Neurophysiologic bases of tinnitus treatment with sound stimulation during sleep

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Almost three decades of research on central auditory processing during sleep support our treatment of tinnitus. Hearing is an important telereceptive modality active during sleep, which was fundamental in the phylogenetic evolution, acting as a continuous monitor of the environment. The auditory system has a conspicuous efferent pathway in parallel with the ascending system, functioning as an input controller. The high sensitivity of the hair cells was not designed to tolerate the unnatural intensities provoked by the human technologies. A minimal lesion of this delicate and sophisticated system may create a misbalance on the input information which could be misunderstood by the brain, creating the tinnitus as a phantom sensation(1).

We demonstrated in guinea pig model that:

-Cochlear potentials exhibited amplitude increment during slow wave sleep (SWS), compared with wakefulness (W) and paradoxical sleep (REM, rapid eyes movement).

-Fifty percent of the auditory cortical units recorded during SWS and REM maintained a firing similar to the ones recorded during W, postulated to continue monitoring the environment; while 50% increased or decreased their firing when the animal was asleep.

-Neuronal discharge rate shifts were found in the brainstem nuclei in different percentage than in the auditory cortex.

-The auditory neurons that increase/decrease firing in sleep are postulated to be engaged in some sleep processes, participating in sleep-active cell assemblies/networks.

-No auditory neuron exhibited a firing stop on passing to sleep.

-Hippocampal theta rhythm has temporal relationship with auditory units (phase-locking) all along the auditory pathway, appearing as a time-giver to organize auditory storage, also during attention changes and sleep.

-In human studies, we demonstrated that sleep architecture changes when profound post-lingual deaf patients with an intra-cochlear implant maintained the implant “on” during the night.

Other authors had demonstrated that:

-The auditory evoked potentials (middle and late components), show a steady increase in peak to peak amplitude during SWS.

-The transiently evoked oto-acoustic emission is modified during sleep, evidencing the efferent action over the receptor itself.

-Semantic information processing is possible in stage II and REM.

-Mismatch negativity was reported in SWS and REM. Moreover, this negativity has recently been reported also in newborns “quiet sleep” and it was linked to learning.

-A magnetoencephalographic approach described amplitude changes and anatomical place shifts of the sound evoked dipole in the human *planum temporale* during sleep.

-Data exhibited by functional magnetic resonance imaging strongly support the notion that the sleeping brain is able to process information.

CONCLUSIONS. Sleep and sound are closely related. As well as regular environmental auditory stimuli (e.g. mother lullaby) facilitate sleep, sound stimulation during sleep improves sleep disorders caused by tinnitus and decreases tinnitus perception.

Since the auditory processing happens during both wakefulness and sleep, the reorganization of neural networks –taking advantage of neural plasticity- could be induced by sound stimulation during sleep.

(1)Velluti R.A. The Auditory System in Sleep. 2008. Academic Press-Elsevier(Amsterdam)