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Live Complexity Training - LCT

LCTx2 (Dual Channel) for BioExplorer

Including Theta Alpha Gamma Synchrony

TAG Sync

June 2020 – Rev 3

Operations – Introduction

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Preface

When I started studying neurofeedback in 2008 I was intrigued by the standard “alpha-theta” technique that had been so helpful in promoting self-regulation. This technique normally used a single electrode on the back of the head. It emphasized a state change marked by “theta-crossover”. Theta amplitude crosses over (exceeds) alpha amplitude in the hypnogogic state before sleep. I envisioned a different type of alpha-theta regulation that promoted phase synchrony between Fz and Pz at two different frequencies. I called it alpha-theta synchrony. I believe it was the first explicit use of cross-frequency coupling in neurofeedback. I expected this type of self-regulation practice to be adaptogenic and promote valid perception, cognition and maturation/evolution rather than the hypnogogic drowsy state so useful before sleep.

When clients started learning alpha-theta synchrony it was clear that there was a simultaneous expression of global broad-band synchronization (**GBBS**) especially of theta, alpha and gamma activity. This led to the creation and distribution of Theta-Alpha-Gamma Synchrony – **TAG Sync** – starting in 2010. I predicted that sudden TAG Sync was the EEG signature of insight, in particular the insight that might appear in the space (bardo) between two thoughts (when fictitious narrative rumination relaxed and the “natural mind - Rigpa” appeared). Later TAG Sync was shown to be the signature of the near death experience (Borjigin et al 2013 PNAS).

I felt there was still a large piece missing from the theory behind these methods. I was also troubled by the fact that some individuals would initially respond well to the training but would end up days later with an aggravation (often autoimmune and/or neurocognitive) and a characteristic change in the EEG.

In 2015 I understood that synchrony was needed to harness the growth of complexity that comes with successful, adaptive maturation/evolution. I also observed that when individuals had a worsening after treatments it was because of the subsequent appearance of what I call **EEG sickness behavior**. I used a Kuramoto oscillator model (tagsync.com) to show and explain a continuum between an EEG or HRV signal that displayed complexity and one that displayed what I now recognize is canonical sickness behavior. Live Complexity Training (LCT) was created. It is now a simple but powerful way to categorize physiological signal behavior and use it to train recognition and change of states between wellness behavior (managed complexity) and sickness behavior (generally fast waves riding on slow waves with habitual redundancies, inefficiency and loss of complexity).

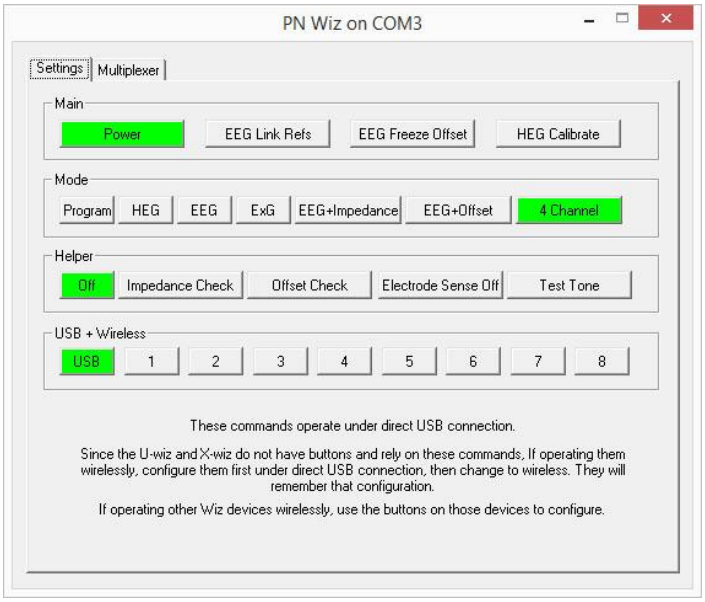
I have pointed out the use of EEG as a **transdiagnostic biomarker** of sickness behavior. Because we are not talking about one state versus another, but rather a trend in movement toward either extreme, we can appreciate the concept of the adaptogen. An **adaptogen** is also applied transdiagnostically and leads to more adaptive/skillful functioning with few or no side-effects. Good sleep is the prototypical adaptogen. Loss of sleep also moves the EEG toward sickness behavior.

It is my hope that Live Complexity Training (LCT) will continue to be investigated and that it will be able to support the evolution of theory and methods in both functional medicine and mindfulness/meditation practices. Our lives exhibit complexity. Shouldn't our EEGs?

Amplifier Setup

Here I comment on the setup for Pocket Neurobics Q-Wiz 4-channel amplifier. Please consult the technical resources for your own amplifier.

If you have a Pocket Neurobics amplifier you will see the following screen when you plug your USB cable into your computer and launch BioExplorer.

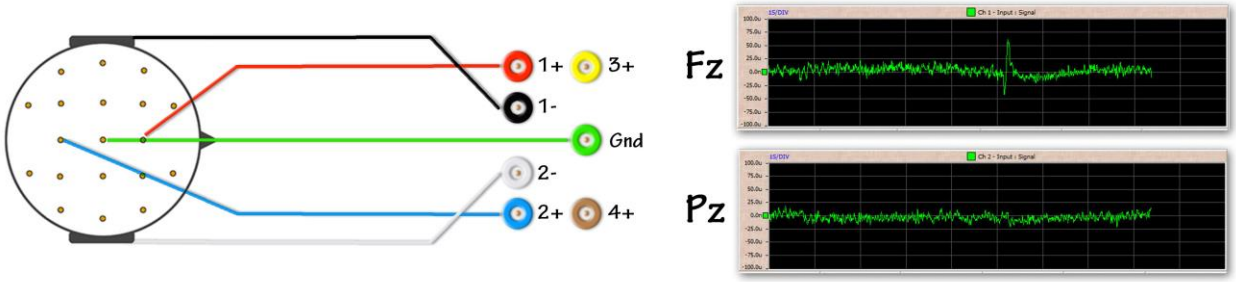


The **MODE** we use is "4 Channel" even though we typically only use 2 channels for LCT or TAG Sync. This is because 4 Channel Mode provides us with a higher **sampling rate** - 256 per second. This enables us to reliably record and represent frequencies up to about 128 cycles per second (Hertz, Hz) [cf. Nyquist principle]. During a recording session you will see the following indicator in the upper right hand corner of your BioExplorer application:

Only the **USB** button should be selected unless you absolutely must use a wireless link. Otherwise you will needlessly increase your radiation exposure.

Electrode Setup

Typically only two amplifier channels and two exploratory electrodes are used for LCT and TAG Sync. They can be placed anywhere on the scalp in order to train 1) *synchrony between* them as well as 2) efficient *complexity underneath* them. The most common sites are the midline anterior and posterior sites known as Fz and Pz in the front and the posterior of the midline of the scalp as shown below. They give the most reliable signal for detecting slight changes in the state of wakefulness and the availability of skillful means.



The 1+ and 2+ electrodes are called “exploratory” electrodes. Each has an electrode partner (1- and 2-) that is called a “reference” electrode. The Ground is shown connected to the vertex. I prefer to attach it below the sternal notch using a disposable adhesive electrode. There are other alternatives. The ear references *are* not linked together. The exploratory electrodes give us a recording of the electrical activity in the regions underneath and around each electrode. We will also be recording the synchrony between the two regions. In general Channel A is placed in front of and/or to the left of Channel B by convention. Your placement, of course, will reflect your intentions.

The instruments on the right in the above figure are called oscilloscopes. They show the “raw” EEG in each channel. Since the frequencies of interest are below 100 Cycles per Second (Hz) we can compare the back and forth pulsing of the electrical charges in the electrodes above with the physical back and forth pulsing that you can see and hear in the diaphragms of stereo speakers playing loud bass. There is a characteristic Cross-Frequency Coupling (CFC) between the low frequencies and the high frequencies that gives the brain a characteristic tone just as it gives musical instruments timbre.

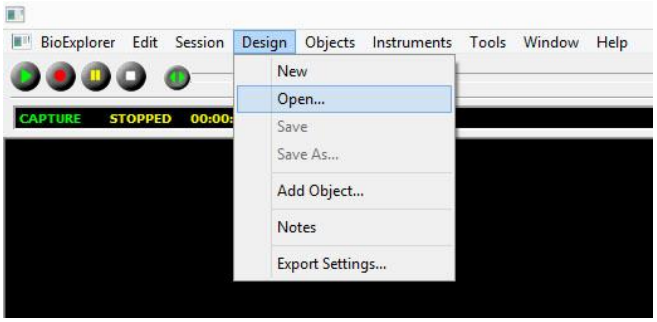
The head illustration above shows approximate locations only. In order to have your recordings be consistent please refer to the International 10-20 System of electrode placement. There are many other locations on the cortex and scalp that may be useful to examine and train, for example areas of trauma or areas with inefficient white matter connectivity. The most common sites for LCT and TAG Sync training are 1) midline anterior and posterior (Fz-Pz), 2) Right or left fronto-parietal networks (F3-P3 and F4-P4), 3) interhemispheric (e.g., F3-F4, C3-C4, P3-P4, etc.).

Introduction to the Screens

The default BioExplorer installation places your screen designs and client session files in a non-intuitive location deep within the Users folder - This PC ▸ Local Disk (C:) ▸ Users ▸

For consistency and ease of use I suggest keeping all your BioExplorer resources together with the program files - This PC ▸ Local Disk (C:) ▸ Program Files (x86) ▸ BioExplorer

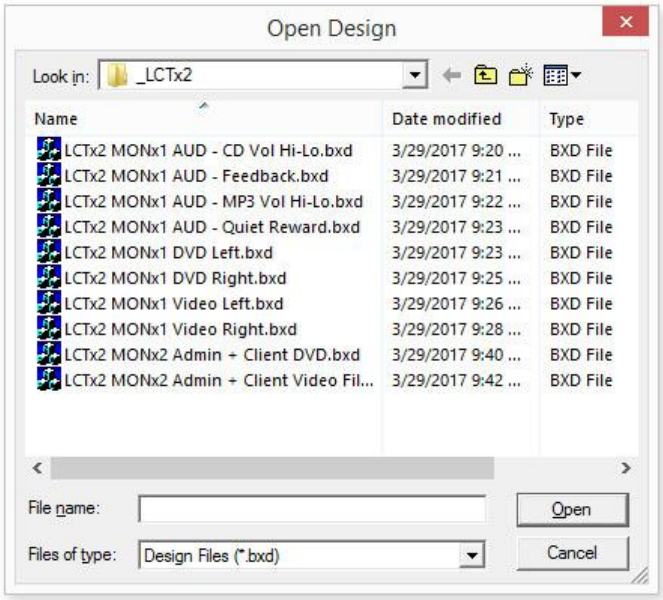
To load one of the Live Complexity Training Designs select “Design” on the BioExplorer’s top menu bar. Then select “Open…” as shown in the following screen shot.



CAUTION: The folder that actually opens may depends on the past state of your BioExplorer installation. Regardless of which folder opens use the “Up One Level” button (see below) to navigate to “Desktop” or “This PC”. These are root level file directories. By finding them you can navigate to the desired folder. In this case navigate to look in the folder, “_LCTx2” (see below).

This folder containing the LCTx2 screen designs is located at:

This PC ▸ Local Disk (C:) ▸ Program Files (x86) ▸ BioExplorer ▸ Designs ▸ _LCTx2



Double click to select and load "**LCTx2 MONx1 AUD – Quiet Reward.bxd**". This is a good place to start since the instruments on this screen are common to all the LCT and TAG Sync screen designs.

I introduced **Quiet Reward** in 2009 and have not found any other systems that have employed it. Other systems tend to shape physiological and behavioral responses by rewarding target EEG changes with an audio-visual cue such as increased volume or size of a DVD, or by a variety of system sounds such as chimes or other MIDI sounds. In Quiet Reward the instruments and thresholds are adjusted so that when the trainee is slightly more awake, adaptive and/or balanced and graceful then the sounds of the software stop. The client is told not to listen to the system sounds anyway but to listen to the silence and increase its duration. The goal is to recognize certain state changes such as in rumination, tension, disconnection, irritability, and so forth.

This mindful discrimination of states is accompanied by following the raw EEG which takes 5 seconds to go from left to right before it is refreshed to the left side again. The breathing is then easily adjusted to six breaths per minute – five seconds in and five seconds out. This is also known as 0.1 Hz, a frequency produced by the cardiovascular system as well as the anterior cingulate in the frontal midline of the brain. Each breath should be fully diaphragmatic if possible. The posture should reflect mindfulness of our one-pointed relationship with gravity and the vertical. The client is instructed to move h-is/er attention to the top of his body near the completion of the inhalation and then scan down the body, arms and legs during exhalation. At each point in the scan we recognize any imbalance or unnecessary tension. The cycle repeats. Tendency to ruminate, drift off, or exhibit fast waves riding on slow waves (sickness behavior) will be preceded by system sounds. When we drop repetitive behaviors, become more awake and exhibit an increase in complexity then we are rewarded with silence. It is helpful to train with the eyes open. With the salience of silence both operator and trainer can recognize a change of state that is both subjective and objective.

This is all based on easily visible changes in both the raw visual signal (EEG in this case) as well as the digitally quantified and analyzed signal (qEEG in this case). This is discussed with supportive references at tagsync.com.

Three Fundamental Signals in Constructal Nature

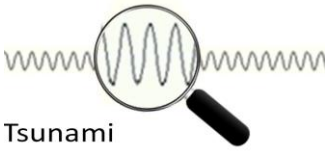
It is useful to consider three basic types of signals that can usually be easily classified by casual visual examination of the raw waveform as well from its digital quantification. I call these three waveforms 1) Sizzle, 2) Tsunami and 3) Sickness Behavior. I explain their origin using a Kuramoto oscillator model at tagysnc.com. Here is how they will look on your instruments

Sizzle appears random but is actually what is called pink noise, or 1/f noise. It is the hum of persistence and evolution in the sense of the Constructal Law of Physics. This is complexity. It is

produced by Self-Organized Criticality (SOC) in and among the Small-World Networks (SWNs) of the macro- and micro-biome.

The body, speech, mind and EEG all move toward complexity as we mature and evolve, as well as when we refresh from sleep, or when we recover from sickness behavior. A characteristic of truly biologically complex signals is that as you zoom you continue to see complexity – not details. This is like the self-similarity of fractals when you zoom in or out. This complexity represents the accumulation of skillful means such as executive control over limbic activity. Optimally Sizzle is characteristic of the EEG over the entire cortex when the eyes are open (EO). Here is the icon for Sizzle:

Tsunami appears as a series of more or less regular looking waves, just like in the icon below. In the eyes closed state (EC) tsunami occurs as the posterior dominant rhythm (PDR). Sizzle remains the dominant anterior rhythm in both EO and EC states. The posterior dominant tsunami occurs when visual processing stops due to eye closure. This lasts up to a few minutes as the visual cortex adapts to other types of processing or until drowsiness and sleep appear. Tsunami can also be seen in the fronto-temporal regions when external auditory processing goes off-line. It can also occur bilaterally in the motor cortex at C3 and C4. This is usually described as the mu rhythm. It may represent a diminished processing of external social and behavioral signals. It is characteristic of both Tsunami and Sickness behavior that when you zoom in you see detail rather than the scale-independent sizzle of complexity.

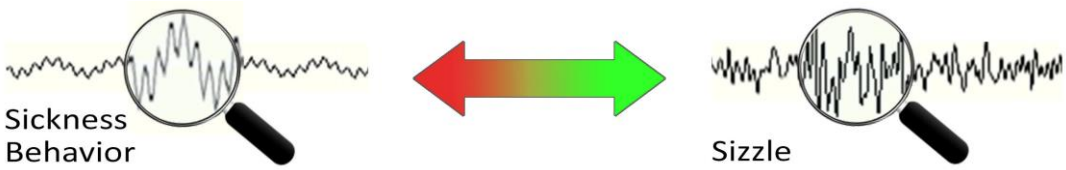


Sickness Behavior appears as fast waves riding on top of slow waves (see image below). I have called such changes away from complexity (sizzle) in the EEG a "**transdiagnostic biomarker** of sickness behavior". This pattern is observed in 1) electroencephalography (EEG), 2) heart rate variability, 3) nitric oxide regulation and 4) "dirty electricity". Sickness behavior in the EEG may occur focally or may be widespread. Unlike the sizzle of complexity, when you zoom in on Sickness Behavior you simply see a larger version of the same pattern of fast waves riding on slow waves. In general the slow waves occur in a band of EEG frequencies I call the Lower Alpha Skirt (*LAS) below 10 Hz*, and the fast waves occur in the upper alpha skirt *(UAS) above 10 Hz*, and often in the beta frequencies in the form of spindling. The relationship between the two frequency regions is called Cross-Frequency Coupling (CFC). A variety of common CFC patterns are described at tagsync.com.

By Sickness Behavior (SBeh) I also mean the canonical form, specifically the behavioral and physiological changes that accompany a toxic microbiome or chronic encephalopathy.

The Transdiagnostic Biomarker of Sickness Behavior (TDBM-SB)

Absolute wellness and absolute sickness do not exit. But wellness behavior and sickness behavior do. This means that regardless of certainty regarding diagnoses and comorbidities it is usually possible to easily identify when a trainee moves along the continuum of Sizzle and Sickness Behavior as shown below.



Any intervention that replaces sickness behavior with sizzle (complexity) is called adaptogenic. This physiological change is also observed when individuals shed repetitive, redundant and habitual behaviors. The appearance of redundant patterns in the EEG such as polymorphic slow waves, beta spindles, conserved morphologies, frontal alpha, etc., indicate a loss of complexity and skillful means..

Introduction to the Instruments

Here we will look at the different instruments which make up the dual-channel Live Complexity Training (LCT) screens and show how they work together.

Please take a moment to look at **Figure 1** and note the instrument names. This is one of 10 LCTx2 training screens. This one gives feedback by increasing the size and volume of the DVD when the trainee is above threshold for synchrony (instruments 5 & 6) and below threshold for redundancy (instruments 7 & 8). Other screens in the suite give only audio feedback, or show the DVD or other video file on a second monitor, etc. All 10 screens have the same instruments in fundamentally the same arrangement. They only differ in the type of feedback given.

Figure 1 – Dual Channel Live Complexity Training with DVD feedback

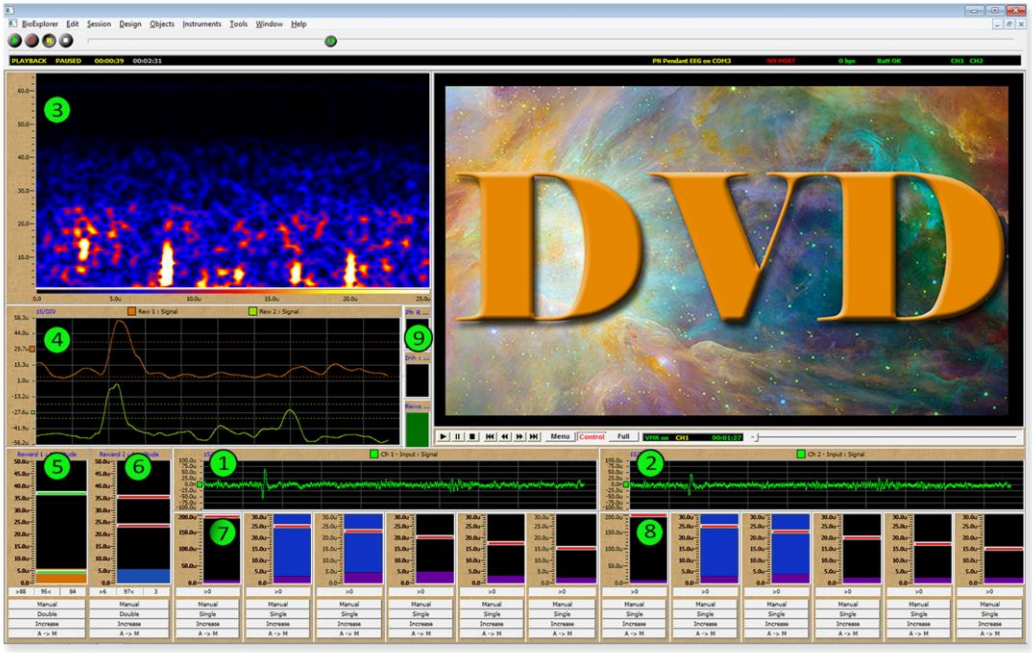
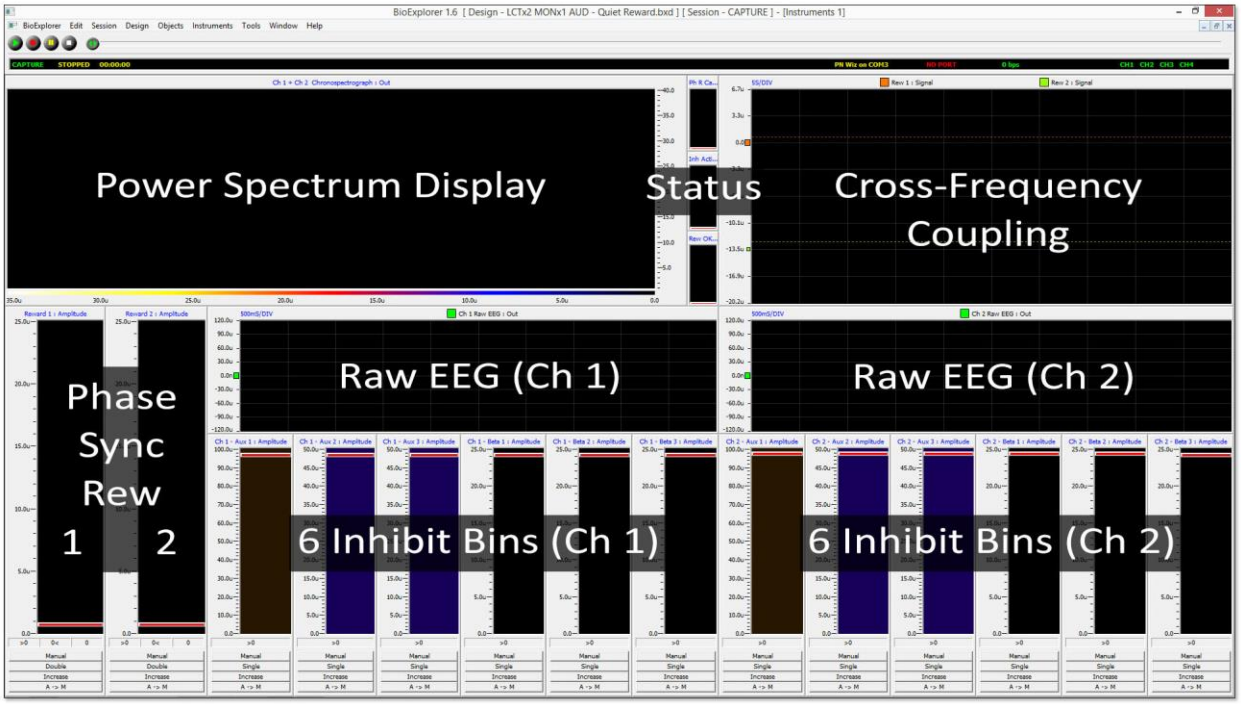
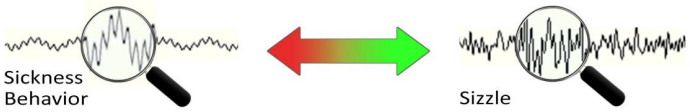


Figure 2 (below) shows the screen design file **LCTx2 MONx1 AUD - Quiet Reward.** These same screen instruments are in each of the 10 LCTx2 designs. The difference is in the type of file they play (audio or video) for feedback and whether there is a second monitor.

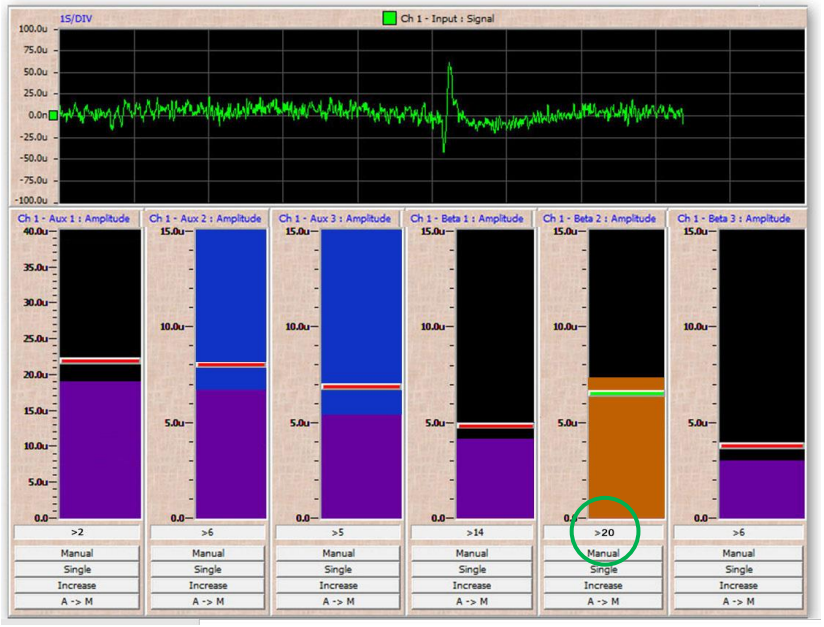


Raw EEG / Oscilloscopes: In the middle of the image above you can see the raw EEG for channel 1 (on the left) and channel 2 (on the right). These instruments are called oscilloscopes and are labeled 1 & 2 in figure 1. It is very useful to study and familiarize yourself with atlases of EEG patterns. But for our purposes we are looking for movement along the continuum from sickness behavior to sizzle.



Changes that are difficult to see in the raw EEG are often more easily detected by the "multiple inhibit bins" underneath each oscilloscope.

Multiple Inhibit Bins: **Figure 3** below shows the raw channel 1 input signal and underneath it are 6 vertical bar graphs with threshold indicators. These are called inhibit bins and are used to train down excess power and rogue excursions of any frequency, commonly in the lower (5-10 Hz) and upper (10-15 Hz) alpha skirts and in the beta range. When such excursions develop during a neurofeedback session they should be addressed immediately because they may represent maladaptive cross-frequency coupling of fast and slow waves. Left unattended they can lead to increased sickness behavior. This is why "bad reactions" to neurofeedback can result.



Notice in Figure 3 as we move from left to right that the threshold bars in each bin get lower in amplitude as the frequency gets higher. This is the usual expectation and is called the "1/f power law" (pronounced "1 over f"). Repeated violation of this expectation in one or more inhibit bins may indicate sickness behavior such as inefficient, maladaptive or redundant network processing.

Note above that the 5th inhibit bin has changed color as the amplitude of the 20-25 Hz EEG increases above threshold. This will 1) cause the yellow status signal to display (see below), 2) will create an alerting sound in the Quiet Reward and other AUD screen designs, and 3) will shrink the video or DVD if one of them is playing.

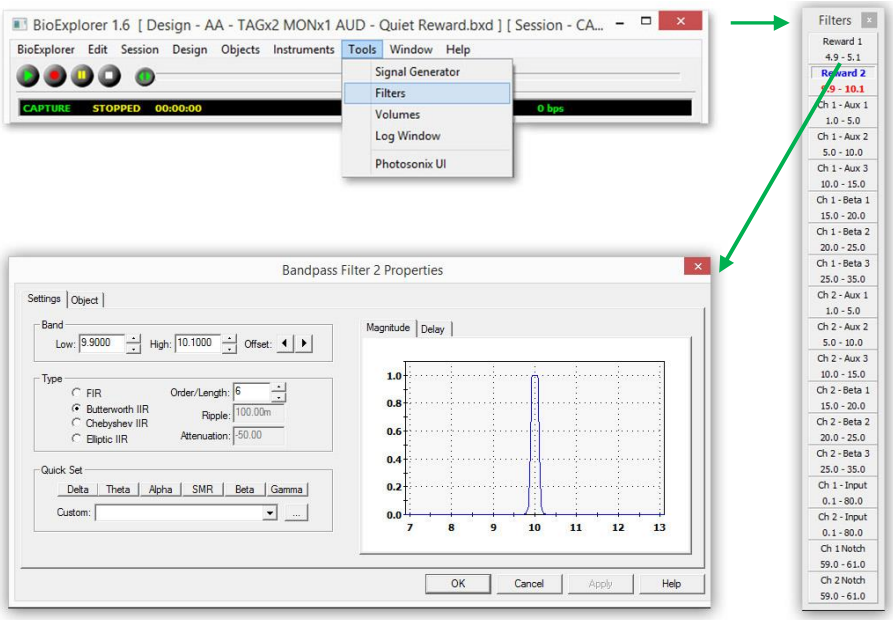
This is a violation of the 1/f power law. We see that it has been above that threshold for 20% of the time, also higher than its neighbors. Excess energy production in a narrow beta band is often associated with poor performance. The inhibit bins are used to reduce excess energy output across the entire spectrum, especially when it involves persistent cross-frequency coupling of lower and upper alpha skirts, or when it involves spindling beta.

When you total all the "% above" values in figure 3 you get about 50%. This means that about 50% of the time the feedback will either pause or set off an auditory alert. 50% is too often for most people. Adjust the thresholds upwards so that they occur just often enough that the trainee can tell when his state has changed and the duration of silence has increased (quiet reward) or the video or music feedback has become more constant. Usually the ideal total for all the inhibit bins in both channels added together should be about 5-15%.

In the Quiet Reward screen the trainee will also produce audio alerts when synchrony between the two electrodes falls at either of the reward frequencies.

Filters Tool: To see and adjust the exact frequency ranges for each of the inhibit bins you must open the "**Filters**" tool. This is under the "Tools" entry in the BioExplorer menu bar. In **Figure 4** below we open the filters tool and adjust Reward 2 to 9.9-10.1 Hz. In a moment we will discuss how the 2 reward instruments work. But first we will discuss some of the general settings for the filters tool.

Figure 4 – Open the "Filters" tool and adjust Reward 2.



At the bottom of the filters column are Ch1 and Ch2 **Notch filters**. They reduce the effect of 60 Hz (50 Hz in Europe) power contamination of your signal. For 60 Hz power sources they should be set round 59-61 Hz.

Above the notch filters are the Ch1 and Ch2 **Input frequencies**. Be cautious not to exceed the frequency response of your amplifier.

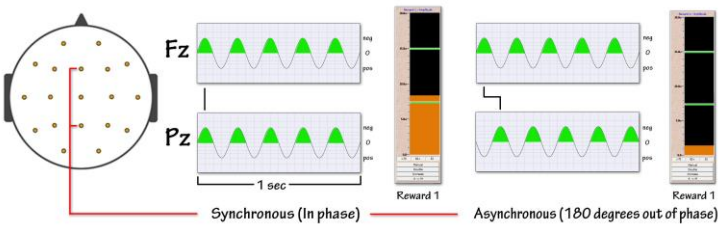
Above the input frequency row you will see the Ch1 and Ch2 **inhibit bins**. These can usually be left the way they are. Note that the lower and upper alpha skirts are labeled Aux 2 and Aux 3 for consistency with earlier versions. 15 Hz and above are divided into 3 beta bins. If you have a prominent or persistent beta spindling activity at the midpoint between two of the beta bins, you may need to adjust one of the make certain it catches and responds to the spindling episodes.

The inhibit bins are used to reduce excess energy output across the entire spectrum, especially when it involves persistent cross-frequency coupling of lower and upper alpha skirts, or when it involves spindling beta.

The **reward instruments** regulate the *synchrony activity* *between* the two electrodes. The inhibit bins regulate the *amplitude activity* *underneath* each electrode. Increased synchrony between areas stimulates neuroplasticity and development of long white matter tracts. The trainee may need to support neuroprotection and neuroplasticity through dietary, environmental, and lifestyle modification.

Regions of the brain can vary widely and rapidly in their relative charges. We can measure such voltage fluctuations even at a distance from the cortex on the scalp. The voltage measurements can average as low as 5 microvolts or as high as 50 or more. Some voltages change rapidly from positive to negative. These changes happen at common frequencies described as delta, theta, alpha, beta, gamma, etc. Sometimes the concentration of electrons and negative charge is slowly altered using transcranial direct current stimulation (TDCS) or by walking barefoot in the grass. When a region of the brain has an increase in the local number of electrons then that region is said to be excitable. *For the anterior and posterior parts of the brain to communicate they must both be excitable at the same time - they must develop temporary* ***phase synchrony***.

Figure 5 below shows the effects on Reward 1 when anterior and posterior theta (4.9-5.1 Hz) go in and out of phase. The instantaneous voltages in each channel are added together. When the activity is synchronous at a particular frequency (Rew 1 or Rew 2) then it combine additively and the Reward amplitude is increased. When the activity is 180 degrees out of phase they combine subtractively and cancel each other. This causes the Reward amplitude to decrease.



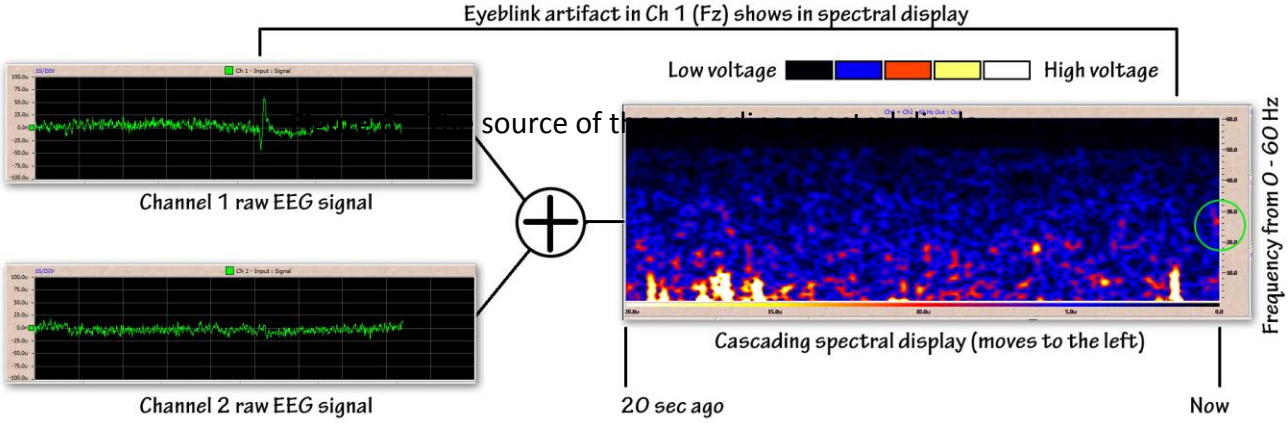
When the 2 parts of the brain are synchronous for part of a cycle, then they can communicate using higher frequencies during that brief phase synchronization. The higher frequencies are said to "**nest**" within the lower frequencies.

The goal of this type of training is to increase the client's production (i.e., time above threshold) of reward 1 and reward 2 in such a way that the areas underneath the two electrodes become more *synchronous with each other in two different frequency bands at the same time*. These two frequencies, Rew 1 and Rew 2, are then said to be cross-frequency coupled (CFC). Rew 1 and Rew 2 do not refer to the two channels. They refer to the two CFC synchronization frequencies, such as alpha-theta, theta-gamma, and so forth, that communicate between the two areas (channels).

The reason for the very narrow reward bands such as 9.9-10.1 Hz instead of the more commonly used 8-12 Hz is that if you want two regions of the brain to synchronize briefly (like handshaking) it will not be possible if one part of the brain is operating around 8 Hz and the other around 12 Hz. By using 9.9-10.1 Hz we provide a much more reliable indicator of when synchrony does occur. The same applies to using 4.9-5.1 Hz for theta synchrony rather than 4-8 Hz. In the early days of theta-alpha-gamma synchronization (TAG Sync) such a narrow frequency band was called a "hailing frequency or channel".

The goal is *not* to increase the amplitude at that narrow frequency activity under either electrode. In fact that activity at 9.9 Hz and at 10.1 Hz will be inhibited by the inhibit bins. Rather the goal is to allow brief but reliable communication between Ch1 and Ch2 such that higher frequencies can nest into the negative voltage troughs. This is called momentary "Global Broad-Band Synchronization – GBBS". As I discuss at tagsync.com, the feature set required for adaptive evolutionary function is "**Global Broad-Band Synchronization (GBBS) over Small World Networks (SWNs) operating near Self-Organized Criticality (SOC) and fulfilling the Constructal Law of Physics (CLaw).** A useful mnemonic is *GiBBs SWaN plus SOCk & CLaw*. The reference to the physicist Gibbs and the Swan of Hindu mythology is intentional. [Note: This is not the swan of Greek mythology.]

Figure 6 (below) shows how the raw EEG for the 2 channels is added together and then appears in the **cascading spectral display** (**CSD**) – instrument 3 in figure 1. The CSD (also called a chronospectrograph) scrolls right to left during the recording.

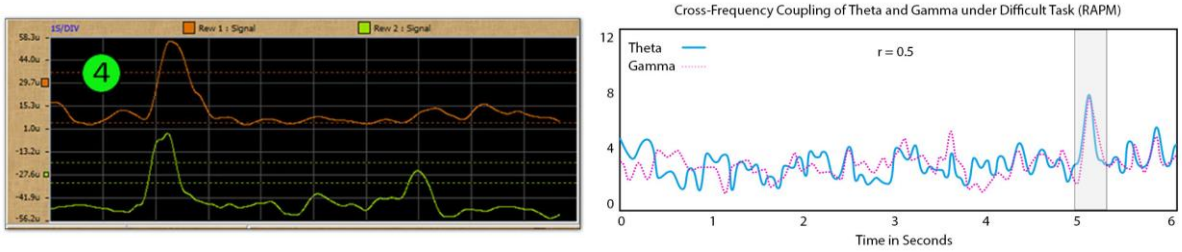


Note the eye blink in Channel 1 that occurred about 2 seconds before the recording was paused. The spectral display shows the approximate voltage that was produced at every frequency from 1-60 Hz for the last 20 seconds. Normally we do not need to see spectral activity all the way to 60 Hz unless, for example, we want to see if we are picking up 50 or 60 Hz artifacts from the municipal power mains. I usually only observe up to 40 Hz since this is where most of the clinically relevant changes take place during a session.

Figure 7 below left shows the "**Amplitude Envelopes/Curves - Cross-Frequency Coupling Instrument**" that I introduced in 2009. It is instrument #4 in Figure 1. Changes in alpha and theta synchrony over time, as well as large phase resets, can be seen using this instrument. Unlike "theta-alpha crossover", a marker of drowsiness in standard alpha-theta training, theta-alpha-gamma synchrony training and LCT aim to produce self-regulation of cross-frequency coupling, i.e., the amplitude envelopes move together as seen in the top left instrument in Figure 7. Note the similar instrument on the right in the same figure.

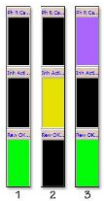
Here is an example of its use. If Rew 1 were set to a narrow theta band and Rew 2 were set to a narrow gamma band then the Curves Instrument would show the amount of theta synchrony (top) and the amount of gamma synchrony (bottom) over time. Notice how the amplitudes are synchronously augmented around the first third of the recording. You can catch and announce these "Phase Reset Candidates" using the second thresholds of the Rew 1 & 2 instruments. In 2009 I my model suggested that this condition was a prerequisite for valid perception and cognition. I also hypothesized that feedback of such state changes to the individual would have an adaptogenic function. When Rew 1 and Rew 2 amplitudes simultaneously exceed the *second* threshold then a "phase reset candidate" chime is sounded and the top status bar light is illuminated (see below). Notice a similar instrument on the right.

Figure 7 – Left - Original TAG Sync curves instrument (2009); Right – Pahor et al (2014).



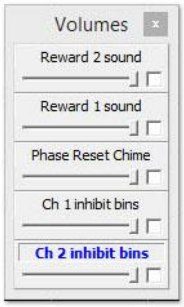
In 2014 Pahor et al independently described an instrument that also allowed moment by moment comparison of theta and gamma synchrony amplitude curves and declared "These findings demonstrate for the first time that **theta–gamma cross-frequency coupling** in frontal areas, and partly also in parietal areas… relates to the **level of intelligence**."

Figure 8 (to the right) shows the vertical group of three status indicators as they go through three conditions. This is instrument #9 in Figure 1. In condition 1 the "Reward OK" light on the bottom shows green. This means that Rew 1 & 2 are both above threshold. This means that there is phase synchrony between electrode 1 and 2 at the frequencies of Rew 1 and 2.



The example of Global Broad Band Synchronization (GBBS) called TAG Sync was, to my knowledge, the first neurofeedback approach to explicitly address cross-frequency coupling. What we had already been doing with TAG Sync involved what I called the "*fronto-parietal* kernel". It involved midline areas as well. Users learned to create the physiological amplitude curves that have been shown to relate to the "level of intelligence". Intelligence is a valuable adaptogen. Live Complexity Training extended the model with the understanding that synchrony is used to harness complexity. Complexity ("sizzle") was seen in relationship to sickness behavior in the EEG as described above.

Using Sounds – The Volumes Tool



Under the main BioExplorer menu you can find Tools > Volumes. I suggest starting each recording with all the volumes disabled as shown here. Otherwise it is easy to suddenly startle the trainee with unfamiliar sounds.

When ready to start the training I activate **Reward 2 sound**. It is usually set to reward inter-electrode synchrony at 9.9-10.1 Hz alpha. The client is instructed regarding mindfulness of posture and breathing. The Rew 2 threshold is adjusted so that about 90% of the time the trainee is above threshold and the instrument is silent. When the inter-electrode synchrony falls below threshold (e.g., due to sickness behavior, rumination, sleepiness, etc.) the sound appears (usually pink noise). Through careful adjustment of the thresholds the client is guided toward increasing the duration of inter-electrode synchrony at the reward 2 frequency. This state is *heralded by silence*. The client is instructed to attend to the silence, not the noise. In many situations the client starts learning to recognize the state of increased Rew 2 synchrony. Important: the increased synchrony state is not the goal. The awareness and regulation of state changes is the goal. Synchrony is used here in order to harness complexity.

You may train Rew 2 frequency synchrony for an extended time if the client appears to be responding to the feedback. Always watch for the sudden appearance of energy in any of the inhibit bins. This indicates a compensation to the feedback by a regression into sickness behavior with its limited and redundant responses. Evidence that learning is taking place appears when the reward thresholds need to be raised or the inhibit bin thresholds need to be lowered.

Reward 1 sound can be activated at any time. If a new client does not respond to reward 2 training after a few minutes I activate reward 1 sound (theta synchrony by default). This sound is ideally a low pitched hum, almost a rumble. This may be difficult to hear on many laptops unless external speakers are plugged in. A subwoofer in addition to the regular left and right stereo channels provides a richer sonic environment with better low frequency response.

Phase reset chime alerts user and/or trainee that long-distance synchrony at both Rew 1 and 2 frequencies have simultaneously exceeded their thresholds. This involves the use of a secondary threshold on the reward instruments. This technique is discussed elsewhere and is not necessary for the early stages of training.

Channel 1 inhibit bins: There are 6 inhibit bins each with its own frequency range. When the amplitude of one or more of the Channel 1 inhibit bins exceeds the threshold an alerting sound will be produced. It is generally better to start with only a few but significant inhibit bins are producing sound. The thresholds should be adjusted so that the noise only appears when one or more thresholds are significantly exceeded.

Channel 2 inhibit bins: These produce a slightly different pitch than the channel 1 inhibit bins. This provides an auditory clue regarding which electrode is measuring the increased activity.

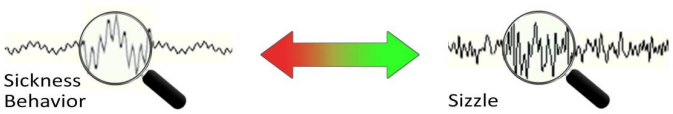
How much audio feedback to use: Underneath the individual bins is a number display that shows the percentage of time above reward threshold and below inhibit threshold. All of these should add up so that there is sound only about 10% of the time. This keeps the client from becoming disoriented. I adjust the thresholds so that occasionally the trainee notices that the sound as paused temporarily. Then I ask them if they notice the difference in internal state when the silence is more persistent. I ask if the state would be useful for anything in their day-to-day life such as concentration, relaxation, rejuvenation, inspiration, etc.

The volume sliders should be set to the trainee's preferences. Sometimes I set all the volumes so low that it can almost be ignored. Some people like to have the inhibit bins at higher volume so that it shakes them out of a state of rumination, reverie, or sleepiness. Everyone is a bit difference. The key is to make certain that the feedback is salient and can be used practically.

If the different sounds are silent for too long then the client is not receiving feedback and the EEG and internal states are not being shaped. If the sounds are present for too long then the client is not receiving salient feedback and internal states are not being shaped.

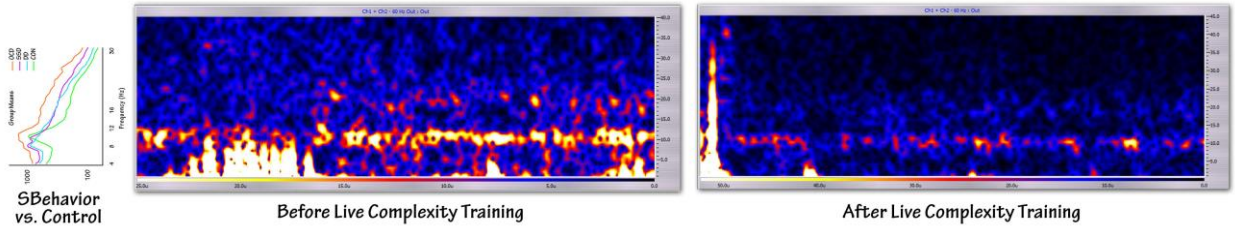
Record Keeping:

Live Complexity Training (LCT) promotes identification of changes of state. There are unreliable states (dukkha) that hinder deployment of adaptive skills. I have proposed the use of electroencephalogram and other measures as transdiagnostic biomarkers of the change of state toward unreliable sickness behavior. With LCT the trainee is given a digital finger pointing to the movement of the EEG and HRV along the continuum I have described as complexity ("sizzle") and sickness behavior. The goal is for the trainee to recognize such shifts and recover adroitly.



As an important record I take a screen shot when the EEG shows a state change and the client can also recognize a change of state. By pasting the screen shots into the trainee's record/notes you can compare state changes over time.

Figure 9 below shows a screen recording of the cascading spectral display before and after several sessions of Live Complexity Training (LCT). Before training the display showed the expected aspects of sickness behavior: 1) unreliable 10 Hz alpha activity, 2) increased energy expenditure in the lower and upper alpha skirts and beta (fast waves ridding on slow waves) and 3) increased cross-frequency coupling between lower and upper alpha skirts.



This is the behavior I predicted with a Kuramoto oscillator model (tagsync.com). After LCT training the total energy expenditure by the fast and slow waves has been clearly reduced from greater than 25 microvolts to less than 5 microvolts. Also notice that the 10 Hz privileged alpha regulatory signal has been considerably restored. Also note after LCT there is not the obvious persistent cross-frequency coupling between sub-alpha and supra-alpha activity.

When you take a screen shot during a change of state of the client and/or the EEG you have a way to duplicate the reward and inhibit settings as well as chart the availability of complexity. Such complex electrical activity over the small world networks of the body and brain enables us regulate, among other things, limbic over-reactivity.

It is my observation that lifestyle engineering and functional medicine are perhaps the most efficient ways to restore and promote adaptive maturation. In any case there is the high probability of sickness behavior under the control of the poorly regulated mind. With LCT there is the possibility to observe and regulate habitual maladaptive states. You may use provocation as you see fit in order to train resilience and recovery of the flow state that characterizes constructal complexity.

A Comment on Abhidharma

The root *–buddh* means awakened. The historical Buddha stated that of all the factors leading to awakening none except perhaps mindfulness itself was as important as recognizing state changes between states of less reliability (dukkha) and states that generate and employ skillful means.

How do we know what helps us and what hinders us? In order to generalize this to most people we require a transdiagnostic biomarker that can tell us whether we are increasing or decreasing sickness behavior with its habitual and unreliable responses.

I find it useful to equate the regression into sickness behavior and apoptosis of the self with the Buddhist concept of “dukkha”. It is regrettably translated as “suffering” when the Pali word originally mean a “bad hub in a wheel”. It could be that the hub is loose or eccentric with respect to the spokes that transmit pressure. The net result is that the hub is unreliable and dangerous. In LCT when the hubs of the small world networks are loose or eccentric the result is loss of reliability, loss of network capacity to carry complexity, and so forth.

Please let me know about any ambiguities or problems with this document.

Best wishes,

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