The BrainMaster 3.0.8 software includes within the Event Wizard an adjustable Sustained Reward Criterion (SRC) and Refractory Period (RP) for each event. The example screen below shows these values set (to 1000 milliseconds) as an example. These variables default to values of 0 for all events. These capabilities are important for designing protocols that use the concepts of operant conditioning, and that use variables other than amplitudes for training. Note that the standard built-in protocol processor in the BrainMaster software already provides the SRC and RP functions for amplitude training. The improvement now provides the use of an SRC and RP to each of the 16 events that can be created using the Event Wizard.

Note that the Event Summary at the bottom of the Event Wizard Designer explains the entire event in English, in a human-readable form. It tells us, explicitly what the event is "thinking," and summarizes the control settings that have been selected on the control panel.

This event says, simply, "If Alpha Coherence is greater than the Coherence Threshold for 1000 milliseconds, then play a MIDI sound (organ), using a refractory period of 1000 milliseconds." (The event itself also has the value "true" during the refractory period.)

Explanation of definitions and use of SRC and RP

The SRCis a duration of time that the event condition must be held, before the event becomes "true." It can be used to ensure that the event conditions are true continuously for a minimum time, before the event action is taken, and the event flag is set to "true." It is managed continuously in the following manner. The following steps are taken on a continuous basis, at a rate of approximately 30 times per second:

1) If the event condition is true, the amount of time credited toward the SRC is increased.
2) If the SRC duration has been met, the event is set to true, the amount of time toward the SRC is reset to zero, and the Refractory Period begins.

The RP is a duration of time, after an event becomes true, that two things happen:

1) The event flag remains "true" during the RP.
2) No event conditions are tested during this period. Therefore, after the RP time has elapsed, the system again starts to count up, from zero, the time that the event condition is met, in order to meet the SRC.

Note that, during the RP, the trainee cannot accumulate any credits toward the next reward. It is only after the RP has elapsed that the checking of the event condition again resumes. This should become clear in the examples given below. If both the SRC and RP are set to zero, the system behaves normally. The event becomes "true" the instant that the condition is met, and will become "false" the instant that they are not met.

If the SRC is set to a value, and the RP is zero, then the event will become true only after the condition has been met for a period of time equal to the SRC. It will then immediately become false again, until the SRC is again met. If, for example, the event condition is continually met, this will produce brief instants of the event being true, separated by intervals equal to the SRC.

If the SRC is zero, and the RP is set to a value, then the event will become true the instant that the condition is met. It will then remain true for a period of time equal to the RP, after which it will become false. It will immediately then become possible for the event to become true, if the condition is met. If the event condition is continually met, this will produce periods of the event being true, separated by brief instants of it being false.

This document shows examples of various settings, illustrating the use of the SRC and RP in a practical design for coherence training. This design approach can be used for any variables accessible in the Event Wizard, including coherence, similarity, phase, spectral correlation coefficient (SCC), comodulation, z-scores and so on. It should be noted in passing that an alternative or adjunct to use of the SRC and RP is the use of a "damping factor" for any event variable, which has the effect of slowing (smoothing) its response, thus providing an ability to average and accumulate activity over time.

Connectivity training using Sustained Reward Criterion and Refractory Period

The following screen shows typical operation. The top panel shows the raw coherence values and the coherence threshold for alpha. The second panel shows the coherence and coherence threshold on a scrolling trend graph. The third panel shows the flag for Event 1, showing the times of it being true (value 1) and false (value 0). Note that the times of being true are, in this example, always 1000 milliseconds long. Note also that the event does not become true until the coherence has been above threshold for 1000 milliseconds.
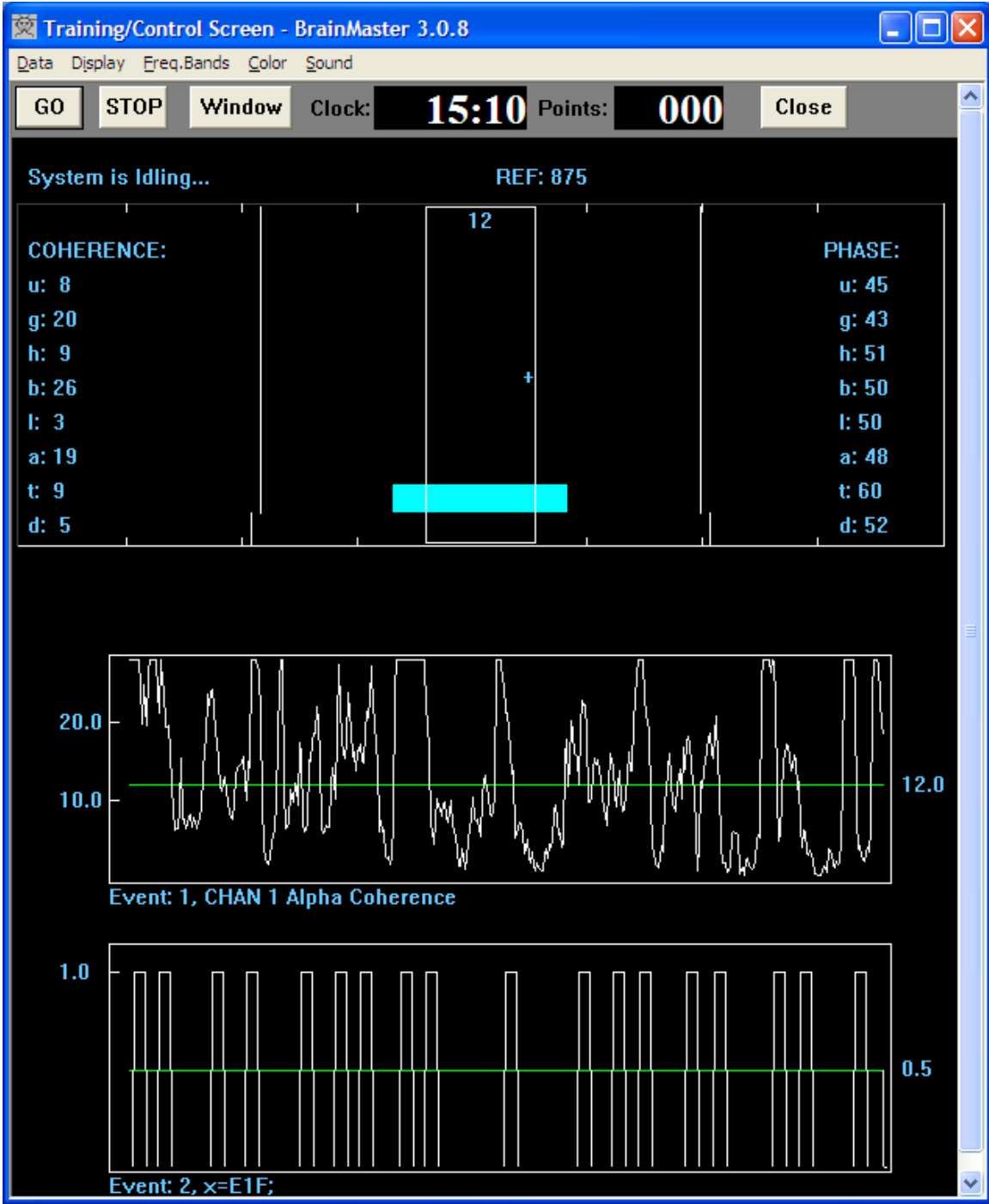
Connectivity training using Sustained Reward Criterion and Refractory Period

The following screen shows the protocol in operation, with the Multimedia Player (MMP) and Flash Player working alongside. Both the MMP and Flash Player advance during the refractory period. Thus, 1-second bursts of game or animation are provided, after the Sustained Reward Criterion is satisfied. It is also possible to configure the MMP player to play one frame of an animation for each reward, which would occur at the beginning of the refractory period, immediately after the SRC is satisfied.
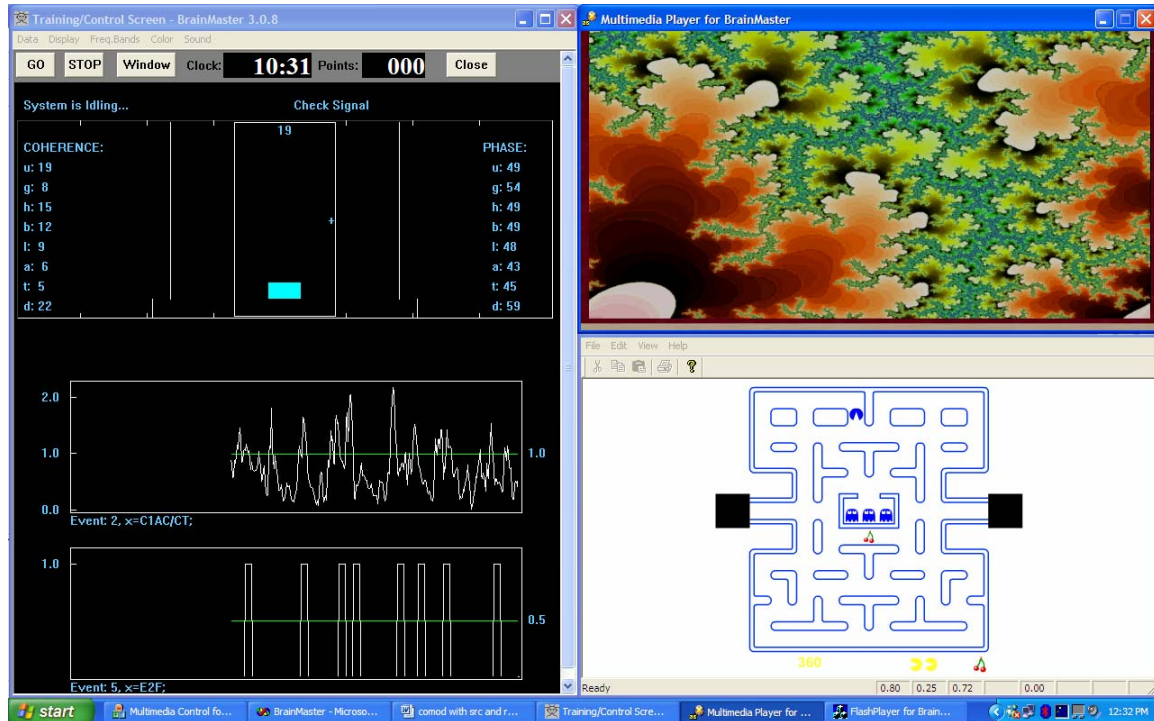

Note that if a sustained voice is chosen, it will be heard during the entire RP. If a percussive voice is used, you will hear one brief tone, then silence during the refractory period. The games and animations all progress during the RP.

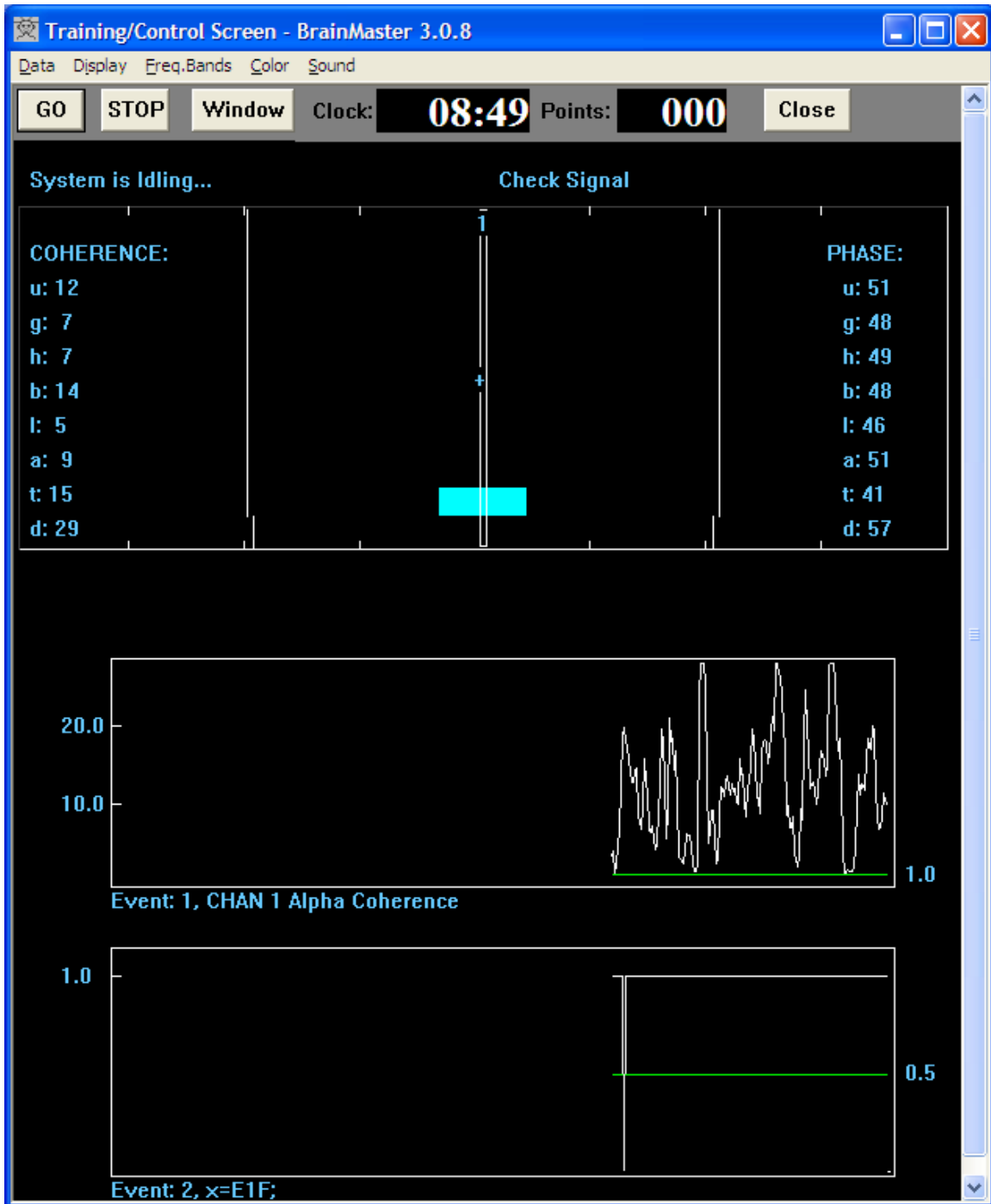Connectivity training using Sustained Reward Criterion and Refractory Period

The following examples are set up with the threshold set very low, so that the event condition is essentially always true. This allows us to examine the behavior of the system with various settings.

SRC = 1000 REF = 1000 ; Once the condition has been met for 1000 milliseconds, you hear a 1000 millisecond tone during refractory period, then 1000 millisecond pause while the SRC is again satisfied
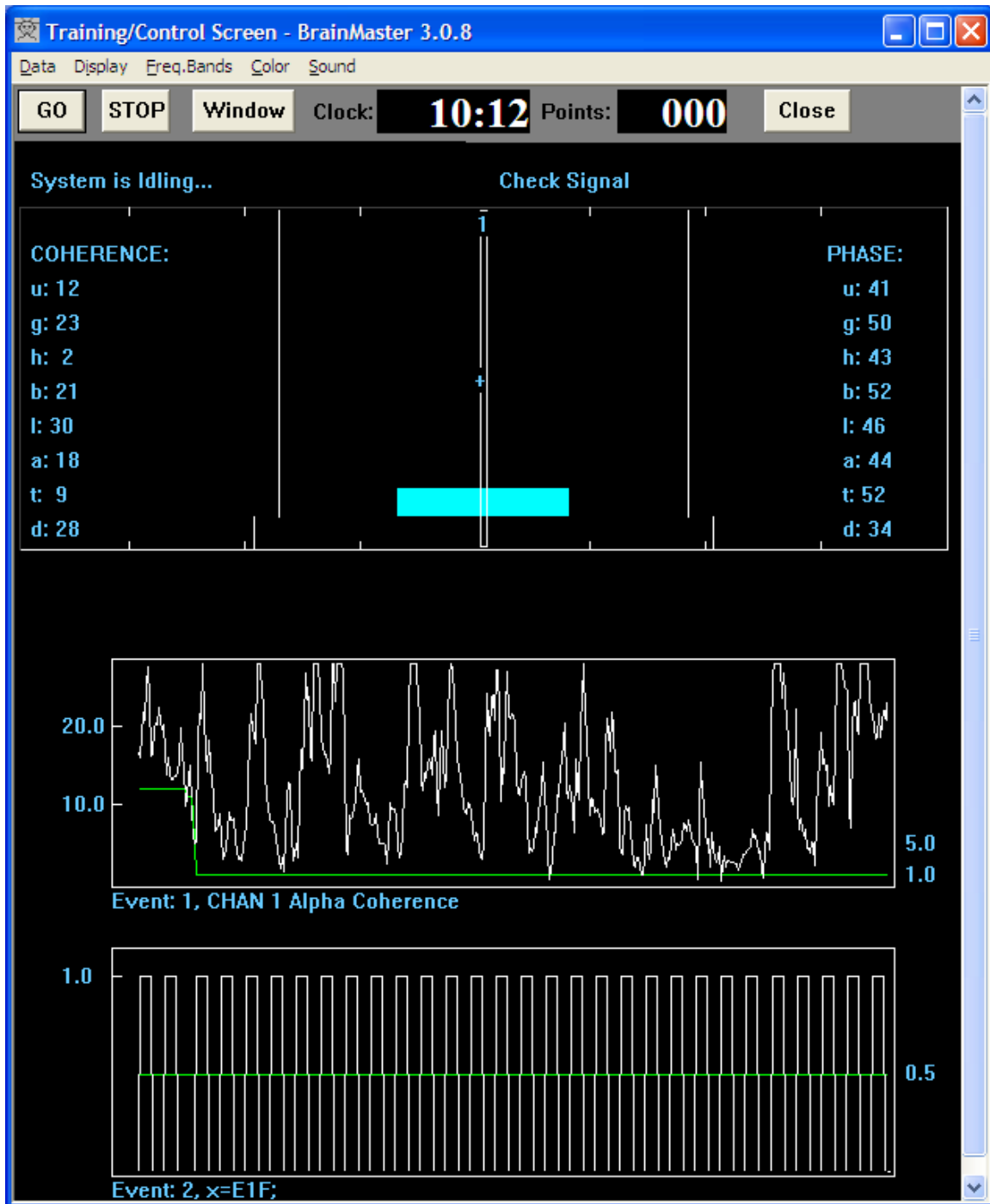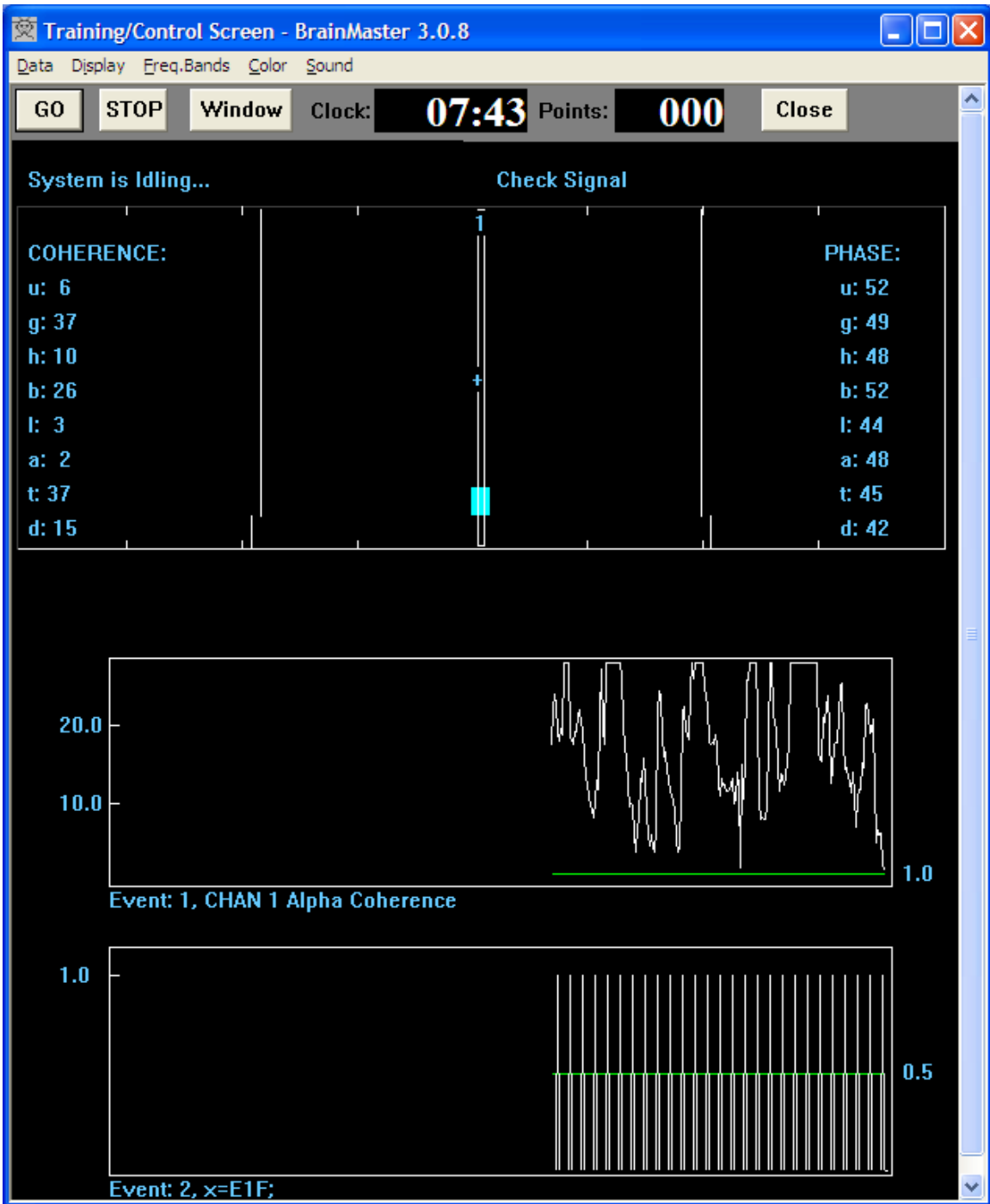
Connectivity training using Sustained Reward Criterion and Refractory Period

The following example shows SRC =0 and REF = 0 ; sounds and rewards are therefore on continuously

Connectivity training using Sustained Reward Criterion and Refractory Period

The following example shows SRC=1000 and REF = 0; The trainee hears one brief tone every 1000 milliseconds. The tone is brief whether a sustained or percussive voice is selected, because the event becomes false immediately after becoming true.

Connectivity training using Sustained Reward Criterion and Refractory Period

The following example shows SRC=0 and REF = 1000.

If a sustained voice is chosen, the trainee hears 1000 millisecond tone, then a brief break, then a repeat of the 1000 millisecond tone. If a percussive voice is chosen, the trainee hears a single tone at the beginning of each refractory period.