

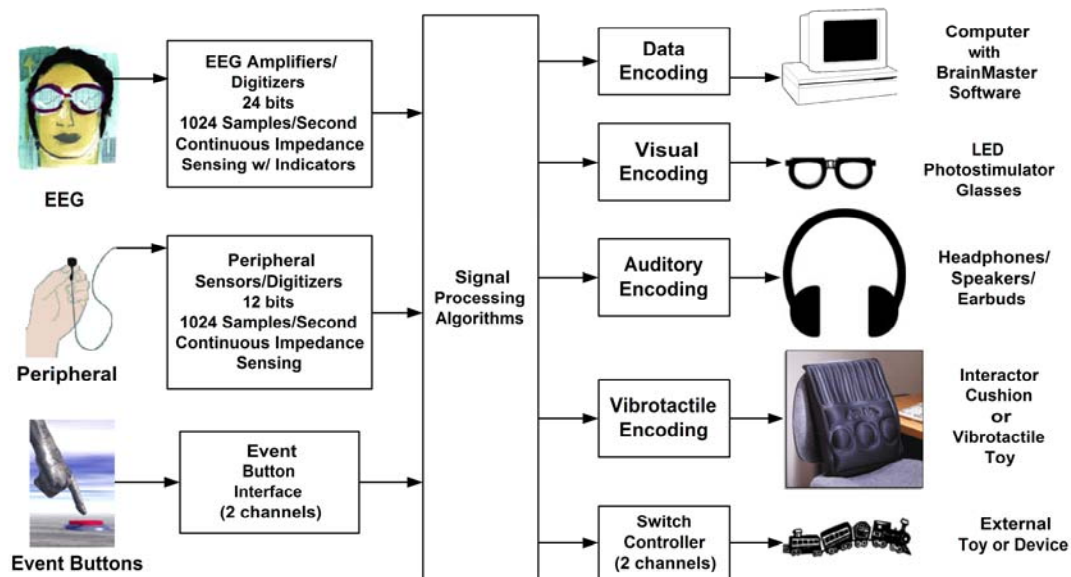
The Atlantis Visual/Auditory/Tactile (V/A/T) Immersion System

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The Atlantis system from BrainMaster Technologies is a new series of devices offering advanced neurofeedback and biofeedback applications. It evolves the BrainMaster products into the next level of technology, and continues our tradition of innovation. One of its more important capabilities is providing rapid, continuous phase-sensitive sensory immersion EEG biofeedback. It also supports conventional neurofeedback, is expandable for peripheral biofeedback, and also provides simultaneous impedance monitoring on EEG as well as peripheral channels. It is available in a new series of hardware, including a 4-channel (2x2) module and an 8-channel (4x4) module. The series employs state-of-the-art hardware sampling with 24-bit resolution at a maximum sampling rate of 10,000 samples per second, providing real-time response and stimulation. The system continuously monitors the trainee's EEG and produces output in the form of auditory, visual, and vibrotactile stimulation. All phase-sensitive feedback is generated entirely within the hardware, avoiding the need for an external PC. This prevents the delays associated with PC operating systems, and provides feedback with a response time of less than 1 millisecond (1/1000 of a second). This system response is essentially real time, comparable in physiological effect to an analog system.

Atlantis by BrainMaster



Atlantis Visual/Auditory/Tactile Neurofeedback System

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The Atlantis system utilizes a new phase-sensitive feedback method in which every detail of the EEG signal is presented, in an unbiased and responsive manner, to the trainee's senses in the form of light, sound, and vibration. The intent of the system is to provide instantaneous, protocol-free feedback that allows the brain to become immersed in its own electrical activity through the three senses. Any learning or modification that occurs is based upon the brain's own interpretation of the information, and its own goal-seeking behavior relative to the new information presented. This is consistent with self-adaptive theory, and takes advantage of the brain's flexibility in establishing its own goals, and in creating strategies for their fulfillment.

Atlantis stands for "Advanced Technology Local Autonomous Training Immersion System". The system is self-contained, and all data acquisition, signal processing, and stimulation, are controlled within the pocket-sized hardware module. In addition, the module also controls the continuous impedance monitoring and LED indicators, event detection inputs, and control relay outputs. Finally, it is capable of sending data to a PC for processing using the BrainMaster software for Windows.



The Atlantis V/A/T system is integrated with a high quality 2 or 4 channel EEG encoder, sampling at 24-bit resolution, and a maximum sampling rate of up to 10,000 samples per second. The typical operating rate with all features enabled is 1024 samples per second. The amplifiers record DC (Direct Current) and SCP (Slow Cortical Potential) activity as well as conventional EEG. This system advances the existing BrainMaster products into new technology, while retaining compatibility with existing software and applications.

The system also includes real-time, continuous sensor impedance monitoring on all channels, to help ensure quality EEG recordings. The impedance monitors operate at all times throughout the feedback training, whether or not EEG data are being sent back to the PC. The PC runs standard BrainMaster EEG neurofeedback software (version 2.5SE or later), which can be run concurrently with, and independent of, the V/A/T sensory immersion feedback.

The system also supports a set of optional peripheral interfaces that are capable of monitoring variables such as skin conductance, skin potential, EKG, heart rate, temperature, nIR HEG, pIR HEG, and other biological signals. The interface includes a 5 volt supply to power peripherals when required. The EEG and the peripheral channels all include simultaneous potential and impedance recording, using a proprietary "Triamp" design. The system is capable of a maximum

sampling rate of 10,000 samples per second, without continuous impedance sensing, but retaining the DC, SCP, and peripheral recording, and all immersion stimulation capabilities. (Note that full expandability to all of these operational features will require the forthcoming BrainMaster 3.0 software release).

The use of combined visual, auditory, and vibrotactile stimulation has a long history. Kahn (1954) implemented and reported on such a system, used to produce subjective states, as well as EEG responses. Variations in rhythms, particularly when made user-selectable based upon individual preference, were found to produce systematic changes in internal states. Evans (1972) applied a similar system to severely retarded children, and also reported clinically useful effects. Collura (1978) applied visual and auditory stimulation in a vigilance task, and reported evoked EEG changes associated with changes in attention.

EEG-controlled photostimulation has been reported by previous authors. There are a wide range of possible algorithms that can be used, and no individual “owns” the concept of EEG-driven sensory stimulation. Early studies that combined photic stimulation with studies of human psychophysical responses were done in the 1970’s using entirely analog instruments (Collura, 1978, 1996). Other methods depend on detecting the EEG dominant frequency, and adjusting the stimulation based upon this information (Carter et. al. 1999). The V/A/T system is not based on any such approach, is much more direct, and is phase-sensitive instead of frequency-dependent. Still other methods employ protocol-based approaches, used to selectively stimulate, based upon predefined amplitude-based EEG parameters (Collura 2002, 2005). Others have fed back rapid information based upon momentary information in the EEG, and have reported significant clinical efficacy (Srinivarsan 1988, Davis 1999, Hammond 2001).

The Atlantis “Local Autonomous” V/A/T system does not use any of these previously described methods. The basic phase-sensitive algorithm does not depend on any specific protocol or decision-making based upon the EEG conditions, and it does not use any previously reported algorithms. Its signal processing produces immediate, unbiased feedback intended to reflect the state of the EEG directly to the trainee, without any interventional processing or protocols. Both hemispheres are reflected in the two-channel control system. In addition to the phase-sensitive feedback, the hardware is also capable of interacting with the BrainMaster software (forthcoming version 3.0), to provide other protocols, including specific inhibit-based protocols, and related EEG-controlled methods (Collura 1999, 2002, 2005)

The Atlantis auditory stimulation algorithm utilizes a proprietary method that encodes the EEG waveform in the form of frequency and amplitude, producing a new type of feedback. The method produces a complex, aesthetic sound that yields an other-worldly, ethereal sound with rapid and engaging variations. Every detail of the EEG waveform is heard in the modulation of the sound output. There is no thresholding or synthetic signal generation per se, as is common with conventional auditory neurofeedback. Instead, the EEG signal is transformed into a sound that encodes the EEG information directly, for the brain to process. The brain seems to be able to process auditory information much more rapidly than visual material, and is acutely sensitive to subtle variations in timing and rhythm. The Atlantis system thus produces “music” of the brain, in a form that is readily comprehended and understood, despite its subtlety. The two-channel auditory feedback controller provides stereo sound, for an immersive and engaging experience.

The vibrotactile stimulation algorithm is similar to the visual and auditory methods, except that it encodes the EEG signal into a vibratory stimulation, rather than a light or sound signal. Again, the detailed EEG signal can be felt in the vibration, providing detailed information that can be sensed by the back, hands, arm, or any other suitable part of the body. The Aura Interactor

Cushion technology is available in the form of a cushion, as well as variations such as a vibrotactile backpack, a “dolphin,” a “bear,” and other forms. The vibrotactile feedback is a single-channel, and is produced by combining (summing) both channels of the EEG into a single vibratory signal. By providing a built-in “sum channel” mode, it automatically provides phase-sensitive “synchrony” training when, for example, homologous sites are used. For example, if sensors are placed at P3 and P4, or O1 and O2, then the vibratory signal will be largest when the brain produces synchronous bursts of alpha or theta, wherein the two channels are reinforced in the signal sent to the cushion.

Atlantis is also an ideal platform for virtual reality, sensory immersion, and other systems. Because it integrates event control inputs and relay control outputs along with the EEG and biological monitoring, it can be used for a variety of physiologically controlled systems. It can control a wide range of devices, through the two-channel external relay output controls. The PC interface to the BrainMaster software provides flexible data processing, monitoring, and storage, plus the ability to program custom applications in many Windows-based languages (C++, Visual Basic, Delphi/Pascal, Flash, etc).

It is capable of monitoring EEG, EKG, EMG, and other biological signals, and integrating them into the feedback and control system for a wide range of applications. For example, Mrklas et. al. (1994) describe a stress reduction system that incorporates visual, sound, tactile, and environmental feedback, including a laser delivering complex visual feedback, to represent the target and actual stress level.

The Atlantis V/A/T system offers new approaches to neurofeedback and biofeedback in addition to updated capabilities for conventional neurofeedback. The new autonomous capabilities are intended to be used as adjuncts or precursors to conventional feedback training. Since V/A/T does not include specific targeting, it is more of a conditioning or general method, and less of a targeted training program. Depending on the trainees’ brain state and intentions, the system can produce profound relaxation, activation, or general change. It is suitable for use by practitioners and trainees who are looking for improved brain flexibility, and who can benefit from methods that provide the brain with profound new information. When used in conjunction with other forms of neurofeedback or biofeedback, it offers new approaches to revitalizing brain function and potentiating brain learning and adaptation.

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