Interdisciplinary Research (IDR) Origination Awards

Cover Page

Project Title

Title: Leveraging ASR and Natural Language Processing Systems to Support Discourse Production by Persons with Aphasia

Principal Investigator(s) (full-time faculty)

Name (PI listed first)	Department	College
Dallin Bailey	Communication Disorders	McKay School of Education
David Wingate	Computer Science	Physical and Mathematical Sciences
Derek Hansen	Electrical and Computer Engineering	Fulton College of Engineering
* Tyson Harmon	Communication Disorders	McKay School of Education

* *Consultant*

Track

Track one

Abstract

Aphasia is a disorder of language acquired by damage to the brain due to stroke, traumatic brain injury, or neurodegenerative disease. The language output of persons with aphasia varies, but typically includes difficulty with generating well-formed words or producing grammatical sentences. Automatic speech recognition technologies and natural language processing systems, such as GPT-3, are well positioned to be incorporated into therapeutic activities and assistive communication devices, but little development has been done in these directions. The aim of the current project is to further develop a web application designed to recognize whatever speech a person with aphasia provides, then use GPT-3 to automatically suggest more complete or informative sentences. Pilot testing of a beta version has already been completed with two persons with aphasia, with encouraging results. These results included positive overall responses to the application by both participants. In addition, the participants endorsed the accuracy of specific sentences proposed by the application in several instances. However, refinement of the user experience is required, as well as wider testing with persons with aphasia. This collaboration brings together faculty with experience in clinical management of aphasia with faculty with experience in application development and human-computer interaction.

Summary of Plans for External Funding

The current award, if funded, will support the development of the novel system and two phases of usability testing with persons with aphasia. This will be used to apply for funding from Microsoft and the ASHFoundation following year one. Following further development and data collection in year 2, we will apply for an R25 award from the NIDCD division of the NIH, as well as a Core Program Award from the NSF's Human-Centered Computing program.

Project Narrative

Introduction

1. Background

Aphasia is a communication disorder defined by a loss of language skills resulting from a stroke, brain injury, or neurodegenerative disease; nonverbal cognition is typically relatively spared, compared to the severity of the language deficits (Papathanasiou & Coppens, 2022). This combination of impaired language with intact nonverbal cognition decreases quality of life (Bullier et al., 2019), as affected individuals experience inefficiencies or reduced effectiveness when attempting to communicate with others. The rate of aphasia prevalence in the United States for those who recover from stroke is estimated to be about 150,000 individuals per year (Ellis et al., 2017), many of them living for years with aphasia chronically. People with aphasia (PWA) are among the millions with communication disorders who may benefit from the use of augmentative and alternative communication (AAC) support (Dietz et al., 2020). These supports may be low-tech (such as a paper and pencil) or high-tech (based on digital technology; see Taylor et al., 2019). However, PWA have needs that are unique compared to many other AAC users: with impairments of language, PWA may have difficulty with word selection and grammatical construction, in addition to the word production deficits those with a motor impairment only (like ALS) may have. From a communication point of view, the potential supports provided by AAC may take many forms: input support (receiving input in a modality other than speech, such as using finger to select icons), message support (assisting the user with finding relevant words or desired messages to communicate), and output support (assisting or providing the speech output). Previous tools have been specifically designed for the aphasia population, but further research is needed to better meet the needs of PWA in all three areas of AAC support. Artificial intelligence (AI) and modern natural language models, like GPT-3 (CITE) have vast potential for providing this support for PWA but have not yet been applied to such AAC tools for PWA The aims of this study are to further develop an existing prototype AAC software system designed specifically for PWA that incorporates such techniques, and to perform thorough usability testing with PWA. This system allows PWA to use their remaining speech output as input, but then provides message and output support using artificial intelligence and natural language processing techniques. The two-year project to expand development and testing of the system as described here will powerfully support applications for external funding. These external funding opportunities include a Microsoft AI for Accessibility grant, grants to support usability testing from the ASHFoundation and the Human-Centered Computing (HCC) program of the National Science Foundation, and a proposal for expanded clinical testing through an R25 from the National Institute on Deafness and Other Communication Disorders and award from the NSF's Human-Centered Computing Division.

Prototype System

The existing prototype AAC system (named "AGPT"), version 0.1, was designed in 2022 by undergraduate students Forrest Burton and Grant Pitt under the supervision of Dr. David Wingate in BYU's Department of Computer Science. This system uses Google automatic speech recognition (ASR) to take the natural speech of a user (presumably with aphasia) as a starting point (see Figure 1 for a screenshot). Traditionally, AAC software tools have used keyboard text input or tactile selection of icons within a grid display, which, although slow, are ideal supports for individuals without any intelligible speech. However, many PWA still maintain some level of intelligible speech, and so ASR may allow faster input and reduce frustration by taking advantage of the residual speech output of PWA. Following recognition of the speech input, the system then processes the input through the GPT-3 language model (Brown et al., 2020) to transform the input into a more "natural" form, and again to provide realistic predictions for words to add to the input, augmenting the output. This system implements natural language processing and artificial intelligence (AI) techniques in ways that have not been applied to AAC for aphasia, providing input support and message support in novel ways.

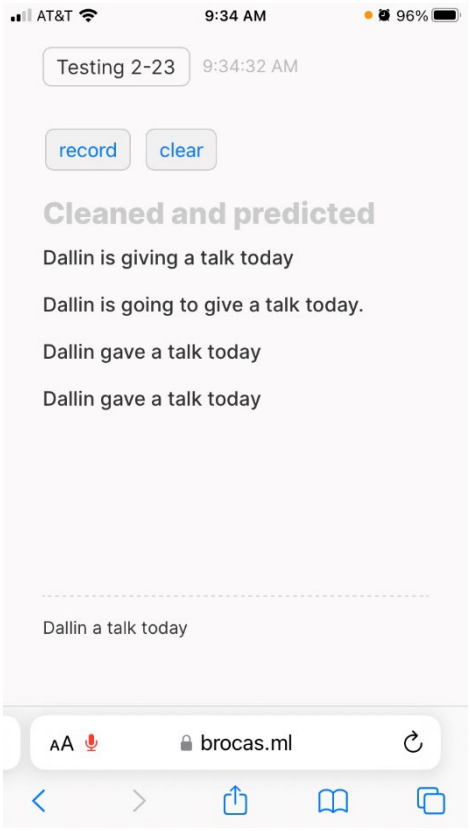

Figure 1. Screenshot from AGPT prototype system, with ASR input pictured below, and GPT-enhanced predictions above.

The current AGPT system (v. 0.1) was examined in an exploratory usability study in our lab with two PWA (Guynn et al., submitted). In the study protocol, the participants provided a variety of discourse samples, including simple action picture descriptions, a complex picture description, a picture sequence description, and a role-play scenario in which they asked for information from a store employee. In its current form, the system had mixed, but promising results, particularly for the simple action picture description. For example, in describing a line drawing of a person with a watering can watering a plant, the participant with aphasia stated, "the woman water and the flowers." This statement shows common aphasic language characteristics including incomplete grammatical construction and difficulty with word choice. In response, the system proposed an output sentence of "the woman is watering the flowers," which provides a more complete and typical grammatical structure that the participant expressed approval of, presumably representing her intended communication. Overall, the two participants both expressed enthusiasm and positivity about the system, and the desire to see further developments.

2. Long-term goals and short-term objectives

The proposed project has two basic long-term aims: 1) to further develop the existing prototype system, and 2) to perform large-scale usability testing with PWA using participatory design methods.

Long-term AIM 1: Further Development of the Existing Prototype System (v. 1.0 and 2.0)

Specifically, developments of the prototype system are being planned to adjust the user interface and to explore ways to improve the predictions generated for users. See Figure 2 for a conceptual sketch of how the system's user interface (UI) may be developed. Such changes in the UI may appear simple but may have major implications for usability. In addition to this, other planned developments will provide further support for all three major AAC supports: input support, message support, and output support.

Input support: Adjustments to the speech recognition system and/or parameters will be explored. PWA have varied levels of intelligibility of their remaining intact verbal speech output (the input for the system). Concomitant apraxia of speech, a disorder of programming the motor movements required for speech, is a frequent culprit comorbid with aphasia; dysarthria may also co-occur (Duffy, 2020). Research efforts optimizing ASR for disordered speech will be tested as alternatives to the current ASR system.

Message support: one of the primary novel aspects of the prototype and planned developments are the use of an artificial intelligence language model (GPT-3) to provide predictions for users. By further exploring GPT-3 and different language models and their parameters, these predictions may be customized in ways that improve the quality and personal relevance of the predictions. Such AI applications to aphasic speech have received very little research attention (see review by Obiorah et al., 2021). Customizability is generally accepted as a factor increasing the acceptability of high-tech AAC (Curtis et al., 2022). Although a large amount of customization during development may be done in direct

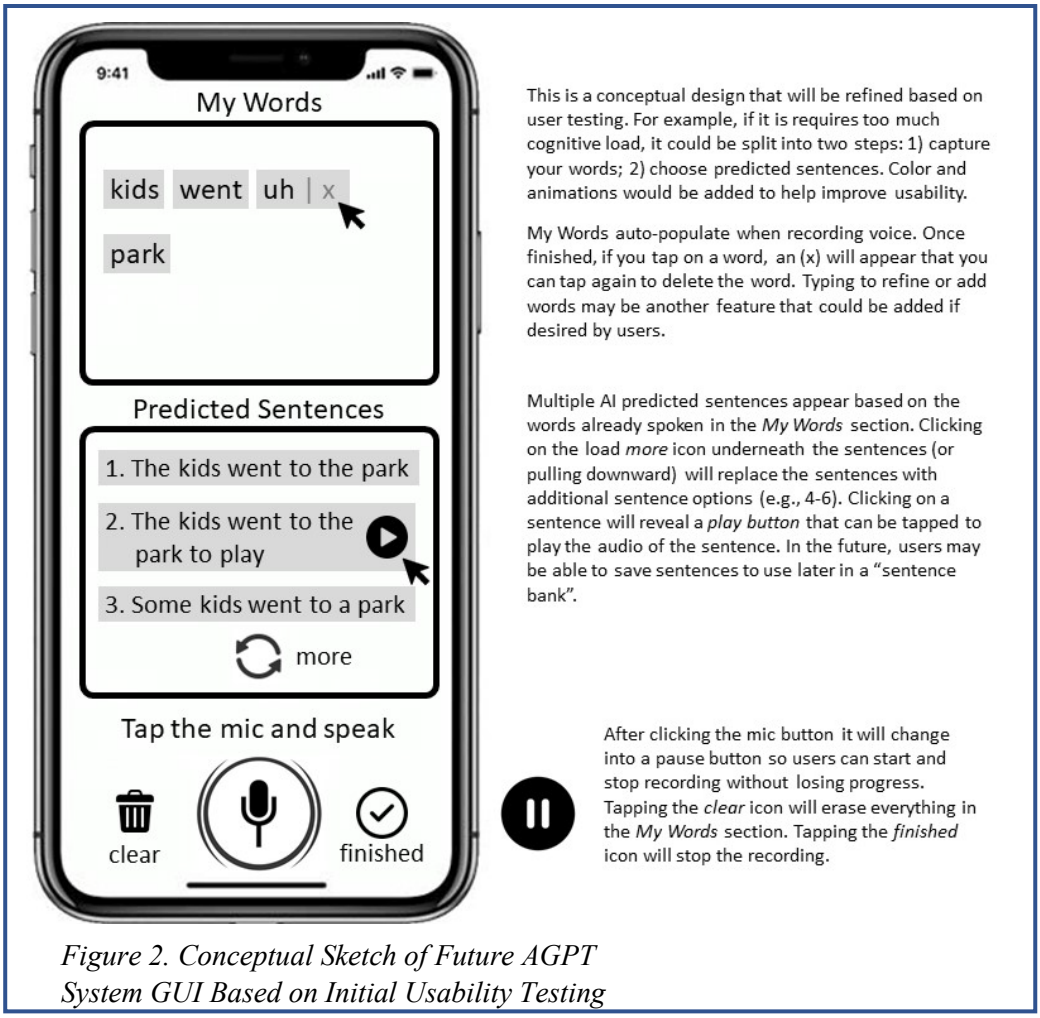

Figure 2. Conceptual Sketch of Future AGPT System GUI Based on Initial Usability Testing

response to usability studies (see the following section in Long-term Aim 2), another avenue for customization requires development of the backend of the system to provide more relevant predictions based on user-specific information such as location, time of day, conversation partner, and previous topics of conversation. The context-aware and user-aware advancements will build on systems that take the form of adjusting the prediction algorithm for different sources of data, such as GPS data for location-aware predictions and machine vision for conversation partner facial recognition (Kane et al., 2012). For example, food vocabulary and personal information may be more likely when at a fast-food restaurant or with a friend. Time of day and day of the week are other factors that influence vocabulary and as such would also be likely candidates to improve message predictions (Hossain et al., 2018). Incorporating such data sources would have the affect of influencing the predictions generated by the more generic language model to make them personalized for the user.

Output support: The current system uses text output only, but work is currently underway to enhance the output support by incorporating an on-demand text-to-speech option. The text-to-speech option may provide output support in at least two ways: 1. Widely accessible, high-quality text-to-speech voices may provide a proxy output voice for the PWA. 2. Another option, verbalized by one of the usability pilot test participants with aphasia, is to use the output to support their own speech output, wherein the output voice serves as an auditory model for the PWA to practice. Auditory models commonly facilitate spoken output in PWA, and so may serve as a therapeutic model even when a clinician is not present. Future work is also planned to examine the usability and acceptability of providing the display on head-worn augmentative reality system (i.e., Google Glass) in order to further enhance the acceptability of AAC

support by PWA (see work by Williams et al., 2015). With a head-worn AR display and simple headphones, this second option could also be combined with articulatory cues from an animated human mouth, which may provide further spoken output support (Cherney et al., 2015) in a private, unobtrusive manner.

The specific short-term objectives for Long-Term Aim 1 include the following:

1. For v. 1.0,
    a. the development team will test adjustments to the ASR system used for speech input.
    b. The development team will implement text-to-speech models to support output, and
2. For v. 2.0,
    a. The development team will implement additional data sources to augment the generic language model and make more personalized utterance predictions.
3. The development team will also prototype an adaptation of the system for use in an Augmented Reality system such as GoogleGlass.

Long-term AIM 2: Large-scale Usability Testing with PWA using Participatory Design Methods

A common slogan in disability activism is "nothing about us without us." Pairing the development of the tools with usability testing with people with aphasia allows for early and frequent feedback from PWA during development, reducing chances of AAC technology abandonment (Curtis et al., 2022). AAC technology abandonment may occur when users judge communication benefit from the technology to be outweighed by the costs, which costs may include the social stigma associated with atypical forms of communication, problems with the technology itself, reduced communication speed, or lack of personal relevance. Modifications that we can anticipate as a research team include adjustments to the GUI to adjust for cognitive load, options to provide customization of text displayed, and the option for on-demand text-to-speech audio feedback. However, participatory design usability studies will assist the development team in focusing their attention on developing features that matter the most to PWA, thereby preserving resources. Such an approach was used effectively by Moffatt et al. (2004) in their development of a digital planner for PWA.

The participatory design process requires user-participants to provide communication regarding their experience with the software, and communication is the core problem being addressed in PWA. Previous research has used speech-language pathologists (SLPs) as proxies (Boyd-Graber et al., 2006) in the participatory design process. However, the current collaboration with BYU's speech-language pathology program allows for members of the team involved in the user studies to be trained in supported communication techniques. These techniques, when implemented properly, allow persons with a variety of aphasia symptoms and severities to communicate competently and effectively, using their communication partners as supports, rather than proxies (Kagan, 1998). This removes a source of bias in the process and allows participants with aphasia to directly participate in developing and testing technology that is being designed to benefit them (Roper et al., 2018). In our exploratory usability study, we demonstrated the utility of such supported conversation techniques in facilitating usability interviews with PWA.

The specific short-term objectives for Long-Term Aim 2 include the following:

1. In year 1, the usability team will perform usability testing of the refined prototype of the system (v. 1.0) with an expanded group of fifteen PWA. Research staff will be trained in supported communication techniques and provide suggestions and practice opportunities to help PWA learn how to use the system. PWA will be loaned an iPad mini and invited to use the system in their typical communication environment for about a week. They will then be interviewed, and logged data will be analyzed, to explore how the system aided communication in various settings.
2. In year 2, the usability team will perform usability testing of v. 2.0 with another group of fifteen PWA. The methods and analysis will be performed in a similar manner.

3. Also in year 2, the usability team will perform a pilot study of the AR system prototype. This will involve 2-4 persons with aphasia testing the system in the lab.

3. Schedule of project and expected milestones

The project will proceed according to the schedule in the following table to the best of our abilities.

	2023 Q2-3	2023 Q4	2024 Q1	2024 Q2	2024 Q3	2024 Q4	2025 Q1
Submission of prototype paper to SIG ASSETS or CHI	X						
Completion of revised UI of prototype (v. 1.0)	X						
Data collection and analysis for usability study #1		X	X				
Apply for Microsoft AI grant		X					
Submission of usability study #1 data to Clinical Aphasiology Conference and/or CHI			X				
Apply for ASHFoundation grant			X				
Development of v. 2.0		X	X	X			
Data collection and analysis for usability study #2				X	X		
AR prototype pilot study data collection						X	
Submission of papers based on v.2.0 development and usability study to SIG ASSETS/CHI and to JSLHR or AJSLP					X	X	
Apply for NIDCD R25 grant					X	X	
Submit AR prototype paper to SIG ASSETS or CHI							X
Apply for NSF HCC Core Program award							X

The Interdisciplinary Project Team

The assembled team for the aforementioned project is an interdisciplinary team involving Communication Disorders, Computer Science, and Electrical and Computer Engineering. The team lead is Dr. Dallin Bailey. He will lead out in carrying out tests with PWA and providing communication support for participants. He will also lead out in analyzing the effects of usage of the system on communication. His clinical background in working with people with aphasia makes him the content expert in this area. User-interface programming and backend system development will be carried out by Dr. David Wingate and his research team. His extensive machine learning and artificial intelligence system development experience make him the content expert in this area. The lead for the usability testing will be Dr. Derek Hansen. His extensive experience with usability testing design and human-computer interaction research make him the content expert for the team. Lastly, the team will receive consultation as needed from Dr. Tyson Harmon of the Dept. of Communication Disorders. His expertise in quantitative language analysis and qualitative analysis of interviews involving PWA make him an important contributor to the team, particularly in preparing manuscripts based on usability interviews.

How the IDR Origination Award Will Lead to External Funding

The research activities described herein, if funded by the IDR Origination Award, will enhance competitiveness for external funding by providing pilot usability data and development support for updates to the system as described. Specifically, following year 1, we will apply for an ASHFoundation award and Microsoft AI for Accessibility grant using usability data from v. 1.0 testing. Then, following year 2, we will apply for an NIH NIDCD R15 award and an NSF Human-Centered Computing research award. These will be focused on further clinical testing and further refining of user-aware prediction capabilities (such as using ASR+AI in conversation to detecting conversation partner's speech and topic, and provide a useful prediction for a response by the PWA).

Budget and Budget Narrative

The budget proposed will primarily support the development of the proposed software system, as well as the usability testing of the systems with persons with aphasia. Undergraduate support and graduate student support will be provided for each lab. In addition, some limited funds are needed to purchase software and cloud services, testing equipment and materials, and recording equipment. These will support the continued operation of the system and the usability studies. Participant compensation is also included to improve recruitment and retention efforts. Finally, travel funds are requested in order to disseminate the findings and network with supportive potential collaborators.

Item	Year 1	Year 2	Total	
Undergraduate Student Support				
Bailey lab	$ 5,760.00	$ 5,760.00	$ 11,520.00	8 hrs/wk, 3 semesters, $16/hr
Wingate lab	$ 6,800.00	$ 6,800.00	$ 13,600.00	8 hrs/wk, 3 semesters, $17/hr
Hansen lab	$ 6,800.00	$ 6,800.00	$ 13,600.00	8 hrs/wk, 3 semesters, $17/hr
Graduate Student Support				
Bailey lab	$ 6,480.00	$ 6,480.00	$ 12,960.00	8 hrs/wk, 3 semesters, $17 or 18/hr
Wingate lab	$ 13,600.00	$ 13,600.00	$ 27,200.00	10 hrs/wk for Fall/Winter, 20 hrs/wk for Spring/Summer, $20/hr
Hansen lab	$ 13,600.00	$ 13,600.00	$ 27,200.00	10 hrs/wk for Fall/Winter, 20 hrs/wk for Spring/Summer, $20/hr
Equipment and Supplies				
iPad minis x 5	$ 2,750.00	-	$ 2,750.00	
iPad mini cases	$ 75.00	-	$ 75.00	
Subscriptions for Software and Cloud Services	$ 2,500.00	$ 2,500.00	$ 5,000.00	
Aphasia Speech and Language Testing Materials	$ 500.00	$ 150.00	$ 650.00	
recording equipment (video camera, microphone)	$ 1,000.00	-	$ 1,000.00	
Participant Compensation (15 participants x $100) x 2 phases	$ 1,500.00	$ 1,500.00	$ 3,000.00	
Travel for Dissemination of Findings at Conferences				2k per person total over both years
student travel	$ 3,000.00	$ 3,000.00	$ 6,000.00	1.5k per student
faculty travel	$ 2,000.00	$ 4,000.00	$ 6,000.00	2k per faculty member (higher conference fees)
Total	$ 61,365.00	$ 57,190.00	**$ 118,555.00**	

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Plans for External Funding

A minimum of two smaller grants and one larger grant from external sources will be applied for.

- The first of the two smaller grants is the Microsoft AI for Accessibility Grant. This grant funds $20,000 for research projects applying artificial intelligence to the needs of people with disabilities. Substantial credits ($10,000 to $20,000) towards Microsoft's Azure cloud-based applications and hosting services are also included, which would be useful resources for this project. As aphasia is a disability involving communication, and the proposed system depends on AI, the fit seems natural. Further, the grant specifically calls for low-cost assistive technology development, and the end result of our project is a very low-cost solution for assisting communication in people with aphasia. The focus of this grant will be the further enhancement of the back-end of the natural language processing, with likely directions including integration of conversation partner speech recognition to provide conversational response suggestions to users with aphasia based on their conversation partners' speech, in addition to suggestions based on their own speech.
- The second of the two smaller grants applied for will be one of two funded by the ASHFoundation, which is the foundation arm of the American Speech-Language Hearing Association. These grants, the New Century Scholars Research Grant and the Clinical Research Grant: Collaborative, support work applying technology and innovative approaches to the management of communication disorders. This foundation traditionally values research with strong clinical application to communication disorders, and so the project funded by these grants would focus on initial testing of the conversation assistance technology developed through the Microsoft AI for Accessibility Grant. Or, if the Microsoft grant is not funded, it would focus on further testing of the use of the AGPT system, with a particular focus on how individual and family member quality of life are impacted by use of the system.
- One of the large grants that will be applied for is an R15 Academic Research Enhancement Award from the National Institute of Deafness and Communication Disorders (NIDCD) of the National Institutes of Health (NIH). In their recently published 2023-2027 Strategic Plan, the NIDCD stated as Theme 6 their plans to fund projects that "harness advanced technology to improve prevention, diagnosis, and treatment," with Goal 2 specifically supporting research to "enhance augmentative and alternative communication capabilities…leveraging AI/ML [artificial intelligence and machine learning] as tools that can…improve accessibility for those with communication disorders" (2023-2027 NIDCD Strategic Plan). The focus of the project proposed for this grant will be expanding the clinical testing of the system in persons with different profiles of aphasia, with investigations into its usability, acceptability, and wider impacts on quality of communication and quality of life in persons with aphasia and related disorders. The opportunity ID is PAR-21-154.
- The other large grant to be applied for will be a medium-sized Core Program grant from the Human-Centered Computing Division of the National Science Foundation's Computer and Information Science and Engineering Directorate. This grant will support the interdisciplinary nature of the project, involving computer programming, user interaction, and working clinically with people with aphasia and related disorders. The program supports research that includes assistive and adaptive technology, which definitely is applicable for this line of research. The opportunity ID is 22-631.

Proposed External Funding Submission Timelines

	External Funding Opportunity	Submission Date	Funding Date
Year 1—backend focus	Microsoft AI for Accessibility Grant	November 2023	Estimated February 2024
Year 1—clinical testing focus	ASHFoundation New Century Scholars Research Grant OR ASHFoundation Clinical Research Grant: Collaborative	April 2024	December 2024
Year 2—clinical testing focus	NIH NIDCD R15 Academic Research Enhancement Award—PAR-21-154	October 2024	July 2025
Year 2—user interface and usability focus	NSF HCC Core Program Medium-sized award—Opp ID: 22-631	Jan-Feb 2025	Aug 2025

Investigator Biographical Sketch

OMB No. 0925-0001 and 0925-0002 (Rev. 12/2020 Approved Through 02/28/2023)

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors. Follow this format for each person. DO NOT EXCEED FIVE PAGES.

NAME: Bailey, Dallin

eRA COMMONS USER NAME (credential, e.g., agency login): dallinbailey

POSITION TITLE: ASSOCIATE Professor of Communication Disorders

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Brigham Young University, Provo, UT	BA	04/2011	English Language (Linguistics)
Brigham Young University, Provo, UT	MS	04/2013	Communication Disorders
University of Utah, Salt Lake City, UT	PHD	12/2016	Speech-Language Pathology and Audiology

A. Personal Statement

My academic training, clinical expertise, and academic track record demonstrate my research capabilities for working with persons with aphasia. Specifically, I have been trained in assessment and treatment strategies for persons with aphasia, as well as persons with concomitant apraxia of speech. My research has also involved computer program development collaborations with computer engineering faculty and students in order to provide more software options in the management of speech disorders and in the clinical training of speech-language pathologists. A selection of my publications demonstrates the impact I have had on this area so far in my career:

Selected Publications:

1. **Bailey, D. J.**, Speights Atkins, M., Mishra, I., Li, S., Luan, Y., & Seals, C. (2021). An Automated Tool for Comparing Phonetic Transcriptions. *Clin Linguist Phon*, *36*(6), 495-514. https://doi.org/10.1080/02699206.2021.1896783

2. **Bailey, D. J.**, Whitfield, J. A., Dromey, C., & Speights Atkins, M. (2020). *The role of mental simulation in speech motor learning.* Poster presented at the Conference on Motor Speech, Santa Barbara, CA, Feb. 19-23, 2020.

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6. **Bailey, D. J.**, Bunker, L., Mauszycki, S., & Wambaugh, J. L. (2019). Reliability and stability of the metrical stress effect on segmental production accuracy in persons with apraxia of speech. International Journal of Language & Communication Disorders, 54(6), 902-913.

7. Wambaugh J, Shuster L, **Bailey D**, Mauszycki S, Kean J, Nessler C, Wright S, Brunsvold J. (2016). Self-Judgments of Word Production Accuracy in Acquired Apraxia of Speech. American Journal of Speech-Language Pathology, 25(4S):S716-S728.

8. **Bailey, D. J.**, Nessler, C., Berggren, K. N., & Wambaugh, J. L. (2020). An aphasia treatment for verbs with low concreteness: A pilot study. American Journal of Speech-Language Pathology, 29(1), 299-318.

9. Wambaugh, J. L., Wright, S., Mauszycki, S. C., Nessler, C., & **Bailey, D.** (2018). Combined aphasia and apraxia of speech treatment (caast): Systematic replications in the development of a novel treatment. International Journal of Speech-Language Pathology, 20(2), 247-261.

B. Positions, Scientific Appointments, and Honors

2016 - 2022	Assistant Professor of Speech, Language, and Hearing Sciences (formerly Communication Disorders), Auburn University, Auburn, AL
2022 - present	Associate Professor of Communication Disorders, Brigham Young University, Provo, UT

Other Experience and Professional Memberships

2016 - present	Certified Member, CCC-SLP, American Speech-Language and Hearing Association (ASHA)

NSF BIOGRAPHICAL SKETCH

Provide the following information for the Senior personnel.
Follow this format for each person. **DO NOT EXCEED 3 PAGES.**

IDENTIFYING INFORMATION:

NAME: Wingate, David

NSF ID: 000700514@nsf.gov
ORCID: 0000-0003-1850-6926

POSITION TITLE: Associate Professor

ORGANIZATION AND LOCATION: Brigham Young University, Provo, UT, USA

Professional Preparation:

ORGANIZATION AND LOCATION	DEGREE (if applicable)	DATE RECEIVED	FIELD OF STUDY
MIT, Cambridge, MA, USA	Postdoctoral Fellow	2008 - 2012	
Brigham Young Universit, Provo, UT, USA	BS	2002	Computer Science
University of Michigan, Ann Arbor, MI, USA	PHD	2008	Computer Science
Brigham Young University, Provo, UT, USA	MS	2004	Computer Science

Appointments and Positions

2021 - present Associate Professor, Brigham Young University, Provo, UT, USA
2015 - 2021 Assistant Professor, Brigham Young University, Provo, UT, USA

Products

Products Most Closely Related to the Proposed Project

1. Johnson CC, Quackenbush T, Sorensen T, Wingate D, Killpack MD. Using First Principles for Deep Learning and Model-Based Control of Soft Robots. Front Robot AI. 2021;8:654398. PubMed Central PMCID: PMC8129000.
2. Hyatt P, Wingate D, Killpack MD. Model-Based Control of Soft Actuators Using Learned Non-linear Discrete-Time Models. Front Robot AI. 2019;6:22. PubMed Central PMCID: PMC7805923.
3. Mielke E, Townsend E, Wingate D, Killpack M. Human-robot co-manipulation of extended objects: Data-driven models and control from analysis of human-human dyads. arXiv preprint arXiv:2001.00991. 2020.
4. Seaman I, van de Meent J, Wingate D. Nested Reasoning About Autonomous Agents Using Probabilistic Programs.(2020). arXiv preprint arXiv:1812.01569. 2020.
5. Rytting C, Wingate D. Leveraging the Inductive Bias of Large Language Models for Abstract Textual Reasoning. Advances in Neural Information Processing Systems. 2021; 34:17111-17122.

Other Significant Products, Whether or Not Related to the Proposed Project

1. Nyshadham C, Rupp M, Bekker B, Shapeev A, Mueller T, Rosenbrock C, Csányi G, Wingate D, Hart G. Machine-learned multi-system surrogate models for materials prediction. npj Computational Materials. 2019; 5(1):1-6. issn: 2057-3960
2. Brown Z, Robinson N, Wingate D, Fulda N. Towards neural programming interfaces. Advances in Neural Information Processing Systems. 2020; 33:17416-17428.
3. Argyle L, Busby E, Fulda N, Gubler J, Rytting C, Wingate D. Out of One, Many: Using Language Models to Simulate Human Samples. arXiv preprint arXiv:2209.06899. 2022.
4. Sorensen T, Robinson J, Rytting C, Shaw A, Rogers K, Delorey A, Khalil M, Fulda N, Wingate D. An Information-theoretic Approach to Prompt Engineering Without Ground Truth Labels. arXiv preprint arXiv:2203.11364. 2022.

Synergistic Activities

1. Recently finished a one-year sabbatical working at Nvidia's Applied Deep Learning Research group. ADLR trained the world's largest dense language model (530B parameters) on thousands of GPUs, and gave me critical hardware and software experience in at-scale training of language models.
2. Senior conference leadership for major AI conferences (including AAAI and ICML).
3. Conference and journal reviewing / program committee member for over 50 machine learning and deep learning related conferences, plus various NSF review panels.
4. Active collaborations with roboticists at the intersection of deep learning, control and dynamical systems modeling.

Certification:

When the individual signs the certification on behalf of themselves, they are certifying that the information is current, accurate, and complete. This includes, but is not limited to, information related to domestic and foreign appointments and positions. Misrepresentations and/or omissions may be subject to prosecution and liability pursuant to, but not limited to, 18 U.S.C. §§ 287, 1001, 1031 and 31 U.S.C. §§ 3729-3733 and 3802.

Certified by Wingate, David in SciENcv on 2023-02-21 17:17:35

NAME: Derek L. Hansen

POSITION TITLE & INSTITUTION: Professor, Brigham Young University, Provo, UT 84602

A. PROFESSIONAL PREPARATION - (see PAPPG Chapter II.C.2.f.(i)(a))

INSTITUTION	LOCATION	MAJOR/AREA OF STUDY	DEGREE (if applicable)	YEAR (YYYY)
Brigham Young University	Provo UT, USA	Economics with Honors	B.A.	1998
University of Michigan	Ann Arbor, MI, USA	Information	Ph.D.	2007

B. APPOINTMENTS - (see PAPPG Chapter II.C.2.f.(i)(b))

From - To	Position Title, Organization and Location
2022-present	Professor, Electrical and Computer Engineering, Ira A. Fulton College of Engineering Brigham Young University, Provo, UT, USA.
2016-2022	Program Coordinator, IT & Cybersecurity, Ira A. Fulton College of Engineering, Brigham Young University, Provo, UT, USA.
2019-present	Chief Scientist, King's Peak Technology, Inc., Provo, UT, USA.
2015-2020	Associate Professor, IT & Cybersecurity Program, Ira A. Fulton College of Engineering, Brigham Young University, Provo, UT, USA.
2011-2015	Assistant Professor, Information Technology Program, Ira A. Fulton College of Engineering, Brigham Young University, Provo, UT, USA.
2007-2011	Assistant Professor, College of Information Studies, University of Maryland, College Park, MD, USA.

C. PRODUCTS - (see PAPPG Chapter II.C.2.f.(i)(c)) Products Most Closely Related to the Proposed Project

Neupane, Aatish, Derek Hansen, Jerry Fails, Anud Sharma. The Role of Steps and Game Elements in Gamified Fitness Tracker Apps: A Systematic Review. Multimodal Technologies and Interaction. Vol 5. Issue 2. February 2021. Multidisciplinary Digital Publishing Institute.

Neupane, Aatish, Derek Hansen, Anud Sharma, Jerry Fails, Bikalpa Neupane, Jeremy Beutler. A Review of Gamified Fitness Tracker Apps and Future Directions. Proceedings of the Annual Symposium on Computer-Human Interaction in Play (CHI-PLAY, 2020). ACM. ACM Press.

Hansen, Derek L., Amanda Hughes, Sophie Cram, Austin Harker, Brinnley Ashton, Karli Hirschi, Ben Dorton, Nate Bothwell, & Ashley Stevens. The DELAY Framework: Designing for Extended LAtencY. Proceedings of the SIGCHI conference on Human factors in computing systems (Honolulu, Hawaii, 2020), ACM. ACM Press.

Man Huang, Derek Hansen, Bo Xie. Older Adults' Online Health Information Search Behavior. Proceedings of iConference 2012, Feb 7-10, 2012. Toronto, Canada. ACM Press.

Hesse, Bradford W., Derek Hansen, Thomas Finholt, Sean Munson, Wendy Kellogg, John C. Thomas. Social Participation in Health 2.0. Computer. Nov. 2010. Volume 43. Issue 11.

Other Significant Products, Whether or Not Related to the Proposed Project

Hansen, Derek L., Amanda Hughes, Sophie Cram, Austin Harker, Brinnley Ashton, Karli Hirschi, Ben Dorton, Nate Bothwell, & Ashley Stevens. The DELAY Framework: Designing for Extended LAtencY. Proceedings of the SIGCHI conference on Human factors in computing systems (Honolulu, Hawaii, 2020), ACM. ACM Press.

Hansen, Derek L., Ben Shneiderman, Marc A. Smith. Analyzing Social Media Networks with NodeXL: Insights from a Connected World, 304. Morgan Kaufmann Publishers, Burlington, MA, 2011.

Bertot, John, Paul Jaeger, Derek Hansen. The Impact of Policies on Government Social Media Usage: Issues, Challenges, and Recommendations. Government Information Quarterly. Vol. 29. Issue 1. 2012. 30-40. doi: 10.1016/j.giq.2011.04.004

Hansen, Derek L., Holly A. Derry, Paul J. Resnick, and Caroline R. Richardson. "Adolescents Searching for Health Information on the Internet: An Observational Study." Journal of Medical Internet Research 2003;5(4):e25.

Richardson, Caroline R., Paul J. Resnick, Derek L. Hansen, Holly A. Derry, and Vicky J. Rideout. Does Pornography-Blocking Software Block Access to Health Information on the Internet? The Journal of the American Medical Association, Dec. 11, 2002. 288(22) 2887-2894.

D. SYNERGISTIC ACTIVITIES - (see PAPPG Chapter II.C.2.f.(i)(d))

• Runs the Mixed Reality Lab at BYU that works with augmented and virtual reality tools.
• Teaches courses on user experience design, research, ethics, databases, and web technologies.

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Harmon, Tyson Gordon

eRA COMMONS USER NAME (credential, e.g., agency login): tgharmon

POSITION TITLE: Assistant Professor of Communication Disorders

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Brigham Young University, Provo, UT	BS	04/2010	Communication Disorders and Portuguese
Brigham Young University, Provo, UT	MS	04/2012	Communication Disorders
University of North Carolina at Chapel Hill, Chapel Hill, NC	PHD	05/2018	Speech and Hearing Sciences

A. Personal Statement

I am an Assistant Professor of Communication Disorders with a research program focused on aphasia assessment and intervention. More specifically, I am interested in the interactions between spoken language, attention, and emotion. The purpose of my research program is to apply insights about cognitive and emotional processing in language to improve everyday communication for people with aphasia. To this end, I have applied both quantitative and qualitative methodologies to conduct hypothesis-driven and exploratory research aimed to inform assessment and intervention for people with aphasia. Although I am an early-stage investigator, I have have a strong internal funding and publication record, have successfully competed for two competitive external awards, and have experience assisting with two NIH-funded research grants. While at my current institution (BYU), I have established a registry that stroke and brain injury survivors can join to be made aware of research opportunities that they may qualify for and have served the stroke community as a Utah Valley Stroke and Brain Injury Association board member. I have also overseen or been involved with multiple projects that integrate input from people with aphasia and their families when establishing assessment or intervention tools (see below). These experiences along with my research expertise have allowed me to consult Dr. Bailey as he has begun to establish his research program.

B. Positions, Scientific Appointments, and Honors

Positions and Scientific Appointments

2018 - Present Assistant Professor, Brigham Young University, Provo, UT
2022 - Present Member, Aphasia Access
2022 - Present Member, BYU Gerontology Program Committee, Provo, UT
2021 - Present General Member, Collaboration of Aphasia Trialists (CATs)
2018 - Present Licensed as a Speech-Language Pathologist by the State of Utah Department of Commerce
2018 - Present Affiliate, BYU Gerontology Program, Provo, UT
2018 - Present Board Member, Utah Valley Stroke Association, Provo, UT
2012 - 2013 Speech-Language Pathologist, Northwest Texas Hospital, Amarillo, TX

Honors

2020 - 2023 ASHA Advancing Academic-Research Careers (AARC) Award

2021	Tavistock Trust for Aphasia Distinguished Scholar Award, USA
2018 - 2019	ASHA Pathways Protégé
2018	NIDCD Student Fellow for the Research Symposium in Clinical Aphasiology
2015	Graduate Student Scholarship, American Speech-Language-Hearing Foundation
2014	Community Engagement Fellowship, University of North Carolina at Chapel Hill
2014	Student Fellowship, Academy of Neurologic Communication Disorders and Sciences

C. Contributions to Science

1. Integrating stakeholder input from people with aphasia and their families to develop assessment and intervention tools that they find important is a common thread throughout much of my work. My research harnesses mixed method designs to account for the perceptions of clients, family members, clinicians, and other community members during the development of assessment and treatment tools to increase the likelihood that they will be used by clients and provide meaningful information to clinicians.

    a. Pertab, K., **Harmon, T.G.**, Sandberg, J., Evans, W. (submitted). Exploring the Acceptability of Relationship-Centered Communication Partner Training: A mixed-method pilot investigation. Annual Clinical Aphasiology Conference.

    b. Williams, C., **Harmon, T.G.**, Hambridge, T., Brancamp, T., Wallace, S.E., Biel, M., Evans, W.S., Cavanaugh, R. (2022). Exploring post-traumatic growth in aphasia: A qualitative investigation. Aphasia Access Leadership Summit. Durham, NC.

    c. **Harmon, T.G.**, Hardy, L., Haley, K.L. (2018). Proactive social validation of methods and procedures used for training speech production in aphasia. Aphasiology, 32(8):922-943.

2. From my first co-authored publication, I have been involved in research that seeks to understand psychosocial factors in aphasia. These factors play a crucial role on recovery post-stroke as they influence activities, participation, and quality of life.

    a. **Harmon, T.G.**, Nielsen, C., Loveridge, C., Williams, C. (2022). Effects of positive and negative emotion on picture naming for people with mild to moderate aphasia: A preliminary investigation. Journal of Speech, Language, and Hearing Research, 64(3), 1025-1043.

    b. **Harmon, T.G.** (2020). Everyday communication challenges in aphasia: Descriptions of experiences and coping strategies. Aphasiology, 34(10), 1270–1290.

    c. **Harmon, T.G.**, Jacks, A., Haley, K.L., Bailliard, A. (2020). How responsiveness from a communication partner affects story retell in aphasia: Quantitative and qualitative findings. American Journal of Speech Language Pathology. 29(1), 142-156.

    d. **Harmon, T.G.**, Jacks, A., Haley, K. L., Faldowski, R. A. (2016). Listener perceptions of simulated fluent speech in nonfluent aphasia. Aphasiology, 30(8), 922-942.

3. Another focus of my research program is to understand how attentional demands impact spoken language production. The goal of this research is to understand how everyday communication environments impact communication for people with aphasia.

    a. Nelson, B. S., **Harmon, T. G.**, Dromey, C., Clawson, K. D. (in review). Telling stories in noise: The impact of background noises on spoken language for people with aphasia. American Journal of Speech-Language Pathology.

    b. **Harmon, T.G.**, McDonald, E. M., Steele, K. M. (in review). Effects of cognitive and social demands on linguistic production for people with moderate, mild, or no aphasia. Aphasiology.

    c. **Harmon, T.G.**, Dromey, C., Nelson, B., Chapman, K. (2021). Effects of background noise on speech and language in young adults. Journal of Speech, Language, and Hearing Research, 64(4), 1104-1116.

Current and Pending Support

Dallin Bailey
Current support

- Gerontology Program Faculty Research Grant, 2023
    - Project title: "The Role of Mental Practice on Speech Motor Learning in Older Adults and Adults with Apraxia of Speech"
    - Gerontology Program, Brigham Young University
    - Funds requested and awarded: **$9,280**
    - **Not closely related to current project**

Pending support
None

David Wingate
Current support

- CAREER: Blending Deep RL and Probabilistic Programming
    - NSF R1
    - 01/2017 to 02/2023
    - Funds awarded: $525,715
- EFRI C3 SoRo: Between a Soft Robot and a Hard Place: Estimation and Control Algorithms that Exploit Soft Robots' Unique Abilities Blending Deep RL and Probabilistic Programming
    - NSF EFRI
    - 01/2020 to 12/2023
    - Funds awarded: $1,999,984
- NSF EAGER: Harnessing Accurate Bias in Large-Scale Language Models
    - NSF EAGER
    - 09/2021 to 02/2023
    - Funds awarded: $278,914
- MRI: Acquisition of the LanguageLens for Large-Scale Language Modeling
    - NSF MRI
    - 08/2022 to 07/2025
    - Funds awarded: $1,800,000

Pending support

Derek Hansen
Current support

- Collaborative Research: Collaboration in the Future of Work: Developing Playable Case Studies to Improve STEM Career Pathways
    - NSF
    - 07/2019 to 06/2023
    - Funds awarded: $521,418
- LoomVue Browser: Supporting Language Learning with a Dynamic Diglot Weave
    - Institute of Education Sciences (IES)
    - 05/2021 to 04/2023

    - Funds awarded: $900,000
- IT&C Capstone and Cybersecurity Research
    - Department of Energy - Sandia National Laboratories
    - 09/2022 to 08/2023
    - Funds awarded: $20,000

Pending support

- Immersive Problem-based Simulations for Beartooth Digital Twin
    - Department of Energy - Idaho National Labs
    - 03/2023 to 09/2023
    - Funds awarded: $105, 850