Artificial Grammar Learning in People with and without Agrammatism
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Keywords
Agrammatism: An impairment in grammatical production/comprehension resulting from left inferior frontal gyrus (LIFG) damage, often occurring with Broca’s aphasia. Aphasia: An acquired, neurogenic language impairment that is disproportionate to overall cognitive ability. Artificial Grammar Learning (AGL): An experimental paradigm intended to model the structural aspects of language acquisition and examine grammatical behavior substrates. Implicit Learning: Incidental learning occurring in the absence of explicit feedback, and without awareness of what has been learned.

Background
AGL research as it relates to neural language processing
- If LIFG unique to language?
  • AGL investigates grammatical/sequential processing in the absence of linguistic (lexical/semantic) information (Zimmerer, Cowell, & Varley, 2013).
- If the LIFG subserves only language, people with agrammatism should perform worse than those who do not.
- If LIFG subserves domain-general sequencing, people with agrammatism should perform similarly to unimpaired adults. (Christiansen, Kelly, Shilcock, & Greenfield, 2010)

Previous studies examining AGL and agrammatism
- Christiansen et al. (2010): control participants correctly classified the grammaticality of strings significantly better than patients with agrammatism did not.
- Zimmerer et al. (2013): healthy controls showed a significant effect of grammaticality when classifying sequences, and those with agrammatism did not.

Limitations to previous research
- Learning over the course of the AGL has not been observed in people with agrammatism. They may have difficulty specifically with the classification task. Therefore, our study attempted to objectively measure the implicit learning and mapping of the grammar that is occurring during the AGL. This was measured by changes in response time (RT) over the AGL task.
- Furthermore, previous studies have not compared AGL to other aspects of cognition/processing, which may be affected in aphasia. Our study attempted to explore the possible cognitive factors/abilities that may relate to and predict AGL performance.

Research Questions
Purpose: The ultimate aim of this study is to develop methods that will better measure AGL in people with agrammatism. In order to address this aim, this pilot study was developed to determine if a modified AGL task will provide evidence for learning measured throughout the training as well as during performance on a classification task.
Question: Will older adults show evidence for AGL, measured by RT improvements during the training task as well as performance above chance on a classification task?
Pilot Hypothesis 1: Control participants will show a decrease in RT across the SRT training task and perform above chance on a classification task, thereby demonstrating implicit AGL.
Pilot Hypothesis 2: AGL performance will correlate with cognitive sequencing ability.

Methods
Participants
18 participants: 7 male, ages 50+, no neurological disorder or injury.

Cognitive and Language Tasks
A short battery of tasks was given to screen for and also measure various aspects of language and cognition.

Task
Psycholinguistic Processing
Assessment of Language
Production
Processing in People
with Aphasia
Philadelphia Naming Test
Narative Discourse
Trail Making Test
Directed Fluency Task
Stroop
WAIS-IV: Perceptual Reasoning subtest
Digit span forward/backward
Luria Hand Movements Task

Purpose
Screening and Sentence
Screening of Language
Processing Speed
Processing Speed: Verbal
Executive Functioning
Nonverbal intelligence;
Visualspatial sequencing
Working memory
Motor Sequencing

Artificial Grammar Learning Task
Programmed on E-prime (2012). Strings of characters were generated using a finite state grammar used by Christiansen et al. (see Fig. 2).

AGL task is comprised of two phases:
1. Training phase – Symbol strings presented one-by-one on computer screen (see Fig. 1). Participants manually entered the sequences using a serial response (SR) box. They were not told that the strings followed rules. One block consisted of 20 different sequences, three to six symbols in length, presented randomly. Each block was shown four times. No explicit feedback about performance was given. All strings follow the grammar.

2. Classification phase – Participants informed that sequences they saw followed rules. Participants shown new set of 40 novel symbol sequences: either grammatical or ungrammatical. They decided whether the probe sequence presented was grammatical or ungrammatical by responding yes/no on the SR box. They were instructed to use their “gut feeling” only and to avoid attempting to explicitly analyze the sequences.

Results
1x4 repeated measures ANOVA (4 time points), significant differences in keypress RT (F(2,20) = 16.203, p < 0.001).

• Participants’ accuracy rate in classification of novel strings as grammatical or ungrammatical was analyzed using a single group t-test, with chance as the test value (t(16) = 6.271, p < 0.001).
• No significant correlations were found between cognitive screening tasks that met the assumptions for correlational analysis and AGL performance of RT change or classification accuracy (all p > .05).

• The Luria Task was not included in the correlated analysis because it did not meet the assumption of relating linearly to AGL performance. Based on the conceptual link between the task and AGL and visual inspection of the data, we split the control group into 2 subgroups based on their performance on the Luria Task. One group performed at ceiling on this task, receiving a perfect score. The second group made 1 or more mistakes.
• Those who performed at ceiling at this task improved in their RT significantly more than those who did not (t(12) = 2.971, p = .012).
• There was no difference in the two groups’ performance on the classification task (t(15) = 2.15, p = .05).
• No significant correlation was found between RT time changes and classification accuracy (R² = 0.268, p = 0.354).

Fig. 1: How the strings appear to participants. A grammatical string (left) and an ungrammatical string (right).

Fig. 2: The basis for the artificial finite-state grammar used in this study. Grammatical strings are generated by starting at the first node and following the arrows to other nodes for creating allowable (grammatical) strings of symbols (Christiansen et al., 2010).

Discussion
• Older adults appear to demonstrate AGL following the SRT task based on their RT improvements and accuracy in classifying test sequences, as we stated in Hypothesis 1.
• The training task we developed encourages implicit learning of the grammar and could be a valid way to determine whether people with agrammatism are able to implicitly learn the grammar.
• While we have found our training task to encourage implicit learning, the training task results may reflect motor learning rather than implicit learning given the following results:
  • A significant difference was found in RT between the subgroups formed based on Luria motor sequencing performance as predicted in Hypothesis 2.
  • There was no Luria subgroup difference on classification performance, which goes against our hypothesis.
  • Further, there was no significant correlation found between RT changes and performance on the classification task indicating that improvement in keypress time did not indicate better learning as measured by classification accuracy.
  • Without taking similar keypress RT measures during the classification task, we are unable to determine whether motor learning or AGL underlies the RT changes.

Conclusions and Future Directions
• Our results that older adults are able to implicitly learn an artificial grammar are consistent with the results found in previous studies (Christiansen et al., 2010; Forkstam, Elwer, Ingvar, & Petersson, 2008; Petersson, Folia, & Hagoort, 2010; Zimmerman et al., 2013).
• Our task does not represent a significant improvement over previous methodologies.
  • We plan to:
    • Collect keypress RTs in a probe task as well as to collect classification accuracy data.
    • Increase the number of sequences seen during the training task.
    • Improve the sensitivity of the Luria task by altering its scoring system.

Implications
There are many important future implications of AGL in aphasia research if we manage the methodological issues; if there are different levels of impairment on an AGL task, it could be used as a diagnostic tool. It could also be used in intervention because it is simpler than natural language, and the difficulty level is easy to manipulate (Zimmerer et al., 2013).

Acknowledgements
Thank you to the Neurolinguistics Lab and the Speech and Hearing Sciences Department at Portland State University for making this research possible and to all of the members of the lab who supported us.

References

For a handout with more information please visit: http://www.pdx.edu/research/lisatics