Human motor neurones: so well-known or still unknown?

Movements, the fundamental base of normal human life, are produced when our skeletal muscles contract and relax, submitting to control by special nervous cells, the so-called motor neurones (motoneurones) placed in the spinal cord. It is surprising but motoneurones controlling such an important function constitute only lesser than 1% of all the neurones of the human central nervous system. At the same time, scientists always used motoneurones as the paradigmatic model system for exploring many general questions in neuroscience. As a result, motoneurones are the most studied neurones in animals and humans. It appeared, for example, they receive thousands of input signals from other neurones and this information is translated by each motoneurone into a single output signal – discharge trains (firing) controlling our muscles and thus eliciting movements. It is now firmly established that the most important characteristics of motoneuronal activity are firing rate and firing pattern. The same motoneurone may be engaged in different motor behaviour, for example, very gentle muscle contraction during postural maintenance or, on the contrary, strong and fast movements. That’s way motoneurones are possessed of a rich repertoire of firing frequencies and firing patterns – fairly regular firing at low mean rate (with inter-discharge intervals of about 50-200 milliseconds), or at the high rate (with intervals of 20-40 milliseconds). It may seem unreal, but these surprising times (in milliseconds) are very usual for motoneurones.

In addition to this motoneurone behaviour, quite especial firing including the so-called doublets or even triplets (two or three discharges with uniquely short inter-discharge intervals, up to some milliseconds) was discovered in animal experiments. In humans, doublet firing was investigated in detail for normal and some movement diseases. Motoneurone triplet firing, its properties, underlying mechanisms and its origin, quite the reverse, remain mysterious.

In our study, origin of triplet firing in healthy humans was explored. In humans, naturally, the direct intracellular registration of motoneurone firing is impossible. However, there is the method giving the happy possibility to record motoneurone firing (without any distortions!) from the so-called “motor units” (MUs) by the special electrode introduced in the corresponding muscle. This approach has been widely and successfully used to study intrinsic properties of human motoneurones.

The main result of our investigation is evidence that origin of triplet firing was no uniform. It appeared that two kinds of this unusual firing could be occasionally observed during gentle voluntary muscle contractions in healthy humans. Detailed analysis of firing rate and firing pattern of both triplet kinds was made. We have concluded that there are “true” triplets originated in motoneurone and triplet firing originated beyond motoneurone, in motor nerve (axon) connecting

given motoneurone and the muscle that it control. In the Figure, examples of MU firing during gentle voluntary contractions of arm and leg muscles can be seen. Usual firing of 3 MUs (A), doublet firing of one MU, marked by points (B) and triplet firing of 4 MUs (C: “true” motoneuronal triplets; D: axonal triplet firing) are presented. Our findings allow critical considering the hypotheses about the origin of triplet firing reported previously in the scientific literature. Motoneurone triplet origin is of interest not only itself but because doublet and triplet firing is significantly enhanced when motoneurones are diseased or damaged.

In conclusion, it should be stressed that research of motoneurones is certainly to continue to be of importance. And new motoneuronal properties that being discovered will allow better to understand mechanisms of movement disorders of different origin and therefore to conquer them.

L.P. Kudina and **R.E. Andreeva**
Institute for Information Transmission Problems , Russian Academy of Sciences
Moscow, Russia

Publication

Triplet firing origin in human motor units: emerging hypotheses.
Kudina LP, Andreeva RE.
Exp Brain Res. 2016 Mar