1 Experimental Setup

In this study, we employed Virtual Reality (VR) and Electroencephalography (EEG) technologies to create a controlled immersive environment for studying neural feedback under multisensory stimulation. As shown in Figure S1, the subject is equipped with a head-mounted display (HMD) and an EEG cap, and performs experimental tasks using a VR controller. Meanwhile, the display inside the head-mounted display is simultaneously projected onto a large screen for broader observation.

VR Equipment: The VR system comprises a head-mounted display and VR controllers. The head-mounted display offers a 360-degree visual experience, essential for simulating real-world scenarios or multisensory stimuli within a virtual environment. Interaction is facilitated through VR controllers.

EEG Collection: Participants are equipped with an EEG head cap with 32 electrodes, connected to EEG acquisition equipment that records cerebral electrical activity. This setup ensures precise synchronization in capturing neural responses to stimuli presented in the VR environment.

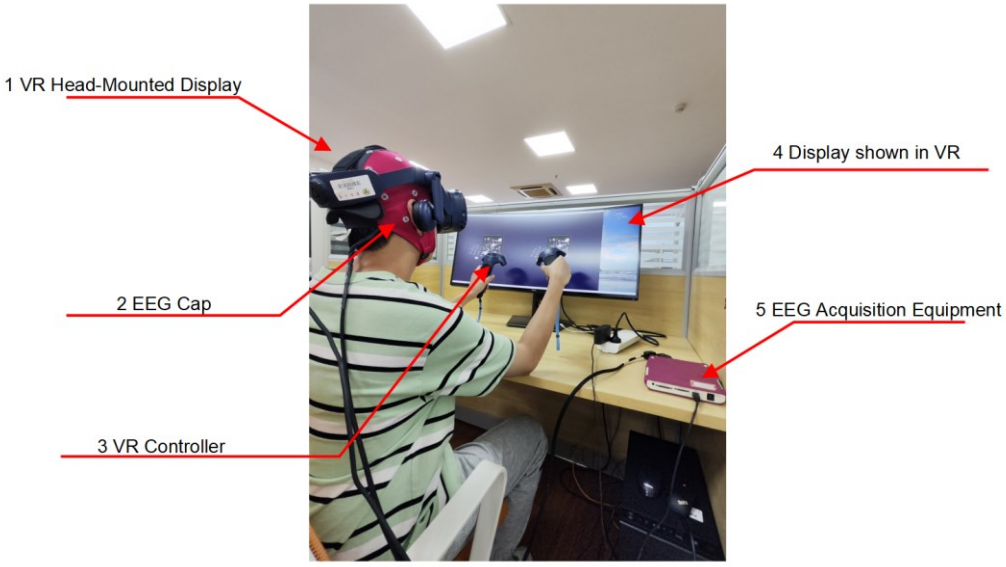

Fig. 1. Hardware Configuration of the CVR-BBI

2 Develop Personalized Paradigms

Panel A: Client-Side Operation Flow

1. Define a New Paradigm: Users start by defining a new paradigm tailored to their needs. This sets the framework for data collection and processing.
2. Start Paradigm: This step initiates the defined paradigm, begins collecting actual data from connected devices, activates stimuli in VR, and starts the transmission of collaborative messages.
3. Start Collecting EEG Data: Alongside the paradigm, the collection of EEG data commences, capturing brain activity data.
4. Start Message Collaboration: Involves initiating real-time communication or data exchange within the platform to facilitate collaboration among multiple users.
5. Stop Paradigm: The paradigm is stopped once the necessary data has been collected.
6. Save EEG Data and Exit Context: The collected EEG data is saved, and the session context is closed to ensure data integrity and privacy.

This client-side process allows users to program their applications according to a personalized workflow, collecting and processing data in a structured manner.

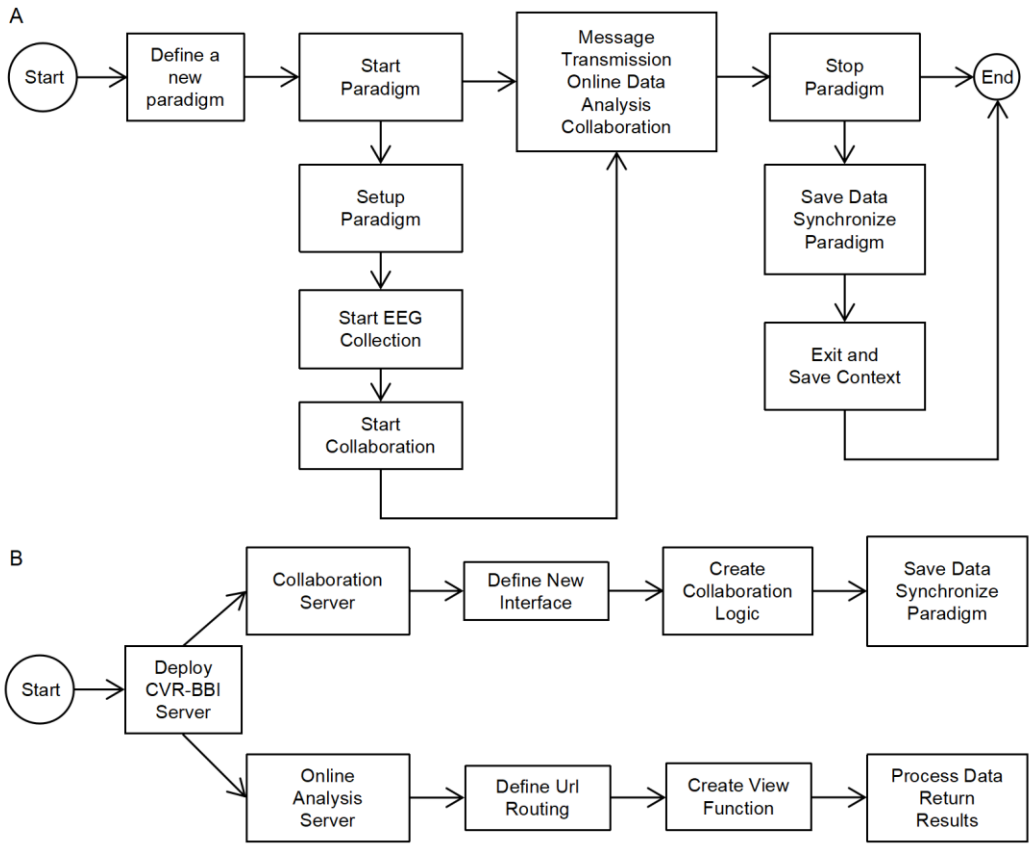

Fig. 2. Development Workflow for Customized Paradigms. A) Client Operation Flow. B) Server Operation Flow.

Panel B: Server-Side Operation Flow

Deploy CVR-BBI Server: Sets up servers that handle all computations and data processing, including collaborative servers and online analysis servers.

Collaboration Server: Manages all collaborative interactions occurring on the platform.

1. Define New Interface: Based on user requirements, new interfaces are defined for interacting with server functionalities.
2. Create Collaboration Logic: Develops specific logic for handling collaborative tasks and data synchronization.

Online Analysis Server: Used for real-time data analysis.

1. Define URL Routing and View Functions: Configure new URL routes in the web server to direct data flow to customized functions.
2. Process Data and Return Results: The server performs data processing on the collected information and subsequently transmits the results back to the client.

This server-side process delineates the development of server components required for the efficient execution of real-time data analysis and collaborative tasks.

3 Using the CVR-BBI Release Client Program

Figure 3 illustrates the sequence of operations for using our CVR-BBI release client. Below is a step-by-step guide that corresponds to the key activities represented in the diagram:

1 Login with Personal Information:
Users initiate the client by logging into the system with their personal credentials. This initial step ensures that all user data and settings are personalized and secure.

2 Select Stimulus Images:
After logging in, users navigate to the image selection interface, where they can choose specific visual stimuli for the experiment. This can be done by clicking on "File" in the interface shown in the top right corner of the figure.

3 Enter CVR Mode:
After selecting the desired images, users can enter the Collaborative Virtual Reality (CVR) mode by clicking "See in CVR-BBI" in the interface shown in the top right corner of the figure.

4 Choose Paradigm and Start Experiment:
In CVR mode, users press a button on the VR controller to open the settings panel, select an experimental paradigm, and configure the parameters for the stimuli. After setting their preferences, users click the start button to start the experiment and continue until it ends.

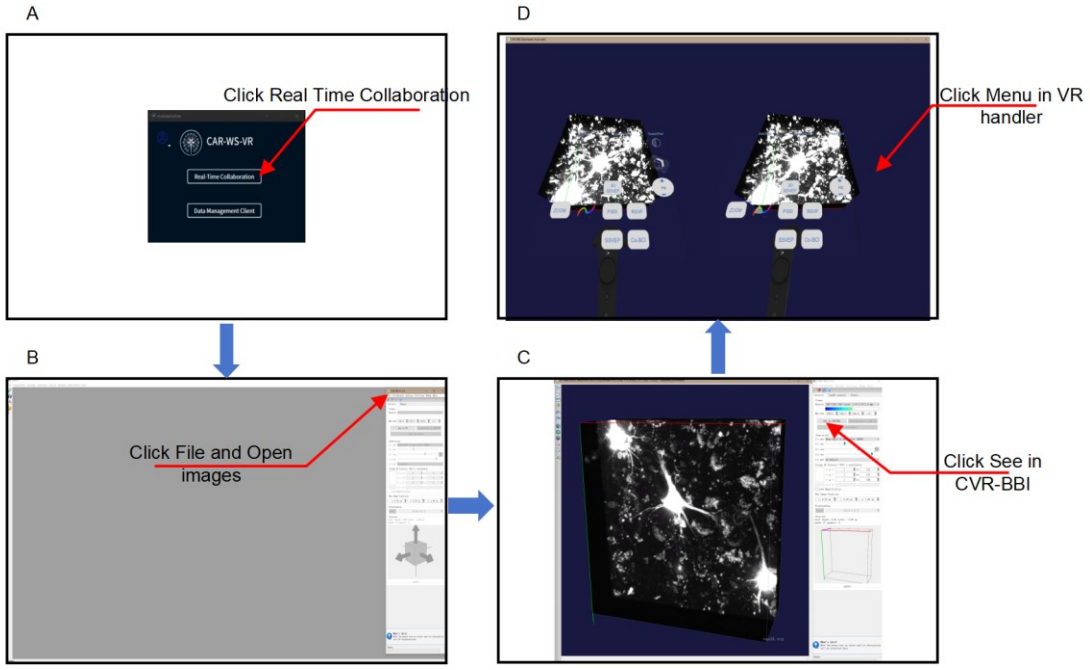

Fig. 3. CVR-BBI Client Usage Workflow.

4 Using the CVR-BBI Release Server

Step 1: Download the Docker Image
First, download the Docker image from the following link: https://zenodo.org/uploads/13118183/cvr-bbi_image.tar
Ensure you save the file as cvr-bbi_image.tar on your local system.

Step 2: Load the Docker Image
Before deploying the server, load the downloaded Docker image into your Docker system. Open a terminal and execute the following command:

```
sudo docker load -i cvr-bbi_image.tar
```

Step 3: Run the Docker Container
Once the image is loaded, you can run the Docker container. To do this, use the following command, which also maps port 8512 on your host machine to port 8000 inside the Docker container. This mapping allows external access to the server via the public IP of the host.

```
sudo docker run -d -p 8512:8000 mysite
```

Ensure that the server machine has a public IP address for external accessibility.

Step 4: Verify the Server is Running
To check if the Docker container is running properly, you can list all active containers:

```
sudo docker ps
```

Look for the container named mysite and ensure it shows up as running and the port mappings are correctly listed as 8512:8000.