Ultrasound stimulation of the auditory cochlea system in hearing and deafened guinea pigs

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Transcranial focused ultrasound (US) has recently emerged as an alternative neurostimulation technique. However, the underlying mechanisms are not well understood. Understanding the US-induced responses of the auditory system is timely since a recent article (Guo et al., 2018) showed that US can produce extensive brain activation via a cochlear pathway. In the present study, we apply focused US towards the cochlea of guinea pigs to understand which elements of the peripheral auditory system are needed to elicit US responses.

Experiments were conducted in normal-hearing (n=10) and deafened (n=4) guinea pigs that were implanted chronically with a recording electrode in their right inferior colliculus (Fig. 1). For the deafened animal group, the deafening protocol of Thompson et al. (2015) combining furosemide and kanamycin was used to destroy the hair cells. The left cochlea was then exposed and the US transducer was placed so that the US fields were directed towards the basal turn of the cochlea. The transducer was excited by sine-wave bursts at frequencies of 3, 7, 14 and 21 MHz. Different sets of US parameters were studied: peak acoustic pressure P ranged from 0.03 to 1 MPa, pulse duration ranged from 1 to 100 μs, using a burst period of 50 ms.

For the hearing group, we found that US elicited inferior colliculus evoked potentials in all animals for peak acoustic pressures as low as 90 kPa and burst durations as short as 3 μs. Moreover, the US-evoked response was very similar to that induced by audible acoustic stimulation (see Fig. 1). For the deafened group, no US-evoked response could be obtained. This study demonstrates that the US-evoked response obtained in our hearing group necessarily involved the hair cells, and that the peripheral auditory system is easily excited by focused US. The use of an animal model of sensorineural deafness is, therefore, required to eliminate confounding effect that can lead to indirect neural activation.

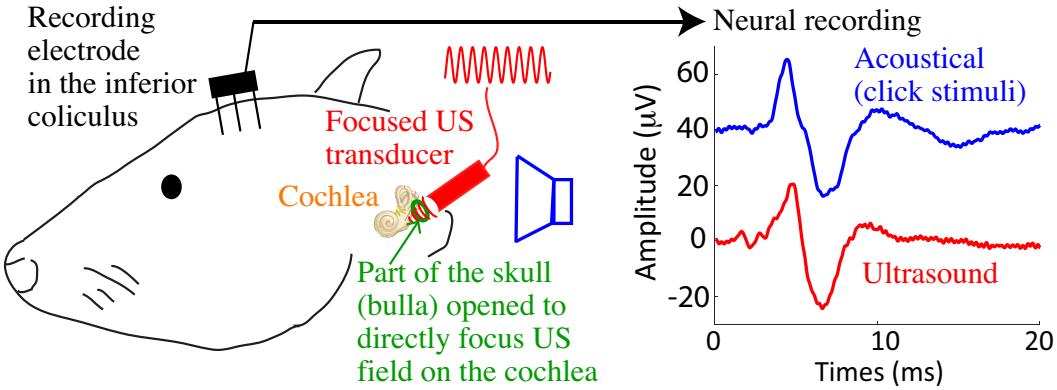

Figure 1. Schematic description of the guinea pig experiments and example of inferior colliculus evoked potentials obtained in response to 50-μs, 7-MHz tone bursts and to an acoustic click.