Speech-Language Tasks Administered Based on Cortical Location During an Awake Craniotomy

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Abstract

Direct cortical stimulation during awake craniotomies is used for mapping language in order to proceed with the greatest precision while ensuring preservation of critical language areas. Intraoperative mapping is typically conducted by having the patient produce route speech and name objects. However, no standardized tests or procedures are used during craniotomies; therefore, speech-language pathologists (SLPs) are unsure of the correct methods to use. PubMed, Web of Science, and CINAHL databases were searched to retrieve studies focused on language tasks including naming, reading, counting, and other verb tasks during awake craniotomies, and the location in the brain disturbed when performing these tasks. We review the tasks reported, list the cortical and subcortical regions whose stimulation inhibited language, and consider the types of task that stimulated regions of the brain. We compiled the research and created a representation of a brain with the locations of stimulation based on task. We argue that particular types of tasks are better used for awake craniotomies serving particular locations in the brain. We discuss the clinical value of the tasks and the limitations of the procedure. We suggest future research towards a formalized approach to language mapping during awake surgery. Further research will answer clinicians' questions as to how to map language with the greatest specificity intraoperatively.

Methods

- **Research Question**:
  In patients with brain pathologies undergoing awake craniotomies, does the type of language task influence what area of the brain is disrupted during direct cortical stimulation
- **Search Strategy**:
  (awake) AND (craniotom* OR surger* OR intraoperative) AND ((language AND (mapping OR testing OR test OR tests OR method OR task OR assessment OR localization)) OR "cortical mapping") AND ((brain OR cerebrum OR cerebral) AND (site OR location OR area OR region))
- **Databases searched**:
  PubMed, Web of Science, CINAHL
- **Research Process**:
  Title and Abstract Review → Full Article Review → Appraisals
  403 articles were narrowed down to 7 articles, including 2 Case Control studies, 4 Case series, and 1 Systematic Review. These were appraised and results were compiled

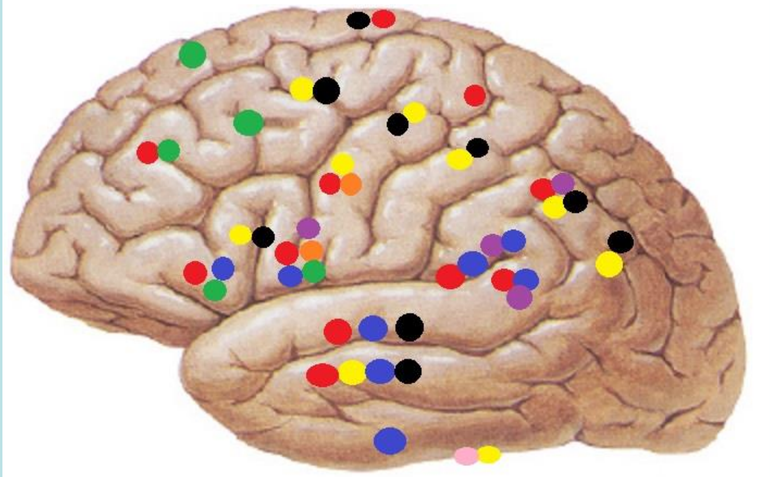
Types of Tasks

Object Naming	Patient presented with line drawings of concrete objects and asked to name drawing (typically from BNT)
Counting	Patient must count from 0-10 continuously.
Reading	Patient must correctly read a short sentence.
Word Generation	For 20 seconds, the patient must come up with as many words as they can think of either beginning with a certain letter, in a certain category, or antonyms of a word.
Auditory Response Naming	Patient hears description of a concrete noun and must generate a label or descriptor.
Word Discrimination	SLP reads aloud one or two syllable words or nonsense words (changing initial or final phoneme). Subject determines whether they heard a word or nonsense word by making a thumb movement.
Symbol Identification	Patient is presented with a symbol (i.e. a stop sign) and must say its name and purpose.
Verb Tasks	Multiple types. Must produce the verb in a picture in the correct form, must complete a sentence with a left out word, must come up with a verb that can be done with objects in picture, patient must produce infinitival form of verb depicted in drawing.

Appraisal Results

	Year	Type of Study	Quality
Rofes	2014	Systematic Review	Lesser
Papagno	2011	Case Control	Good
Brennan	2007	Case Control	Good
Cannestra	2000	Case Series	Good
Gil-Robles	2013	Case Series	Lesser
Duffau	2003	Case Series	Lesser
Brannen	2001	Case Series	Lesser

Task Associated Stimulations



Results

- Object naming stimulated most areas of the brain (parietal, temporal, and frontal lobes) (Brennan, 2007).
- Object naming more sensitive for testing language than counting (Brennan, 2007).
- IFOF- perform reading tasks and picture naming (Gil-Robles, 2013).
- Naming should include both living and nonliving objects (Papagano, 2011).
- Ventral PMC = articulation, speech, and naming (Duffau, 2003).
- Dorsal PMC= naming (Duffau, 2003).
- Broca's area = speech production (Cannestra)
- Wernicke's area= receptive language (Cannestra).
- Broca's area anterior regions=semantically related (Cannestra).
- Broca's area posterior areas= phonologically active (Cannestra).
- Wernicke's area anterior and superior =phonological areas (Cannestra).
- Wernicke's area inferior = semantic functions (Cannestra).
- Speech function was found in Brodmann area 44 (71% of patients) and Brodmann area 45 (57% of patients) (Brannen, 2001).
- Verb comprehension is a better assessment than object naming (Rofes, 2014).
- Verb production is the best assessment of language and requires the highest level of cognitive skills (Rofes, 2014).

Discussion

- Based on research, we compiled the individual tasks and their respective locations stimulated in the brain.
  - We compiled a list of general locations, and suggested tasks for those specific locations.
  - Important: Due to brain plasticity and variability, these are suggestions. Tasks should be individualized to each patient.
  - The areas in the brain listed should be tested using the following tasks:

Brain Locations	Aud. Resp. Nam.	Obj. Nam.	Word. Disc.	Reading	Verb Tasks	Word Gen.
STL & MTL	✓	✓			✓	
WA	✓	✓	✓			
AG				✓	✓	
IFG	✓	✓				✓
PREG		✓		✓		
POSTG				✓	✓	
SUP/MED FL		✓			✓	✓

Conclusions

1. There are a variety of speech-language tasks used to assess different areas of the brain. However, there is not one standard assessment used across patients mainly due to the variability of each brain as well as the difficulty of controlled testing of patients undergoing awake craniotomies.
2. Higher quality studies including randomized control trials are often inappropriate to conduct because of the lack of control subjects. Direct cortical stimulation can be dangerous for healthy control subjects because of the invasiveness of the procedure.
3. Case series and case control studies are appropriate for this topic of research. The primary limitation in these studies are the low number of subjects, the variability among the subjects, and the varied tasks studied among researchers.
4. Methods can be used to increase the reliability and validity of this type of research. Language mapping can be video recorded and disruptions (anomia, hesitations, etc.) can be rated by blind reviewers to increase interrater reliability. Areas of the brain in the patients can be stimulated multiple times to serve as their own control to increase validity.
5. Patterns have arisen from the current research that favor some tasks over others based on different locations in the brain. Until a more standardized assessment procedure is developed, the previously described tasks should be considered when monitoring the speech and language of patients undergoing awake craniotomies.

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