with a virtual reality environment that can be used in a research setting. The research being done will exclusively be focusing on studying the neurological phenomenon known as "Binocular Rivalry" The software being developed will allow for a faster and more dynamic testing environment for gathering data for the previously stated research.

### 1.5 References

*https://www.biosemi.com/faq/trigger_signals.htm*
*https://www.biosemi.com/faq/USB%20Trigger%20interface%20cable.htm*

These are references on the equipment that will be used as well as its general function

## 2. Overall Description

### 2.1 Product Perspective

The desire for this project is to be able to create a Binocular Rivalry experiment environment inside of a VR headset. This is essentially the ability to simultaneously project two different images to each eye. Binocular Rivalry is a phenomenon where when two different images are shown to somebody, the images are not superimposed upon each other, but seen individually. Meaning that the brain fluctuates focus between both images, so the subject will only see one of them at a time.

### 2.2 Product Functions

The Multi-Perception VR System must support the following key functions to enable Binocular Rivalry experiments effectively:

- Image Projection & Control
    - Display two distinct images, one to each eye, using a VR headset.
    - Allow researchers to select and modify the displayed images.
- Flashing & Timing Configuration
    - Enable precise control over image flashing intervals (e.g., every 100ms).
    - Provide adjustable timing settings for experiments.
- User Response Collection

    - Implement a dual-button input system for subjects to indicate which image they perceive.
    - Log and timestamp user responses for later analysis.
- EEG Integration & Synchronization
    - Synchronize image presentation with EEG data collection.
    - Ensure real-time tracking of brain activity correlated with user responses.
- Experimental Session Management
    - Allow researchers to configure and store experiment parameters.
    - Provide session logging for review and data analysis.

## 2.3 User Classes and Characteristics

1) Users - User must have EEG attached to user's body before putting on VR headset. Users cannot select images seen in the headset.
2) Developers - Developers will have the privilege to add or delete images shown in application. Developers can specify a time frame for images to switch or manually switch images.

## 2.4 Operating Environment

We will be using MQDH (Meta Quest Developer Hub) v4.0 for support on the "Oculus Quest 3" VR headset, as well as Unity. We will be using Unity so as to eliminate the need to constantly deploy the app for testing. The base operating system will not be changed. We will be having to use this software in conjunction with the BioSemi Trigger Interface, which will allow for the headset to be used in conjunction with the EEG machine.

## 2.5 Design and Implementation Constraints

The development of the Multi-Perception VR System is constrained by hardware, software, and integration requirements. It must run on the Oculus Quest 3, limiting processing power, memory, and requiring adherence to its SDK and API. The system must integrate with the BioSemi Trigger Interface for precise EEG synchronization, necessitating low-latency USB or Bluetooth communication. Compatibility with EEG software like OpenBCI or BrainVision restricts data formats and logging mechanisms. Development is limited to Unity or Unreal Engine, using C#, C++, or Python, with strict performance optimization to ensure smooth VR rendering. Security constraints require data encryption and compliance with research ethics, restricting cloud-based storage options. Additionally, since researchers will maintain the software, the code must follow modular and well-documented practices for long-term usability.

## 2.6 User Documentation

We plan on delivering an in-depth user guide on how to operate the software alongside the given hardware.

## 2.7 Assumptions and Dependencies

The EEG software may or may not pose a problem. However, we are uncertain at this time.

# 3. External Interface Requirements

## 3.1 User Interfaces

As of right now, the client has two main desires for the interface.

1.) The control of which images are shown in the headset as well as which side of the stereoscopic display will see which image.
2.) The frequency at which the images are shown.

## 3.2 Hardware Interfaces

TBD

## 3.3 Software Interfaces

We will be having to create some sort of communication between the headset and the EEG machine.

## 3.4 Communications Interfaces

N/A

## 3.5 System Feature 1

4.1.1 Description and Priority

*<Provide a short description of the feature and indicate whether it is of High, Medium, or Low priority. You could also include specific priority component ratings, such as benefit, penalty, cost, and risk (each rated on a relative scale from a low of 1 to a high of 9).>*

1.) The ability for the examiner to change and swap the images projected in the stereoscopic displays at will. Priority: High
2.) Ability for the images to be flashed and at a frequency determined by the examiner.

Priority: High

3.) Ability for the examiner to be able to keep track of which images the examinee saw in the headset. Priority: Medium

4.1.2 Stimulus/Response Sequences

*<List the sequences of user actions and system responses that stimulate the behavior defined for this feature. These will correspond to the dialog elements associated with use cases.>*

4.1.3 Functional Requirements

*<Itemize the detailed functional requirements associated with this feature. These are the software capabilities that must be present in order for the user to carry out the services provided by the feature, or to execute the use case. Include how the product should respond to anticipated error conditions or invalid inputs. Requirements should be concise, complete, unambiguous, verifiable, and necessary. Use "TBD" as a placeholder to indicate when necessary information is not yet available.>*

*<Each requirement should be uniquely identified with a sequence number or a meaningful tag of some kind.>*

REQ-1:
REQ-2:

### 3.6 System Feature 2 (and so on)

# 4. Other Nonfunctional Requirements

## 4.1 Performance Requirements

The Multi-Perception VR System must meet several performance requirements to ensure accurate and reliable execution of Binocular Rivalry experiments. The system must maintain a VR frame rate of at least 90 FPS to prevent motion sickness and provide a smooth visual experience. Image switching and flashing must occur with millisecond-level precision (e.g., every 100ms) to align with experimental timing needs, ensuring accurate perception tracking. The latency between VR stimulus presentation and EEG data logging must not exceed 10ms, as precise synchronization is critical for analyzing brain activity.

The system must process dual-button inputs from test subjects within 5ms to ensure real-time response tracking. Data transfer between the BioSemi Trigger Interface and EEG software must be low-latency and lossless, maintaining signal integrity for accurate experimental results.

Additionally, the software must initialize experiment sessions within 2 seconds and load stored configurations instantly to minimize researcher downtime. Given the limited hardware of the Oculus Quest 3, VR rendering and data handling must be optimized to prevent frame drops or system lag. These requirements ensure the system operates with the precision necessary for high-quality neuroscience research.

## 4.2 Safety Requirements

The Multi-Perception VR System must ensure participant safety, data integrity, and secure access during Binocular Rivalry experiments. To prevent motion sickness and eye strain, the system must maintain a 90 FPS frame rate and allow adjustable image flashing intervals. User response inputs and EEG synchronization must be optimized to avoid excessive cognitive load. To protect experimental data, all results must be automatically logged, securely stored, and periodically backed up, with fail-safe mechanisms in place to recover from software crashes. Unauthorized access must be prevented through role-based authentication, restricting system modifications and EEG data access to approved researchers. The system must comply with institutional research ethics policies and, if applicable, IRB guidelines and safety certifications to ensure safe and ethical use in neuroscience research.

## 4.3 Security Requirements

The Multi-Perception VR System must ensure secure data handling and participant privacy by encrypting all experimental data, including EEG recordings and user responses, both in transit and at rest. User authentication will restrict access based on roles, allowing only authorized researchers to modify settings or access stored data. The system must comply with institutional research ethics policies and, if applicable, GDPR or HIPAA standards, ensuring responsible data management. Secure logging mechanisms will prevent data tampering, and any external storage or cloud services used must meet institution-approved security standards, guaranteeing data integrity and confidentiality.

## 4.4 Software Quality Attributes

The Multi-Perception VR System must ensure accuracy, reliability, and usability for precise Binocular Rivalry experiments, with image display and EEG synchronization maintaining 10ms or lower latency. The system must achieve 99% uptime during experimental sessions, with an intuitive interface allowing researchers to configure experiments in under two minutes. It must be interoperable, integrating smoothly with the BioSemi Trigger Interface, EEG software, and VR headset APIs, while maintaining a modular and well-documented codebase for easy updates. Portability is required to run on Windows 10/11 machines without extensive reconfiguration, and robustness is ensured through error-handling mechanisms that prevent data corruption. Finally, the system must be fully testable, with automated and manual verification of core functionalities before deployment in research settings.

### 4.5 Business Rules

N/A

# 5. Other Requirements

# Appendix A: Glossary

# Appendix B: Analysis Models

# Appendix C: To Be Determined List