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An intuitive, bimanual, high-throughput QWERTY keyboard touch typing neuroprosthesis

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Introduction: Keyboard touch typing represents a high information rate communication paradigm that most people are familiar with. In this work we introduce an intracortical brain computer interface (iBCI) typing neuroprosthesis that mimics a bimanually controlled QWERTY keyboard layout with corresponding able-bodied typing imagery. Typing with our keyboard involves minimal attempted finger movements which, as we show, can be decoded accurately and robustly, and may be less effortful for the user compared to other augmentative and alternative communication methods. Decoding is performed at the sentence level, allowing typing speed to be regulated by the user.

Material, Methods and Results: Previous iBCI handwriting [1] decoding has the potential to be limited in accuracy for users with overlapping neural trajectories pertaining to similarly shaped characters. Our typing paradigm provides versatility, by offering an alternative iBCI communication method for users who may have superior finger decoding. Our typing neuroprosthesis performs sequence decoding of key presses using a Recurrent Neural Network (RNN) decoder trained using a Connectionist Temporal Classification (CTC) loss function, similarly to [2, 3, 4]. When paired with a probabilistic 5-gram language model, decoding is much improved via integration of RNN decoder output and English language statistics, where the deliberate QWERTY keyboard layout reduces sentence inference confusion, in an out sized way compared to other communication based sequence decoding paradigms [1, 2, 3, 4]. The results from two iBCI clinical trial participants (T17 and T18) communicating using this decoding paradigm indicates that our neuroprosthesis is user and pathology robust. We report communication speeds reaching 84 characters per minute, approaching the state-of-the-art in hand-motor based iBCI communication rate [1], resulting in 16 words per minute with a character error rate of 1% at this high speed.

Conclusion: In this work we introduce a touch typing neuroprosthesis which we show to be among the fastest iBCI communication methods based on decoding of hand motor cortex neuron populations, while maintaining high precision. Our typing neuroprosthesis represents an intuitive, familiar, and easy-to-learn communication device for individuals with quadriplegia caused by ALS, spinal cord injury, and related conditions.

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