Supplementary motor area functions

Four main hypotheses have been proposed for the function of SMA: the control of postural stability during stance or walking, coordinating temporal sequences of actions, bimanual coordination, and the initiation of internally generated as opposed to stimulus driven movement.

The data, however, tend not to support an exclusive role of SMA in any one of these functions. Indeed, SMA is demonstrably active during non-sequential, unimanual, and stimulus-cued movements.

For human voluntary movement the role of the SMA has been elucidated: Its activity generates the early component of the Bereitschaftspotential (BP) or readiness potential BP1 or BPearly.

The role of the SMA was further substantiated by Cunnington et al. 2003, showing that SMA proper and pre-SMA are active prior to volitional movement or action, as well as the cingulate motor area (CMA) = anterior mid-cingulate cortex (aMCC). Recently is has been shown by integrating simultaneously acquired EEG and fMRI that SMA and aMCC have strong reciprocal connections that act to sustain each other's activity, and that this interaction is mediated during movement preparation according to the Bereitschaftspotential amplitude.

SMA in the monkey brain may emphasize locomotion, especially complex locomotion such as climbing or leaping.

This suggestion was based on studies in which stimulation on a behaviorally relevant time scale evoked complex, full body movements that resembled climbing or leaping. This hypothesis is consistent with previous hypotheses, including the involvement of SMA in postural stabilization, in internally generated movements, in bimanual coordination, and in the planning of movement sequences, because all of these functions are heavily recruited in complex locomotion. The locomotion hypothesis is an example of interpreting the motor cortex in terms of the underlying behavioral repertoire from which abstract control functions emerge, an approach emphasized by Graziano and colleagues.

Apart from its function in speech motor control, the supplementary motor area (SMA) has largely been neglected in models of speech and language processing in the brain. The aim of a review paper was to summarize more recent work, suggesting that the SMA has various superordinate control functions during speech communication and language reception, which is particularly relevant in case of increased task demands. The SMA is subdivided into a posterior region serving predominantly motor-related functions (SMA proper) whereas the anterior part (pre-SMA) is involved in higher-order cognitive control mechanisms. In analogy to motor triggering functions of the SMA proper, the pre-SMA seems to manage procedural aspects of cognitive processing. These latter functions, among others, comprise attentional switching, ambiguity resolution, context integration, and coordination between procedural and declarative memory structures. Regarding language processing, this refers, for example, to the use of inner speech mechanisms during language encoding, but also to lexical disambiguation, syntax and prosody integration, and context-tracking [1)].

Chivukula et al., evaluated plasticity in speech supplementary motor area (SMA) tissue in two patients using functional magnetic resonance imaging (fMRI), following resection of tumors in or associated with the dominant hemisphere speech SMA. Patient A underwent resection of a anaplastic astrocytoma NOS associated with the left speech SMA, experienced supplementary motor area syndrome related mutism postoperatively, but experienced full recovery 14 months later. FMRI performed 32 months after surgery demonstrated a migration of speech SMA to homologous contralateral hemispheric regional tissue. Patient B underwent resection of a oligodendroglioma NOS in the left speech SMA, and postoperatively experienced speech hesitancy, latency and poor fluency, which gradually resolved over 18 months. FMRI performed at 64 months after surgery showed a reorganization of speech SMA to the contralateral hemisphere. These data support the hypothesis of dynamic, time based plasticity in speech SMA tissue, and may represent a noninvasive neural marker for SMA syndrome recovery [2].

1)

Hertrich I, Dietrich S, Ackermann H. The role of the supplementary motor area for speech and language processing. Neurosci Biobehav Rev. 2016 Sep;68:602-610. doi: 10.1016/j.neubiorev.2016.06.030. Epub 2016 Jun 22. Review. PubMed PMID: 27343998.

2)

Chivukula S, Pikul BK, Black KL, Pouratian N, Bookheimer SY. Contralateral functional reorganization of the speech supplementary motor area following neurosurgical tumor resection. Brain Lang. 2018 May 18;183:41-46. doi: 10.1016/j.bandl.2018.05.006. [Epub ahead of print] PubMed PMID: 29783125.