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Using Language Science to Promote Interest in Science in a Science Museum

Nikole D. Patson^a, Nathan Baker^b, Sumurye Awani^a, Nicholas Bednar^c and Laura Wagner^a

^aThe Ohio State University, Columbus, USA; ^bMichigan State University, East Lansing, USA; ^cCenter of Science and Industry (COSI), Columbus, Ohio, USA

ABSTRACT

The current study investigated how science museum visitors react to a demonstration based on language science, a topic typically under-represented in science museums. Language science is the interdisciplinary, scientific study of language. It combines social and biological sciences with computer science and engineering, and has strong connections to humanities, education, and clinical fields. Our qualitative analysis revealed that science museum visitors find language science demonstrations engaging and are able to learn key scientific points illustrated in the demonstration. Finally, our data suggest that language science as a topic might be attractive to the subset of museum visitors that are interested in language. We argue that diversifying the kinds of sciences represented in science museums may be one way to broaden interest in science. Language science may be particularly well suited to spark interest in science among individuals who have lost interest in traditional STEM fields but find humanistic disciplines compelling.

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Introduction

Despite the importance of scientific knowledge in everyday decision-making—from deciding whether to get a vaccine, to managing personal stress, to protecting one's health—it has long been noted that there is a general lack of interest and understanding of science among the public, especially in the United States (Funk & Goo, 2015). As the COVID-19 pandemic starkly revealed, an individual's lack of understanding of science can have far-reaching consequences for both that individual and the ability of a nation to combat crises such as pandemics and climate change. As a result, there is increasing recognition that there is a need to increase public trust and understanding of science (Matta, 2020). The goal of this study is to consider how a non-canonical science topic—language science—may be able to serve as a critical means for broadening interest in science among individuals who may not readily resonate with classic

CONTACT Nikole D. Patson  Patson.3@osu.edu  The Ohio State University, 1465 Mount Vernon Avenue, Marion, OH 43302 USA.

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science topics. Given that science museums are a primary mechanism by which individuals develop an interest in science (Fenichal & Schweingruber, 2010), this study examines how families engage with a science activity based on language science information. The results of this work contribute to research on using science museums to spark interest among museum visitors in science topics. Namely, our results highlight that non-canonical science topics may serve an important role in sparking interest in science in individuals from groups that are historically underrepresented in science.

Science interest and engagement

Science interest is a multidimensional construct that can be viewed as a convergence of affective, intellectual, and social components. Our view of science interest is similar to other researchers in informal science education. We view interest as having at least two dimensions: fascination and value (Bell et al., 2019b). That is, people who are interested in science view physical and natural phenomena as fascinating and value the roles science plays in their life or in society more generally. We view sparking interest as an important goal of informal science education because interest drives choices and preferences such as engagement with science.

Engagement with science is another multidimensional construct that has cognitive, affective, and behavioral dimensions (Bell et al., 2019a). Engagement is connected with interest: Individuals are more likely to engage in activities that align with their interests. There are a number of ways people might show they are engaged with science activities. For example, they may have emotional responses, such as frustration or interest, or they may wrestle with new ideas, posing new hypotheses as they try to understand a new concept. Engagement is fundamental to successful learning, as engagement drives interaction and exploration on the part of learners (Kraiger & Ford, 2021). In the context of informal education, engagement with science is a critical goal for any activity designed to increase science understanding among visitors.

Broadening interest in and engagement with science

Reaching a broader audience with scientific information is important because scientific interest and engagement are not equally distributed. Historically, women and individuals from minoritized racial backgrounds participate in scientific fields at lower rates than white men (Arcidiacono et al., 2016; Blackburn, 2017). There are large gender disparities between the number of men and women choosing specific college majors and career paths: women are more likely to choose careers in the humanities and the social sciences, while men tend toward engineering, math, and physical sciences careers (Aud et al., 2010). This gap exists despite evidence that there is no gender gap in aptitude for STEM related abilities (Turner & Bowen, 1999). Instead, there are gender differences in interests and attitudes toward science which may contribute to gender disparities (Hill et al., 2010; Su & Rounds, 2015). For example, in one study of sixth graders' attitudes toward science, girls were more likely to rate science as difficult to understand than boys were (Jones et al., 2000). Importantly, these differences in attitudes and interests related to science may be partially driven by a lack of access for young women and members of minoritized racial groups to engaging opportunities to participate in science (Bevan et al., 2018). Existing research also suggests that these

gaps may be reduced by creating science environments that are designed with the goals and interests of women in mind (Su & Rounds, 2015). This understanding has led to efforts designed to broaden participation in science by increasing opportunities for women and people from minoritized racial groups to participate in science (e.g., Bevan et al., 2018).

The role of science museums

Science museums and science centers are well-positioned to increase public interest in and engagement with science. Throughout most of an individual's life, access to science material will happen outside of a school setting through informal sources such as museums and popular science content (Bell et al., 2009). Indeed, Miller (2004) found that whether or not an adult is an active consumer of informal science material was the second-best predictor of their science knowledge (after having taken college-level science courses). Informal science environments such as science museums are thus an important resource for maintaining interest and access to science throughout the lifespan. Previous research has demonstrated that informal learning in museum settings can successfully generate interest and excitement for science (Anderson et al., 2007; Fenichal & Schweingruber, 2010; Senturk & Özdemir, 2014; Yildirim, 2020).

Science museums are also important locations for fostering interest in science among children. Research on the impact of informal learning in such settings suggests that they are particularly good at generating interest and excitement for science (Anderson et al., 2007; Fenichal & Schweingruber, 2010; Senturk & Özdemir, 2014) at least in part because they allow children the opportunity to explore and be curious without the pressures of testing and assessment found in school-oriented settings. There is even reason to believe that children may learn more effectively in informal settings rather than formal settings (e.g., the classroom), and are capable of learning and retaining some specific science content after a typical (i.e., day-long) visit to a museum (Senturk & Özdemir, 2014; Sturm & Bogner, 2010).

Museum settings are also key for establishing increased understanding of science as a process. Bell et al. (2009) noted that museum settings contribute to an understanding of science as an epistemological approach to gaining knowledge—the so-called “nature of science”. That is, science is not a static body of facts but instead is a process for drawing inferences about the natural world based on observable evidence and is organized around theories that are revisable (e.g., Lederman, 2007). Among college-level students, a genuine appreciation of the nature of science has been shown to improve understanding of specific scientific concepts (Lombrozo et al., 2008). Letting go of the intuitive notion that science is a fixed item handed down by experts and accepting that it is a method that experts use to gain knowledge seems to open up new—and better—ways of engaging with scientific information.

While science museums offer a wonderful opportunity to spark interest in science, these institutions may currently be poorly positioned to broaden interest in science. There is an increasing understanding that science museums may not always be welcoming to diverse audiences (Dawson, 2014). For example, sometimes museum exhibits overestimate how familiar museum visitors are with scientific concepts and jargon. However, another limiting factor in a science museum's ability to broaden interest in

science is that science museums often present only a narrow slice of science domains. While “canonical” STEM fields such as physics and biology are well represented, non-canonical scientific domains such as those in the social sciences receive much less attention. This is unfortunate because studies show that when girls lose interest in science in school, they lose interest in more canonical areas of STEM, but they do not lose interest in all areas of science (Jones et al., 2000). Designing exhibits that introduce museum visitors to topics outside of canonical fields of science may be one strategy for restoring science interest in people who have already decided that physics and biology are “not for them”. In this paper, we argue that language science is an ideal non-canonical field of science to use in generating science interest.

What is language science?

Language science refers to the interdisciplinary, scientific study of language. Language scientists integrate the social and biological sciences along with computer science and engineering to do basic science designed to understand the structure, processes, and use of language, or to address applied questions in the health sciences (speech and hearing), technology (helping to improve AI), or education (second language learning). What ties all of these together is that researchers in language science are applying the scientific method to questions about the nature and function of language. Indeed, language science research has led to increased understanding of the human mind and brain (Friederici et al. 2017; Gentner & Goldin-Meadow 2003; Pullum 2018), improved educational practices (Norris & Ortega, 2000; Seidenberg, 2013), better quality of life for individuals with hearing impairments (Robinshaw, 1995) and language difficulties (Conti-Ramsden et al. 2001; Garraffa & Fyndanis 2020), and facilitated new technological developments (Bender, 2013; Mitkov, 2004). Thus, language science can be used to teach people about specific scientific tools (such as fMRI, spectrograms, neural networks) as well as the nature of science more broadly.

Language science is a good fit with informal science

Our framework for thinking about informal science learning interactions incorporates the six strands set out in the National Research Council report (Bell et al., 2009), which emphasize promoting interest and helping people think about science as a process, as well as the synthesis of successful informal learning methods laid out in Fenichel and Schweingruber (2010), such as promoting interactivity and juxtaposition. Like other language scientists interested in reaching a broader audience (Denham & Lobeck, 2010; Honda & O’Neil, 2017; Lidz & Kronrod, 2014; McKee et al., 2015) we see language science as a good domain to implement best practices. Everyone has a rich set of personal experiences with language that provide them with ample funds of knowledge to draw on; what’s more, they carry around a specialized language production and comprehension machine with them all the time—their own body and brain. Language science activities can therefore be highly interactive as people use their own bodies and skills to engage in behaviors they are familiar with. Moreover, people can be guided to propose hypotheses about their performance which can be tested out on

the spot. For example, in the current study, we used a demonstration (described in detail below) in which being able to read proficiently makes playing a color-naming game difficult. This demonstration draws on people's ample experiences with reading and allows them to not only consider potential reasons that the task is difficult, but to also try doing the task in different ways to see if their explanations are likely. It also allows for a surprising juxtaposition between the role of reading in one's everyday life, where being an efficient reader is a highly desirable skill, and the role of reading in this particular task, where high reading ability makes the task more difficult.

Moreover, although the current study is focused on one language science-based activity, we note that language science offers a wide variety of potential activities to promote informal learning. For example, people can learn about how speech sounds are produced by trying different actions with their own vocal tracts; people can learn about processes that support word learning in children by participating in games where they themselves learn new words; people can explore the distinctive communicative advantages of human language by trying to express things with and without their words. Our group has developed activities that encourage people to interact in an inquiry-based way around many different aspects of language, including, as the current study demonstrates, the process of reading.

Challenges to introducing language science in science museums

Despite the fact that language is often studied scientifically and the clear alignment between language science and the goals of informal science, language science is rarely represented in science museums. This may be because the study of language is often perceived as being primarily studied through a humanities lens where the emphasis is on good writing, the rhetoric of arguments, and learning about other languages and cultures. Importantly, there is a genuine tradition of studying language in this way that goes back at least to Aristotle (Janko translation, 1987) and this tradition remains strong in many academic departments (e.g., English and foreign language departments). Thus, language science is often not considered part of STEM.

Nevertheless, language is a topic that may have broad appeal among science museum visitors. Jones et al. (2000) found that although sixth grade girls were more likely to rate science as difficult to understand than boys were, the girls indicated a strong interest in a language-related topic (animal communication systems). Furthermore, language continues to be an area of focus for women into the college years as women are more likely than men to choose majors in English, communications, and foreign languages (Aud et al., 2010; American Academy of Arts & Sciences, 2015). And Wagner et al. (2022) found that visitors to a science museum had largely positive memories about language experiences, showed high levels of interest in language phenomena, and recognized that some areas of language study are related to science. Thus, a potential advantage of using language science activities in a science museum setting may be that they would be attractive to people who often do not identify with STEM. By showing that language can be studied from a scientific perspective, these activities may motivate such individuals to engage in a deeper understanding of language science and increase the extent to which they identify with science (Walker et al., 2006).

The goal of the current study is somewhat more modest. It is simply to establish what science museum visitors learn from one particular language science demonstration and whether it lives up to the claims we have made for language science in this setting. We used an activity centered on the Stroop Effect (described in detail below) with groups of science museum visitors and observed the visitors engaging with the activity and interviewed them afterwards. We note at the outset that our approach is somewhat exploratory: our aim was to be guided by the actual experiences of the visitors who participated. Our analysis of the results is largely qualitative in nature.

We were interested in the following specific questions:

1. Do science museum visitors find language science engaging?
2. What do museum visitors learn about science from doing a language science demonstration?
3. In what ways are language-based demonstrations attractive to a different audience than other science demonstrations?

Method

Setting

Family groups were recruited for participation from the Center of Science and Industry (COSI), a science center in Columbus, Ohio. Through a partnership between Ohio State University and COSI, The Language Sciences Research Lab (or The Language Pod) operates out of the museum as part of a permanent exhibition. The lab has two primary goals: to conduct cutting-edge research across the language sciences and their related fields, and to connect with the public in the museum to educate visitors about language research and science as a whole (Wagner et al., 2015). To accomplish these goals, study participants are recruited directly from the floor of the museum to experience the scientific process themselves and contribute to ongoing research by associated faculty. The lab also performs a variety of interactive demonstrations with COSI visitors that highlight linguistic phenomena and promote the understanding of language as something that can be studied scientifically. In this way, both research and public engagement are important aspects of the lab's day-to-day operations.

Participants

Family groups consisting of at least one adult and at least one accompanying child under the age of 18 were recruited from the science museum's visitors. We recruited family groups because this is the most common audience for our demonstrations. Furthermore, due to IRB restrictions, we were unable to recruit groups with children unaccompanied by parents/guardians. Groups were approached from the exhibit that contains the research lab and asked to participate by a team of two researchers (an experimenter to conduct the interviews and a demonstrator to facilitate the activity); families that agreed and met participation criteria were brought inside the Language Pod lab space for the study. As a result, this sampling

method reflects that of the general population in the museum as they entered the exhibit throughout the day.

Thirty family groups contributed to the study, including a total of 50 adults and 58 children. The mean number of adults per group was 1.67, and the mean number of children per group was 1.93. Participant ages ranged from 4 to 67 years old. Approximately 79% of participants identified as White, 19% as Black or African American, and 3% as Hispanic or Latino. Fifty eight percent of participants identified as female and 42% as male.

Thirty-eight participants were visiting the museum for the first time, 45 were repeat visitors but nonmembers, and 24 had memberships, which indicates a range of experience with the content of the museum.

Stimuli and procedure

To evaluate the ability of language science experiences to serve as a gateway to science understanding and interest, these family groups were first recorded participating in one of the lab's established interactive demonstrations: the Stroop Effect activity. This activity was selected for being representative of the lab's engagement activities and because it is popular with both the public and lab demonstrators for its game-based, competitive structure. Additionally, the Stroop demonstration sits neatly at the intersection of language and science. Our laboratory's demonstrations vary with respect to how "language-focused" and how "science-focused" they may seem. For example, one of our demonstrations utilizes a large-scale model of the ear and teaches visitors about the mechanics of hearing. For this demonstration, the connection to canonical sciences is fairly transparent. On the other end of the spectrum, we have a demonstration that teaches visitors about the syntax (structure) of hieroglyphs. While the language content is clear, the connection to science is less transparent. Our goal with this study was to begin by investigating a demonstration that on its face does not appear to be about scientific content, but where the connection to canonical areas of science can be made more salient with some discussion.

The Stroop Effect has been extensively investigated in the field of Psychology (see MacLeod, 1991 for a review) and refers to the cognitive interference generated by presenting people with incongruent stimuli and asking them to focus on the less salient dimension. A commonly deployed version of the task uses linguistic material—specifically, color words written in ink that does not match the meaning of the word. Thus, the word "blue" might be written in red ink and the word "red" might be written in yellow ink. To evoke the Stroop effect, participants are asked to identify the color of the ink. The linguistic version of the effect relies on the fact that for proficient readers, reading the written word is an automatic process which happens extremely quickly and without conscious thought (MacLeod, 1991; Stroop, 1935). Thus, the incongruity is present because the meaning of the word conflicts with the color of the ink, and the automaticity of reading ensures that the ink color is a less salient dimension of the words than their meaning. Labeling the incongruous ink color feels subjectively much harder than reading the word, and it objectively leads to slower and more incorrect responses (MacLeod, 1991).



Figure 1. The Stroop Effect as shown in the Coral Technology Stroop Effect app, which was used in this demonstration. Participants are asked to choose the color block at the bottom that matches the color of the letters.

The Stroop Effect was presented to visitors on an iPad app (see [Figure 1](#)). The app operates like a game: players are given 30 s to identify the “ink” color of as many incongruous pairs as they can. Incorrect answers are greeted with a visual signal (the screen shines as if a jolt of electricity went through it); the number of correct answers is provided in a score at the end of the session.

The general script for this interaction can be divided into several phases, each serving to move groups through an experience of the effect for themselves to connecting language science to that experience.

Phase 1: Introduction

The demonstrator begins by explaining how the game works and prompting participants to correctly identify the color of the text as many times as they can within the 30-second time limit. They are told that this interaction has to do with ‘tricking their brain’ but further explanation on the effect or language science is limited.

Phase 2: Experiencing the effect

As participants play the game, the demonstrator prompts them to think about how they feel, how difficult the task is or is not, and what is causing them to make mistakes, with these points being raised as they are relevant to performance within the game. This serves as the observable phenomenon that sets up later hypothesis discussion on the concept of automaticity in reading.

Phase 3: Hypothesis exploration and reflection

After everyone in the group has had a turn to experience the feeling of difficulty that the Stroop Effect presents, they are asked about what might make this task so difficult or uncomfortable to complete; what happened? Here, the participants serve as impromptu scientists and can replay the game while discussing so as to ‘collect more data’. They are guided by the demonstrator to refine broad assessments of difficulty down to specific statements about automaticity. Once they come to this conclusion—that they cannot help but read the word before doing the task they consciously are aiming to do—they are posed another question: if our thoughts about automaticity are true, how might we make the game easier and interrupt this process? Participants then can try their own techniques and are suggested a few with relevant explanations from the demonstrator—focusing on just the edge of the word or blocking some of it from sight, turning the iPad used for the activity upside-down, or using words from a language that they do not know and cannot read may all interrupt their visual processing. They also reflect on individual differences: if this conclusion is true, who might be better at this game, and why? Younger members of the group, particularly those with developing reading skills, may perform the task more easily than those with stronger, more automatic responses.

Phase 4: Homework

To conclude the interaction, participants are told to think about this effect throughout the rest of their day. They are told to try to avoid reading the signs they see after exiting the interview, and while they can try, it is likely they will read automatically before they can interrupt their perception. This serves to continue their own exploration outside of this activity and promote further interrogation into their experiences.

The demonstration was conducted by the same, highly experienced, individual (the 4th author) for all family groups. The activity was conducted as similarly as possible across all groups. However, there was some natural and inevitable variability as different groups responded in different ways to the structured questions after the game, and the demonstrator responded in an appropriate fashion. Following the activity, participants completed a demographic survey: the Activation Lab’s Science Fascination Scale, a brief questionnaire that assesses interest in science (Chung et al., 2016). This instrument consists of 8 statements for which participants indicate the frequency of their engagement, their overall attitude, and their agreement with various statements. Participants also completed the Language Fascination scale, which is an adaptation of the Chung et al. scale that focuses on interest in language (Wagner et al., 2022). The study concluded with an open-ended interview with an experimenter about the activity and about science more generally. The full experimental session took around 15–20 min

to complete. All portions of the session (both the demonstration and the interview) were videotaped for later coding.

Coding protocol

The video recordings of the families were transcribed verbatim. The initial transcripts were reviewed and every contentful utterance about the activity was identified. Statements that were unintelligible, repeated statements, and general discourse (e.g., “yeah”, “I guess”) were eliminated. There were a total of 1499 relevant utterances that were coded. Utterances were also tagged for whether they were produced during the demonstration phase or the interview phase, and whether they were produced by a child or an adult in the group.

The coding used an iterative, emergent coding process (Williams, 2008). This process uncovered four main themes across the demonstration and interviews. These themes were the following: GAMEPLAY discussion, when participants talked about aspects of the game such as their scores, the way the app worked, or encouragement and comments related to friendly competition; STROOP EFFECT discussion, when participants talked about their subjective experience of the effect, including strategies for improving their performance on the task; CRITICAL TAKE-HOME MESSAGE discussion, when participants articulated the core scientific point of the activity, namely, that reading was an automatic process; and SCIENCE discussion, when participants talked about their attitudes and interests related to science. Examples of each of these themes are shown in Table 1.

Once these themes had been identified, every relevant utterance was coded for its embodiment of one of the themes by two coders—one who had participated in the emergent process generating the themes and one who had not (this coder relied on

Table 1. The four emergent themes with their descriptions and examples from study participants.

Theme	Definition	Example utterances
Gameplay	Utterances that capture the experience of playing the game, strictly in the sense of a fun entertaining activity	<i>“I did, I did good at the game but I did like two of them wrong”</i>
Stroop Effect	Utterances that describe people’s subjective experience of the Stroop effect, including descriptions of what they did and/or felt doing the task and strategies employed to improve their performance, regardless of whether or not they were likely to be effective.	<i>“You know what I was doing, I was using your shoulder to knock off part of the word so I couldn’t always read the word I was just looking at the color cause your shoulder blocked out part of it”</i> <i>“Like if it said blue and like the color of the word was blue then it’d be fine”</i>
Critical take-home message	Utterances that articulated the core scientific message of the activity, namely that reading is an automatic process. This code was to be used generously and includes informal statements about how reading is a process that one cannot consciously stop.	<i>“Cause our brain gets so used to, once you learn to read and stuff, you get so used to automatically reading things”</i> <i>“But like, I look over there and read something my brain always does it as long as it’s in my face.”</i>
Science	Utterances about how science works, people’s attitudes toward science (whether positive or negative) and any statement that notes how language can be studied scientifically.	<i>“It’s a way to discover new things”</i> <i>“But I remember I just was never too in to science”</i> <i>“You know like even the language stuff—science makes it happen”</i>

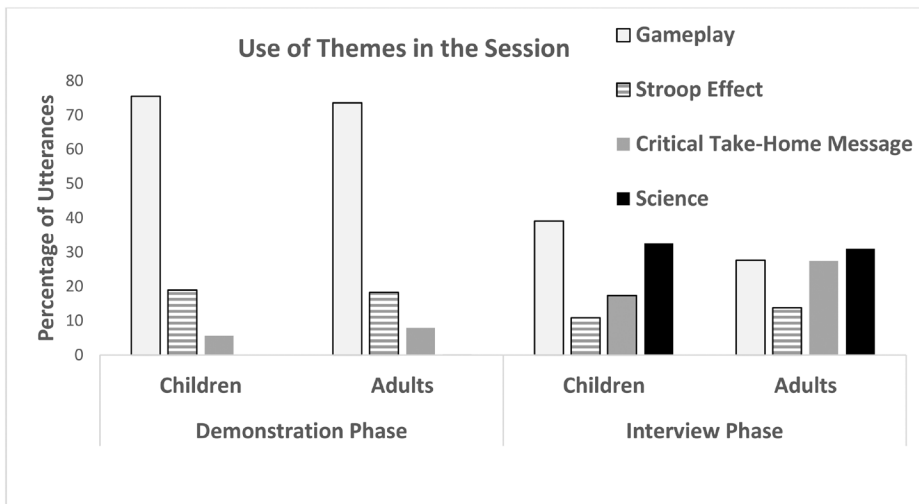


Figure 2. The percentage of utterances across all groups that instantiated each of the four themes. The data is broken down by age group (adults and children) and by the phase of the session (when participants were engaged with the Stroop Effect demonstration and when participants were being interviewed).

the descriptions provided in Table 1). These two coders disagreed on fewer than 5% of the utterances, and those utterances were resolved by discussion.

Results

We note at the outset that our data is largely descriptive in nature. Given the exploratory nature of this study, we were primarily concerned with documenting the nature of visitors' interactions. The utterances were almost perfectly split between the two phases of the study: 49.3% were said during the demonstration phase and the remainder during the interview phase. Adults accounted for approximately two-thirds (63.6%) of all the utterances. The following data descriptions rely on two dependent measures. The first measure was the proportion of utterances that fell into each of the four themes. This measure indicates how the groups distributed their discussion time over the course of the session, and by inference, what themes they found most interesting or important. The second measure was the number of groups that articulated a particular theme (or sub-idea from within a theme). This measure indicates how consistently ideas are evoked by this activity across diverse participants.

Figure 2 shows how children and adults' utterances distributed across the four themes during the demonstration and the interview phases of the study. We did not conduct any statistical analyses on these data, but an examination of the figure suggests that the overall pattern for adults and children is very similar. However, discussion themes seem to vary during different phases of the session. During the demonstration phase, which is the part of the session that most closely resembles the way the activity would be done naturally at the museum, the discussion was dominated by statements related to playing the game but did contain some discussion about the effect itself

and the core take-home message associated with the activity. During the interview phase, which is the part of the session that allowed participants a chance to show what they had learned from the demonstration, the substantive themes related to the scientific content were more prevalent. The next sections consider more specifically how this overall pattern speaks to the three research questions for this study.

RQ #1: Do science museum participants find the demo engaging?

As [Figure 2](#) makes clear, during the demonstration, conversations were heavily focused on the nature and mechanics of the game (75.5% child utterances, 73.6% adult utterances). Moreover, every group made several utterances during the demonstration related to gameplay. This shows that the participants were deeply engaged with the demonstration and were focused on ensuring that they were performing it correctly. However, more importantly, participants made several statements throughout the demonstration that were related to the Stroop Effect itself and to the Critical Take-Home message for the activity. In fact, 25 of the 30 groups mentioned the Stroop Effect and 23 of the groups mentioned the Critical Take-Home message during the demonstration. Thus, even though the groups did not dwell on the scientific content of the game, there is a consistent pattern of each group actively trying to understand the scientific content related to the game, and quite often successfully articulating the critical science content underlying the phenomenon in the game.

RQ #2: What do museum visitors learn about science from doing a language science demonstration?

As noted above, during the demonstration phase, the discussion centered largely on playing the game. However, as can be seen in [Figure 2](#), roughly a quarter of the utterances during this phase moved beyond the game. Looking at the family group level, 25 of the 30 groups explicitly discussed the Stroop effect. Moreover, 22 of the groups accurately described the basic phenomenon, namely, that the Stroop effect causes you to say the word rather than the color of the text. Twenty of the groups discussed how the effect felt (primarily forms of frustration). More interestingly, 19 groups discussed specific strategies for improving their performance, including changing their focus away from the words and explicitly trying not to read. These suggestions are important because they show participants engaging in the inquiry process, and in some cases, allowing the demonstrator to assist in explicit hypothesis testing. For example, when a participant hypothesizes that making reading hard would help them do better, the demonstrator can help them to test that hypothesis by flipping the iPad (and the words on it) upside down.

In addition, most of the groups also talked about the critical take home message at some point during the demonstration phase. Many of the groups ($n=18$) had a fully accurate understanding of the scientific goal of the demonstration. Importantly, though, nearly all of the groups discussed a partial understanding of the critical take home message ($n=21$) and discussed the nature of reading ($n=26$). Looking at the individual responses, many groups discussed an understanding of how quickly the

brain responds to stimuli in the environment and how it works independently from our own conscious control (e.g., *your brain is telling you to do something before you even have the chance to process it right*). The groups that discussed reading understood that once a person becomes a skilled reader, reading becomes an automatic process (e.g., *I'd say just that we read without thinking about it*). What these responses indicate is that although few of the groups explicitly drew these two pieces together, the majority walked away with an understanding of the critical scientific content behind the demonstration.

During the interview phase in the second portion of the session, participants were guided to talk about what they had learned. As can be seen in [Figure 2](#), during this phase, there were more utterances about the science involved. It was also the time when participants were prompted to reflect on their general understanding of science and their experiences with it. When asked to describe what science is, the responses fell into four different categories: 16 groups mentioned that science was a way to figure out how things work, 10 groups discussed how science can be used to learn new things, 12 groups explicitly mentioned the use of experiments, and 16 groups mentioned a specific topic area that scientists investigate. In addition, many of the groups made explicit connections between the demonstration and scientific content. For example, 17 groups discussed what the Stroop effect tells us about how the brain works, and seven groups discussed what the Stroop effect suggests about reading. Finally, two groups demonstrated an understanding that language can be studied scientifically (e.g., *you know like even the language stuff—science makes it happen*).

Taken altogether, these data indicate that science museum visitors can indeed learn about language science from language science demonstrations; most of our groups understood the scientific content from the Stroop Effect demonstration. They also showed that they were able to link this content to their general understanding of what science is and how it works. The one dimension of our work that only a few groups seemed to appreciate was the idea that language per se is a viable topic of scientific inquiry.

RQ #3: in what ways are language-based demonstrations attractive to a different audience than other science demonstrations?

For this question, we took a more quantitative approach to our data. As noted in the methods, we measured interest in science using the Science Fascination Scale (Chung et al., 2016) and interest in language using an adaptation of that scale, the Language Fascination Scale (Wagner et al., 2022). Following the validated practices for the Science Fascination Scale, each level on the scales was assigned a numerical value from 1 to 4 such that higher values indicated increased frequency/interest/engagement/agreement.

Table 2. Mean scores (standard errors in parentheses) for the Science and Language Fascination Scales for adults and children.

	Science Fascination	Language Fascination
Children	1.63 (.08)	2.34 (.1)
Adults	1.56 (.06)	2.02 (.08)

The final score was the average score across all the items. Scores that were above the mid-point (2) indicate an overall positive level of interest and engagement while scores below 2 indicated an overall negative level of interest and engagement.

Table 2 shows participants' mean scores on both the Science and Language Fascination Scales. As can be seen from the data, the participants in our experiment were overall not particularly enthusiastic about either language or science, with the Science Fascination mean scores reflecting negative interest (they are below the midpoint of the scale) and the Language Fascination mean scores reflecting mild positive interest (they are above the scale's midpoint, but not near the scale's ceiling). As we had both scores for each participant, we were able to directly compare them using a paired-samples t-test. The results showed that participants did have significantly more positive attitudes toward language than science, $t(104) = 9.8$, $p < .001$. This result held when we tested adults on their own, $t(48) = 5.7$, $p < .001$, as well as children on their own, $t(57) = 8.5$, $p < .001$.

Importantly, this finding that participants have higher scores for Language Fascination than Science fascination is different from related work conducted in the same location using the same scales. In Wagner et al. (2022) we found that a sample of 660 visitors to the same museum showed significantly higher scores for Science over Language Fascination. Participants in that earlier study, however, did not engage with any language related activity nor were they asked to do so. The different pattern of results on these scales across the two studies, therefore, raises the possibility that museum visitors with a comparatively higher degree of interest in language (over science in general) may be more attracted to language-science demonstrations than those who are more interested in science (than language).

Discussion

The goal of this case study was to provide an in-depth investigation into whether one language science demonstration can be used to promote scientific understanding in a science museum. The broader goal of this work is to begin to explore whether introducing language science within a museum setting can be one way of broadening interest in science among individuals who are less interested in canonical STEM fields. In this study, we explored three research questions:

1. Do science museum visitors find language science engaging?
2. Can language-based content get people to talk about science more broadly?
3. Are language-based demonstrations attractive to a different audience than other science demonstrations?

First, we did find evidence that museum visitors found the Stroop demo highly engaging. This is important because previous work from our lab has shown that, in general, people do not consider language a topic of scientific inquiry (Wagner et al., 2022). This misconception that language can only be studied from the humanities perspective could make it difficult to learn core concepts of language science (e.g., Gil-Perez & Carrascosa, 1990; Yates & Marek, 2014). However, the data here revealed that this was not the case. Participants were actively engaged in not only playing the game, but also in understanding the critical science content. The families all worked

together to describe the effect of the demonstration, and many offered testable hypotheses that helped to further understand the phenomenon.

In addition, participants did talk about science more broadly after engaging with the Stroop demonstration, revealing that language science demonstrations can be used to get people to think about science in general. However, there is a relevant caveat to consider. Wagner et al. (2022) found that while in general people do not consider language a core area of science, there are areas of language study that people find more “science-y” than others, such as hearing science. Arguably, something similar happened in the current study: the way in which participants connected the Stroop demonstration to science was often by talking about the brain, which is something most people consider to be a canonical object of scientific inquiry. Notably, some areas of language science (e.g., hearing science, reading) are more closely connected to canonical areas of scientific inquiry than others (e.g., syntax). As we noted above, the demonstration in this study was more transparently connected to canonical science topics than other language science demonstrations. Future work in our lab is designed to understand whether a language science demonstration’s “science face validity” (i.e., how transparently the topic connects to canonical science topics) affects how likely participants are to make connections between the humanities and STEM.

Finally, we did find that the participants in our study favored language over science rather than the reverse, making our current participants atypical of the wider science museum population (Wagner et al., 2022). This suggests that the demonstrations in our lab may be attracting a subset of the typical science museum visitor who is relatively more interested in language. This is important because it supports the hypothesis that the introduction of less canonical STEM fields into science museums, such as language science, may work to broaden interest in science. Outside of formal educational experiences, science museums are one of the core ways people connect with the scientific enterprise (Miller, 2004). Importantly, not everyone who visits a science museum does so because they are deeply interested in science; people visit science museums for many reasons including entertainment (Dierking & Falk, 1994). One approach to broadening interest in science may be to diversify the areas of science that are represented in the museum, in an effort to generate interest among visitors who may be less interested in canonical science. Much research has indicated that women and some racial and ethnic minorities have lower interest in canonical STEM fields and tend to favor humanistic pursuits (e.g., Aud et al., 2010; Hill et al., 2010; Jones et al., 2000). The fact that there are language topics which are perceived as being primarily studied in a nonscientific manner (Wagner et al., 2022) may help explain why the field of linguistics has been more successful attracting women and nonwhite scholars than other STEM fields (Charity-Hudley et al., 2020). The strong tradition of using humanistic approaches means that language science may be more attractive to individuals who do not readily identify with canonical STEM fields. Engaging these individuals with topics that are already of interest to them and showing them that a scientific approach can be taken with that topic, may motivate them to engage in a deeper understanding of language science, thus increasing their science identity and including more people in the science enterprise (Su & Rounds, 2015; Walker et al., 2006).

Recent work has shown that although science museums intend to be inviting and engaging to a diverse audience, some people may feel less welcome than others. For example, Dawson (2014) found that many science museum exhibits assume a level of “scientific cultural capital” that may not be shared by people outside of the white, middle-class population. In addition, she found that among the low-income, minority ethnic groups included in her study, they did not feel that the cultural capital that they did possess was valued in the museum.

Of course, language science is no panacea for inclusion; however, the introduction of language science could be one way to bring a diverse audience’s experiences and knowledge into the science museum more naturally. This is because language is an inherently personal topic. In previous work in our lab, we asked visitors at a science fair to describe an important “science” memory and an important “language” memory (Wagner et al., 2022). When participants discussed science memories, they tended to focus on a specific activity, often done in school or in a semi-structured environment such as a camp or a museum, such as traditional science class demonstrations (e.g., a frog dissection) as well as fun science demonstrations (e.g., an egg drop experiment). However, language memories were more personal: the majority of language memories focused on foreign language mastery and communicating with people in another language. These personal experiences with language can be readily leveraged during a language science demonstration to deepen understanding of a phenomenon. Indeed, knowledge of another language and the cultural practices surrounding that language are importantly relevant to the field of language science.

Furthermore, language science demonstrations do not require anyone to have specialized knowledge in order to participate and understand. In the Stroop demonstration, one only needs the ability to match colors in order to play the game. Being able to read color words in English (or whatever language the demonstration is being conducted in) is necessary for someone to experience the Stroop effect and is the only knowledge required for understanding it. When people play the Stroop game they feel, in an embodied sense, what is happening and can develop their scientific understanding of the phenomenon based on the phenomenological experience they have while playing the game. This is true of many other demonstrations in our lab where people may be asked, for example, to feel the vibrations in their throat or notice where their tongue is positioned when articulating sounds. These kinds of demonstrations that require no specialized scientific knowledge to understand may be more engaging and welcoming to people from backgrounds that may feel less at-home in a science museum.

In summary, the results of this case study suggest that language science demonstrations can indeed be used to teach scientific content and suggest that these kinds of demonstrations might be attractive to a subset of a typical museum visitor population. Because it is less associated with science, language science may be useful in engaging people who have already decided science is “not for them”. Additionally, the lack of a specialized knowledge requirement and the fact that knowledge of another language and the cultural practices surrounding that language can enhance understanding of the demonstration may make language science demonstrations more welcoming and engaging to a broader audience. Ultimately the goal of any science museum is to help

as many people as possible to connect with the scientific enterprise. Diversifying the scientific content and including topics that may be more attractive than physics or chemistry to other types of people, such as language science, may go a long way to achieve this goal.

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About the authors

Nikole D. Patson is an Associate Professor in the Ohio State University Department of Psychology. She is the PI for the NSF REU Site The Science of Language and the Language of Science which trains cohorts of students to conduct research and engagement each summer.

Nathan Baker is an alumnus of the Ohio State University Psychology Department and is currently pursuing a PhD in organizational psychology at Michigan State University. His current work focuses on issues of employee selection, assessment, and workplace emotions.

Sumurye Awani is an alumna of Wellesley College where she majored in Linguistics. She was a former lab manager at the Language Sciences Research Lab.

Nicholas Bednar is an alumnus of the Ohio State University Linguistics Department. He is currently the Manager of Operational Volunteer Experiences at the Center of Science and Industry (COSI).

Laura Wagner is a Professor in the Ohio State University Department of Psychology. She directs the Language Sciences Research Lab, a research lab embedded in a science museum and committed to engaging with the general public about language science.