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Language assessment in awake brain surgery: designing linguistic tests for the Estonian intraoperative protocol

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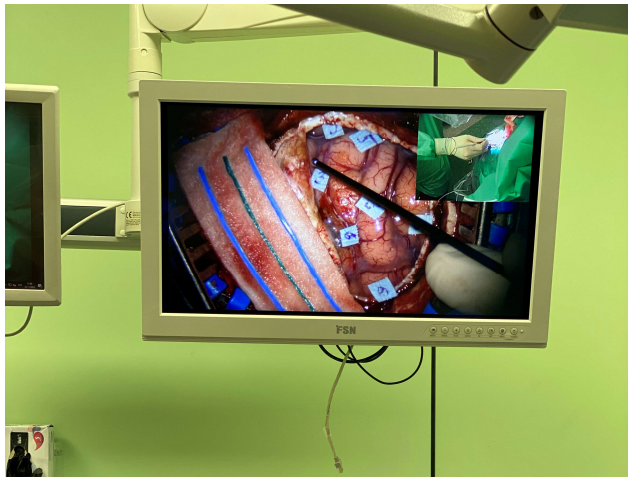
OBJECTIVE(S) AND METHODS

- Awake craniotomy with intraoperative direct electrical stimulation (DES) is widely recognised as a reliable and effective method for reducing the risk of permanent neurological and linguistic deficits during surgery for low-grade gliomas located within eloquent cortical and subcortical regions that were traditionally considered inoperable[1].
- the Estonian neurolinguistic test battery for awake surgery in language-eloquent areas was developed in accordance with, and informed by, the principles of the DuLIP (Dutch Linguistic Intraoperative Protocol)[2]. The development process involved selecting linguistically appropriate tasks, ensuring stimulus equivalence across languages, and creating test materials that reflect the structural characteristics of the Estonian language. The resulting battery was intended for use in preoperative baseline assessment, intraoperative real-time monitoring, and postoperative follow-up.



DES
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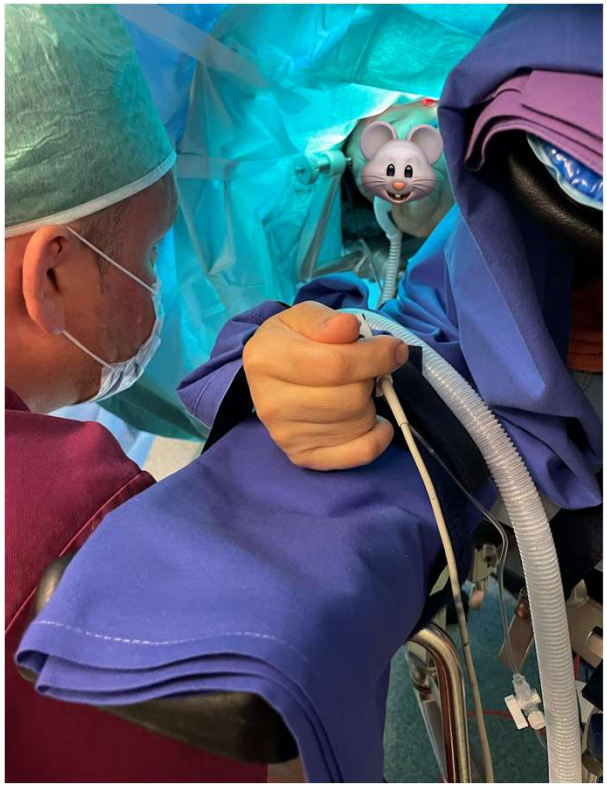
SHORT INTRODUCTION

- In Estonia, this technique has been implemented for more than five years, and at the North Estonia Medical Centre a total of 15 awake craniotomies involving a speech and language therapist (SLT) have been carried out to date.
- Accurate pre-, intra-, and postoperative assessment of linguistic functions is essential for preserving language networks and ensuring optimal functional outcomes. To reliably identify critical language zones in detail, a comprehensive linguistic test battery that evaluates phonology, semantics, and syntax is required.



Intraoperative real-time language monitoring
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RESULTS

- The phonological, semantic, syntactic, naming, and articulatory tasks were carefully designed to be administered during DES, with each item constrained to a 4-second response window. The Estonian Frequency Dictionary was employed to control for key linguistic variables, including lexical frequency, imageability, word length, and word form. Only non-compound singular nouns were selected, and lexemes with potential to elicit emotional responses were excluded. Additionally, the selection of tasks was guided by considerations related to the lesion location.
- Together, these tasks allow for the mapping of multiple linguistic subsystems at both cortical and subcortical levels.

Photo: private collection

RESULTS

Phonological tests

Test	To assess	Description	Stimulus	Example	Brain mapping during DES
1.1 Repetition of words	Word production	Repeat 3-syllable words (with or without clusters)	kajakas (*seagull*), pastakas (*pen*)		left arcuate fascicle (AF), left inferior supramarginal gyrus[3,4]
1.2 Reading with phonological odd word out	Phonological awareness	Read aloud the word that does not phonologically fit	kott (*bag*) pott (*pot*) hall (*grey*) rott (*rat*)		insula, inferior supramarginal gyrus, AF, inferior longitudinal fascicle (ILF) [3-5], occipital lobe[6,7]

Semantic tests

Test	To assess	Description	Stimulus	Example	Brain mapping during DES
2.1 Reading with semantic odd word out	Semantic judgment	Read aloud the word that does not semantically fit	käsi (*hand*) jalg (*leg*) king (*shoe*) pea (*head*)	käsi jalg king pea	temporal (posterior and superior) regions, prefrontal (orbitofrontal and dorsolateral) regions[8] ,the parietal regions[9], occipital regions[6,7], uncinate fascicle (UF), the ILF[5,] inferior fronto-occipital fascicle (IFOF)[3-5]
2.2 Naming with semantic odd picture out	Non-verbal semantic judgment and naming	Name the picture that does not semantically fit	lennuk (*plane*) buss (*bus*) õun (*apple*)		temporal, prefrontal regions, IFOF, ILF[10]
2.3 Semantic association task	Reading, semantic knowledge and generating words according a given concept	Add a semantically related word to a list of two semantically related nouns	roos (rose) tulp (tulip)…	roos tulp …	IFOF[11]

RESULTS

Syntactic tests

Test	To assess	Description	Stimulus	Example	Brain mapping during DES
3.1 Action naming	Syntactic (and semantic) processing	Read aloud a short introductive phrase and complete it with a finite verb in the third person singular	See mees… ronib (*This man… is climbing)*		Broca's area, posterior midfrontal region[12]
3.2 Verb generation	semantic association as well as syntactic competence	Produce verbs that are semantically related with the singular nouns	auto… sõitma (*car… to drive*)		perisylvian regions[13, 14]

RESULTS

Diadochokinesis test

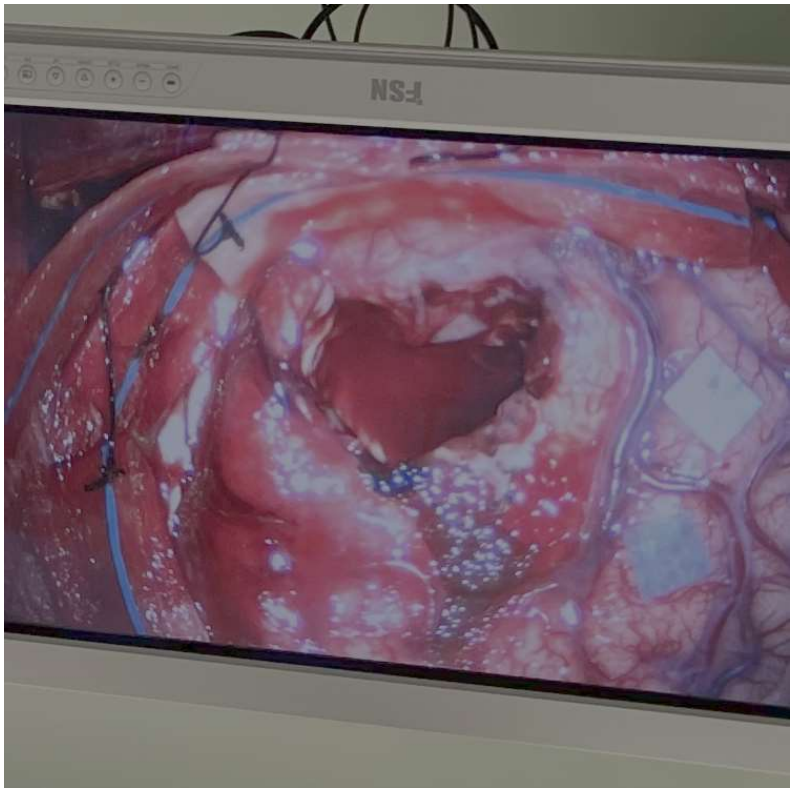
Test	To assess	Description	Stimulus	Example	Brain mapping during DES
4. Verbal diadochokinesis test	planning and coordination abilities of the motor speech system	Repeat of monosyllables as fast as possible 5 times in a row	pa pa pa pa pa		inferior frontal gyrus, frontal ventral premotor areas, anterior insular regions[15], superior longitudinal fascicle (SLF) that connects the supramarginal gyrus with the ventral premotor cortex[3], corticospinal tract (CST) [5]

Object naming

Test	To assess	Description	Stimulus	Example	Brain mapping during DES
5. Object naming	word retrieval	Name of objects and animals depicted on the screen after producing an introductive phrase	See on… õun (*This is… an apple*)		left perisylvian regions, frontal premotor cortex, AF, ILF, IFOF, subcallosal fascicle, UF[4,5,11], Broca's area, temporal cortex (Lubrano et al., 2014).

CONCLUSIONS

- A suitable combination of tasks can be selected for each patient based on tumour location, linguistic profile, and preoperative impairment.
- The Estonian neurolinguistic test battery for awake surgery in critical language areas is scheduled to undergo pilot testing later this year, with the aim of establishing its clinical feasibility and validity.



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