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Title

A Cross-Cultural Study of the Complexity of Legal Language

by **Edward Gibson** in **MITHIC SHASS+ Connectivity Fund**

11/22/2024

id. 48899379

Original Submission

11/22/2024

Project Name	A Cross-Cultural Study of the Complexity of Legal Language
Name of SHASS PI/Project Lead	Tristan Brown
SHASS PI/Project Lead Unit	History
Name of Non-SHASS PI/Project Lead	Edward Gibson
Non-SHASS PI/Project Lead DLCI	Brain and Cognitive Sciences
Other Collaborators	Sihan Chen

Research Statement

Across modern civilization, societal norms and rules are codified and communicated largely in the form of written laws. Although principles of communicative efficiency and legal doctrine suggest that laws should be comprehensible to the common world, legal documents have long been attested to be incomprehensible to those who are required to comply with them (i.e. everyone). Why?

Background

Over the last several years, members of Edward Gibson's team in MIT BCS have been investigating these questions in American English. As a first step we documented the cognitive and linguistic factors that make legal documents difficult to understand for non-lawyers in American English (Martinez, Mollica & Gibson, 2022). Text analyses revealed that legal contracts were laden with psycholinguistically complex structures at a strikingly higher rate than nine baseline genres of English. Experiments further revealed that center-embedded constructions, where an additional clause is embedded between a subject noun and a verb (e.g., "It is understood by Lessees, standing liable for violating obligations inter se, herein before set forth in Clause 3 of this real estate agreement, that Lessors shall be exempt from liability for any damages, to the maximum extent not prohibited by law …" from Figure 1 in Additional Materials) inhibited recall and comprehension of legal content more than other features, and such inhibitions affected both lawyers and non-lawyers, suggesting that difficulties in understanding legal content result largely from working-memory limitations imposed by long-distance syntactic dependencies in all humans, rather than a mere lack of specialized legal knowledge.

In a follow-up paper, we extended these results to other legal genres and investigated the cognitive and linguistic profile of law over time (Martinez, Mollica & Gibson, 2024a). Analyzing every law passed by congress between 1951 and 2022 with matched texts from four different genres, we found that U.S. laws have and continue to be disproportionately laden with psycholinguistically complex structures relative to baseline genres of English (Figure 2 in Additional Materials), suggesting that top-down efforts

to simplify legal texts over this period have largely failed.

In two subsequent papers, we investigated why legal actors write in a complex manner in the first place. We found that lawyers likewise struggle to recall and comprehend legal content drafted in a complex register and prefer simplified legal documents to complex documents across virtually every dimension (Martinez, Mollica & Gibson, 2023). We further found that people tasked with writing official laws write in a more convoluted manner than when tasked with writing unofficial legal texts of equivalent conceptual complexity (Martinez, Mollica & Gibson, 2024b), suggesting either that legalese may either be (a) a byproduct of tradition (copy-and-paste hypothesis), or (b) a mechanism to signal the authoritative nature of law, similar to an incantation (magic spell hypothesis).

Proposed research

To further tease apart these hypotheses and to broaden the impact of the research findings, we propose to extend this work cross-culturally, -linguistically and -methodologically. In particular, we propose to study the cognitive and historical origins of legalese in China, in collaboration with Tristan Brown of MIT's History department. Brown has worked closely with the ongoing Comparative Global Humanities Initiative here at MIT, so his presence on our team will further contribute to interdisciplinary team-building at the Institute.

Chinese is interesting in this regard because the Chinese language and the legal culture developed independently from the English legal language and culture. China also possesses the world's longest continuing tradition of written law codes, dating back to Shang Dynasty in 1600 BCE. If there is a cognitive bias to write laws in a complex, center-embedded structure, then we will see this in modern and ancient Chinese, just as we have seen for English. If, on the other hand, the center-embedded structure of English legal language is a byproduct of tradition (possibly initiated in languages which English legal language is based on), then we may see no especially center-embedded structure in Chinese legal texts, relative to the syntax of non-legal language from Chinese in the same time frame. Uncovering which hypothesis is true has important public policy applications, with the potential to inform us whether and how legal language can be simplified to provide the same meanings.

Research Design and Objectives

Aim 1: Are Chinese legal texts hard to understand?

As a first step, we will analyze whether modern Chinese legal texts are also harder for Chinese native speakers to comprehend, like English legal texts for native English speakers, and if so, which features of Chinese legal texts cause the most comprehension difficulty.

In particular, we will translate 12 examples of short contracts to "Plain Chinese," such that they have the same semantic content as the legalese versions but we remove the features identified in Martinez et al. (2022) that might cause comprehension difficulties, such as center-embedding structures and low-frequency words. We will then have 100 native Chinese participants from the crowd-sourcing platform Prolific read these materials,

and answer comprehension questions, and do a recall experiment for these texts.

If there is no overall difference in comprehension and recall on legal texts compared with plain texts, the result will provide support for the copy-and-paste hypothesis, in that the difficulty in comprehending English legal texts is largely rooted in tradition. On the other hand, if there is a difference in comprehension and recall between the two types of texts, more studies are needed to tease out the two hypotheses.

Aim 2: Why are Chinese legal texts hard to understand?

In this study, we will analyze the prevalence of linguistic features that cause greater comprehension difficulty in contemporary Chinese legal texts as identified in Aim 1.

In this study, we will analyze a large sample of legislative acts currently in force, as well as judicial decisions issued by the National People's Congress, the national legislative authority in China, in the last 25 years; compared with a comparably sized sample of contemporary movie subtitles, fiction books, and newspaper articles as a control.

Following Martinez et al. (2022, 2024a, 2024b), we will parse the two texts using state-of-the-art natural language processing tools, including the Stanza parser from the Stanford NLP group. The parser is language-agnostic, and has been previously validated on Chinese texts, though as a sanity check, we will hand-code a sample of 1000 sentences to verify the accuracy of the parser on Chinese legal texts in particular.

After parsing the two texts, we will analyze the prevalence of linguistic features causing comprehension difficulty in both. For example, we will analyze the average syntactic dependency length across all words in the corpora—that is, for each text we will analyze the average distance between a word and its head word in its corresponding sentence. We will also calculate the average word frequency in each text.

If we do not observe a difference in the average syntactic dependency length or word frequency between Chinese legal text and standard Chinese, this result would again favor the copy-and-paste hypothesis.

On the other hand, if there is a significant difference in such features between Chinese legal text and control text, this could be due to two potential reasons: first, the authoritative nature of law requires it to be syntactically complex (magic spell hypothesis from Martinez et al. 2024), or second, Chinese legal texts were influenced by American legalese systems, because of the increase in commercial, governmental, and intellectual exchange between the two countries over the past century. These two explanations will be further disentangled in Aim 3.

Aim 3: Have Chinese legal texts always been hard to understand?

In this study, we will investigate whether Chinese legal texts were already complex when it was first developed, by analyzing whether ancient Chinese

legal texts are laden with complex features relative to baseline controls.

To do so, we will analyze the Tang Code of 652 CE, the first surviving legal code in China, as well as the Qing Code (Figure 3), the most extensive legal code produced in China's history when it appeared in its first edition in 1740. As a control, we will analyze non-legal texts written from approximately the same time period, such as Cao Xueqin's eighteenth century prose novel Hongloumeng (A Dream of the Red Chamber).

The corpus analysis method would be dependent on the availability of automatic classical Chinese parser by the start of this study. If there exists a reliable parser, we will analyze the entirety of the legal codes as well as the control texts, and we will also hand-code a random subset of 250 sentences in each text to verify the accuracy of the parser. On the other hand, if there is not a reliable parser, we will randomly select and parse 2000 sentences in each text by hand.

What would each potential result tell us about each hypothesis?

There are a total of four potential outcomes when we take the results in Aim 2 and Aim 3 together.

First, if we do observe a difference in prevalence in features causing comprehension difficulty between ancient Chinese legal texts and ancient Chinese non-legal texts, as well as that between modern Chinese legal text and modern Chinese non-legal texts, it will provide support to the magic spell hypothesis, in that if such difference persists despite difference in culture between China and the West, it might be caused by the nature of law.

Second, if we do not observe a difference between ancient Chinese legal texts and ancient Chinese non-legal texts, as well as no difference between modern Chinese legal texts and modern Chinese non-legal texts, it will provide support to the copy-and-paste hypothesis, in that the difference in English law is rooted in tradition.

Third, if we do observe a difference between ancient Chinese legal texts and ancient Chinese non-legal texts, but no difference between modern Chinese legal texts and modern Chinese non-legal texts, it will also provide support to the copy-and-paste hypothesis. The lack of difference in modern Chinese texts might have been caused by a language simplification movement (the New Culture Movement) that aims to make written Chinese language comprehensible to everyone.

Finally, if we do not observe a difference between ancient Chinese legal texts and ancient Chinese non-legal texts, but a difference between modern Chinese legal texts and modern Chinese non-legal texts, it will still provide support to the copy-and-paste hypothesis. The difference in modern Chinese texts might have been caused by the influence of American legalese systems due to increasing contact between the two countries.

Aim 4: Multidisciplinary Workshop on Legalese

To help foster further ties between the two schools within and beyond this research project, we will organize and conduct an interdisciplinary workshop on the topic of legal language featuring experts from history, law and computational linguistics.

This workshop will bring together scientists, linguists, legal scholars, and historians to present on the "language" of law around the world. Invited scholars beyond MIT will include

We will ask these experts to present on the nature of legal writing for the place and time they study (i.e., whether it is easier or harder to understand than other contemporary texts). The findings from the workshop will help evaluate our hypotheses regarding legalese: specifically, whether legalese is new or ancient, and whether legalese has increased over time, and if so, why.

Program: We plan four grouped sets of talks and interactive panels on the day of the workshop, separated by coffee breaks or by lunch. Talks will be 25 minutes long followed by 5 minutes for questions. Panels will be one hour long.

Dissemination: Talks will be video-recorded, live-captioned and stored on departmental websites. The website will also include the abstracts.

Description of Multidisciplinary Collaboration

Together, this team brings a unique set of skills to this project, spanning the sciences to the humanities. Edward Gibson has expertise in the complexity of human language, and how it applies to legal language. He has published extensively on this subject. Tristan Brown is a scholar of pre-modern China and a specialist on the historical development of Chinese law. Specifically, Brown can provide examples of Chinese legal writing over the past 1,500 years, which will provide our research group with a representative corpus through which to draw comparative conclusions. Sihan Chen is a native speaker of Chinese and has expertise in corpus and data analysis and has previously published studies on psycholinguistics in Chinese language. And an outside expert, Eric Martinez, graduate of Brain and Cognitive Sciences and a lawyer (LLD Harvard 2019) is a legal language expert, having published heavily in this area.

Project Team:

PI: Edward Gibson, Department of Brain & Cognitive Sciences, MIT
PI: Tristan Brown, Department of History, SHASS, MIT
Grad Student: Sihan Chen, Department of Brain & Cognitive Sciences, MIT
Collaborating consultant: Eric Martinez, University of Chicago Law School

Anticipated Deliverables and Research Dissemination Plan	Upon completion of the research objectives, we anticipate producing 2-3 research papers, each of which to be submitted for publication in a peer-reviewed scientific or history journal. In line with the principles of open and robust science, we will share all data for the projects online in a public repository upon publication. In addition, we will organize and conduct an interdisciplinary workshop on the topic of legal language featuring experts from history, law and computational linguistics.
Potential Impacts	As noted above, the question of why legal language is complicated and how it can be simplified is not only of theoretical interest but of broad practical significance. Over the past 50 years, the United States government has engaged in a series of top-down efforts to simplify legal texts for the public at large, to no avail. Understanding how and why legal language is complex can help inform these efforts in the United States and beyond. Specifically, if our results support the Copy-and-paste hypothesis, it should be theoretically possible to make laws comprehensible to laypeople. On the other hand, if our results favor the Magic Spell hypothesis, it implies there's a fundamental requirement for laws to be hard to understand, in order to achieve their purpose, thus undermining the feasibility of plain–language efforts, On an institute-internal level, these efforts will foster collaborations between the Department of History and the Department of Brain and Cognitive Sciences. Academics in China are also bound to be interested in the results of our research, as our outcomes may well shape discussions of legal language reform beyond North America.

Title

Anthro-Engineering: Decarbonization at the Million-Person Scale

by **Manduhai Buyandelger** in **MITHIC SHASS+ Connectivity Fund**

11/22/2024

id. 48899733

Original Submission

11/22/2024

Score	n/a
Project Name	Anthro-Engineering: Decarbonization at the Million-Person Scale
Name of SHASS PI/Project Lead	Manduhai Buyandelger
SHASS PI/Project Lead Unit	Anthropology
Name of Non-SHASS PI/Project Lead	Michael Short
Non-SHASS PI/Project Lead DLCI	NSE
Other Collaborators	

Research Statement	● Research Statement: We are applying for the SHASS+ Connectivity Fund to expand our ongoing collaboration to prototype and implement human-acceptable household clean energy solutions. We work on low-cost thermal energy storage banks or alternative briquettes, with the intention of combatting climate change, significantly improving household air quality to alleviate respiratory illness, and increasing households' freedom and agency amidst an increasingly energy- and policy-constrained society. Our field site is Ulaanbaatar (UB), the world's coldest capital city and one of the most polluted due to coal-burning as the main energy source. Our project consists of three interrelated areas. (1) The most immediate one is to continue to improve and facilitate usage of our low-cost thermal energy storage prototypes, the technical efficacy of which has been demonstrated in our previous studies, but for which the social acceptance and effects on all stakeholders have yet to be fully identified. (2) To do so, we will explore the continually evolving larger context of geopolitics, policymaking, business development, infrastructure, and lifestyles to integrate the prototype into these shifting contexts (changing it if necessary), and to facilitate new support structures at the household and community levels. (3) We will also quantitatively explore whether expanding options for heating sources will enhance individual autonomy, and will measurably foster a more open, free, and democratic society, where citizens are demonstrably empowered to shape their collective future. Our research is keyed to our co-taught class in the fall semester titled Anthro-Engineering: Decarbonization at the Million-Person Scale and is followed by an immersive, ethnographic research expedition to Mongolia during IAP, with student travel separately funded. By bringing engineering innovation together with anthropological methods and knowledge, our project fully aligns with the goals of the fund: to carry out multidisciplinary projects and build bridges between SHASS researchers and colleagues in other schools at MIT. Our project also pushes the boundaries of our respective disciplines, and we are hoping to innovate both our pedagogy and the research and innovation practices of our respective disciplines for more ethical, integrated, and helpful service for diverse groups of people.
Research Design and Objectives	● Research Design and Objectives: In this section, Part One is an overview of our overall project and Part Two explains the segments of the project for which we are seeking funding. Part One: We combine rigorous design and physical prototyping, finite element method modeling & simulation, and field testing in Mongolia on heat-saving substances with engineering prototyping of a heating device. In doing so, we consider the constantly evolving socio-cultural, infrastructural, economic, geopolitical, environmental, and kinship context of Mongolia's semi-urban neighborhoods. We combine our respective methodologies to bring the technological innovation from the lab to people's homes in Mongolia and, hopefully, beyond. Our research project is unique in three ways. First, as mentioned, it is keyed to a class that is team-taught by anthropologists and engineers (the PIs) in the fall semester prior to January IAP. Second, we partner with the local grassroots organizations, residents of different peri-urban groups, DIY individuals, NGOs, companies, research firms, and most importantly, we collaborate with the NSE and anthropology departments at the National University of Mongolia by integrating students as members of our team to test, prototype, and explore. NUM students will continue our field work with constant remote research meetings, so that our research will continue on-site throughout the year. Third, we will take MIT students for research to Mongolia to live with local families and do prototyping both in individual households and in the labs at NUM, and to do hands-on ethnographic research in different neighborhoods. The students will observe what people do on the ground to keep warm, how their lives are structured around energy usage and conservation, and experience the choking pollution which envelopes the city. The following describes our larger research methods for our IAP trip to Mongolia. 8-10 MIT students from the AnthroEngineering class will travel to Mongolia to do research with us. Our teams will be divided into small groups of 1-2 MIT students paired with NUM students. Together, they will be tasked with a combination of survey creation, administration, and analysis, in-home observational studies, and heat bank system prototyping in order to explore facets of this multidimensional, multidisciplinary problem. The key anthropological and engineering methods in this project are participant observation and prototyping, respectively, though here they are highly coupled activities. Some MIT/NUM student teams will undertake 2-3 of these projects, as they have different durations: some short, some ongoing. The activities will include: (1) Heat Bank Prototyping and Modification. Two MIT/NUM student teams will make modifications to heat banks to make them safer, more user-friendly, and/or more thermally efficient. (2) Sociological Surveys. One MIT/NUM student team will survey residents' interest in testing the heat banks and the difficulties in using it. These students will also incorporate questions surrounding the potential existence of a smokeless thermal energy storage system, seeking to explore the balance between desire to uptake this system and the maximum daily life perturbation(s) acceptable by its users. Another MIT/NUM student team will survey the residents of the apartment district, who do not burn coal but who experience the same level of air pollution as the suburban districts, and to see what they are willing to sacrifice personally and financially to realize a thermal energy distribution system such as ours, which will positively affect their lives in the long run. (3) Formal and Informal Interviews. Another MIT/NUM student team will conduct in-depth, open-ended interviews with the residents of both ger/off grid and apartment/centrally-heated districts to understand how our evolving energy storage system might work for their lifestyle, economic situation, and overall energy landscape. (4) Ger District Participant Observation. All students will conduct extended participant observation by living with their host families in the ger districts of UB. These host families have agreed to test our heating systems. The students will observe and participate in testing these energy systems with these

families in their daily usages. Daily observations will be collected during morning get-togethers at NUM to accumulate data, to formulate new daily research questions, to guide surveys and prototyping, and to ensure that all students are aware of and can perceive the behaviors, initiate the conversations, and conduct the observations necessary to both answer the primary social science research questions as well as to optimize the thermal energy engineering solution in its socio-cultural context.
(5) Workshops to gain local knowledge and hear stakeholders' opinions, interviews will be conducted with select residents, local scholars (anthropology and engineering), local NGOs, activists, and international organizations, all of whom work on similar issues of energy systems and distribution. We will explore answers to our main interviews (mentioned earlier) in a focused group discussion setting.
(6) Trips to Thermal and Solar Power Plants in/around UB. The MIT and NUM students will visit one of the city's main thermal power plants, which burns coal, so they can see firsthand the scale of the pollution being generated there, so they can learn from the plant operators how energy is distributed to the citizens of UB, and so they can understand what happens if the overtaxed thermal plants were to fail. Students will also visit solar power projects under construction around UB, as the >300 days of bright sunlight per year is the most likely carbon-free source of heat to charge their heat banks, in the form of concentrated solar power plants.
All students, both from MIT and NUM, will continue to participate in weekly seminars, debates, and follow-on studies in their respective senior design courses each year. Our goal is the optimization of this heat bank, which raises several fundamental scientific questions. For example, how to design a material with the maximum volumetric heat capacity? How to design a liquid with the highest enthalpy of melting? What are the optimal shapes and sizes of the device depending on the dwelling and circumstances of use?
From an anthropological perspective, we aim to determine the broader impact of enabling city-scale emissions reductions initiatives. In particular, we will test our hypothesis that greater access to diverse sources of energy will facilitate not only economic improvement but also a greater sense of autonomy, fostering a more democratic and less polarized (apartment vs. off-grid dwellers) society overall. In the long-term, our shared goal is to assess the degree to which the clean energy initiative can contribute to a decrease of air pollution and an improvement in public health.
Part Two: For this round of SHASS+ Connectivity Fund, we are applying for funding to fund the following components of our project:
(1) Funding for a postdoctoral fellow. The postdoc will undertake the following: conduct research for developing the concept of Anthro-engineering, co-teach our class, serve as a liaison between MIT and NUM, organize student travel to Mongolia, co-lead students' anthro-engineering research in Mongolia during IAP, develop pedagogical resources and institutional infrastructures that center people, places, and equity in climate and sustainability solution-building. The postdoc will help develop the Living Climate Futures lab in Anthropology and will also redesign, expand, and promote the 21E major to undergraduates, since not many students know about it. The 21E curriculum development will be keyed to themes related to climate change and anthro-engineering.
(2) Two-thirds of a month of a summer salary and (3) travel funds for the summer research for Co-PI Manduhai Buyandelger. The prototyping of the low-energy heating devices involves an acute understanding of the transforming nature of the energy landscape in our field site. Our trips with students during the IAP are too short for an in-depth exploration of the shifts in the geopolitical, economic, and policymaking landscapes of the country. During our IAP trip with students, we also prioritize students' immersive ethnographic research and focus on prototyping our energy storage systems in people's homes. Co-PIs Melenbrink and Short will have their time on the project and travel separately funded through other mechanisms as a method of cost sharing.
Thus, it is necessary that Co-PI Manduhai Buyandelger devote a full summer month (August 2025) for an in-depth exploration of the continually evolving geopolitics, policymaking, business development, infrastructure, and lifestyle transformation. She will expand her existing research network by meeting energy-related scholars, leaders, and decision-makers, and will build a rapport with them in order to do the following: (1) conduct open-ended interviews with government leaders in energy sectors; (2) survey the country's private sector development that focuses on energy systems by conducting interviews with large and small business owners and importers; (3) conduct interviews with scholars and leaders in international relations in Mongolia to learn about the impact of recent geopolitical changes, especially Russia and China's energy-related strategies in Mongolia, on the country's policy-making, energy development, economy, and private sector; (4) conduct participant observations in select districts in UB to document the transformations in household economy, diversity of energy usage, citizens' dependence on government for energy, and public health conditions. By studying these sectors, Prof. Buyandelger will be able to teach the complex shifting contexts in Fall 2025 to prepare our students to better integrate the prototype and to facilitate the development of new support structures in the neighborhoods and households of suburban UB during their IAP research trip in January 2026. By conducting this segment of our research, we also lay out the current conditions (from economy to public health), which we will be necessary for comparison after we get results from our energy source development and implementation.
(3) Travel funds for 2 students for their 2026 IAP travel to Mongolia. We will garner additional funds to support more students from other sources from MIT and beyond.
(5) Travel funds for the postdoctoral fellow to go to Mongolia with students during IAP.

Description of Multidisciplinary Collaboration	● Description of Multidisciplinary Collaboration: Over the past four years, we have led 4 cohorts of MIT students exploring the possibilities of molten salt heat banks through coursework. In fall 2020, Co-PI Short's senior design course at MIT conceived of and prototyped a molten salt heat bank capable of storing ~100 kJ of thermal energy. Further work was conducted in a capstone course in spring 2021, where students focused on delivery logistics for the heat banks. Heat banks could be heated using waste heat from the coal power plants and delivered either to depots in the ger district or directly to residences. The results of the two engineering prototyping courses were evaluated in fall 2022 through a newly created collaborative course, "AnthroEngineering Decarbonization at the Million-Person Scale," co-taught by Profs. Buyandelger and Short. This course challenged students to consider the perspective of the ger residents who would interact with the devices proposed by the engineering students. In January 2023, we took a cohort of 8 students and 3 faculty/staff members to UB to work with the NUM students and local non-governmental organizations (NGOs) to prototype molten salt heat bank within a full ethnographic immersion. Upon returning to MIT, the students participated in another iteration of the engineering capstone class, this time informed by their personal experiences on the ground in UB. Students developed and prototyped an insulating box that would facilitate safe transportation of the heat banks as well as regulate their heat dissipation when placed in a ger. Furthermore, students conducted experiments to compare heating the banks with waste heat in a distant power plant as opposed to induction heating directly in the ger districts. Our cumulative results, shown in Figure 1, demonstrate that each household's daily energy needs can be met with a once-per-day delivery of pre-heated, steel-sealed molten salt. However, at this point, without the substantive funding provided by the SHASS+ Connectivity Fund, this project cannot continue.
Anticipated Deliverables and Research Dissemination Plan	● Anticipated Deliverables and Research Dissemination Plan: Our anticipated deliverables are a physical product, a shift towards a more democratic and free society in Mongolia, and publications that present our research. Specifically, we aim to make clean energy heat storing system coupled with an operation and logistics system, both of which will lead to UB's decreased air pollution, better public health, and a more democratic society that is less dependent on the government. Our equally important outcome is successive cohorts of students trained in Anthro-Engineering: a new, transdisciplinary, human-centered branch of engineering. Finally, we will produce publications (articles, papers, and a book) on the Co-PIs' experience of collaboration. These publications will detail our attempts to expand our disciplinary boundaries, pedagogical experiments, and students' experiences between MIT and Mongolia and between the lab and people.
Potential Impacts	● Potential Impacts: The impacts are to (1) foster the importance of transdisciplinary collaboration, (2) innovate pedagogical experience for students in lab and field via transdisciplinary collaboration, (3) work towards a locally acceptable, scalable, and economically feasible energy storage system that could be modified to use beyond Mongolia (northern Europe, Canada, Central Asian and other parts of the globe that needs clean energy solutions for household heating).

Title

Socio-culturally Aware AI

11/21/2024

by **Graham Jones** in **MITHIC SHASS+ Connectivity Fund**

id. 48891551

Original Submission

11/21/2024

Score	n/a
Project Name	Socio-culturally Aware AI
Name of SHASS PI/Project Lead	Graham Jones
SHASS PI/Project Lead Unit	Anthropology
Name of Non-SHASS PI/Project Lead	Arvind Satyanarayan
Non-SHASS PI/Project Lead DLCI	CSAIL
Other Collaborators	

Research Statement	How do emerging computer science design paradigms associated with the advent of generative AI (GenAI) centrally position anthropology to shape the future of computational technology? In our recent work, we have argued that GenAI has ushered in an era of more open-ended computer systems. Trained to learn patterns from vast datasets of human cultural expression, these technologies exhibit tremendous flexibility in the kinds of input they can parse; they can also produce output that is far more contextually responsive to open-ended interactions with users. We have already demonstrated that models of verbal interaction derived from linguistic anthropology, which emphasize socio-cultural dimensions of collaborative meaning-making, significantly improve our ability to describe the behavior of current systems such as GenAI-powered chatbots (Jones, Satran and Satyanarayan 2024). Moreover, we have theoretically demonstrated that GenAI optimized for socio-cultural awareness should more successfully co-produce meaning in open-ended use scenarios, which suggests more expansive conceptions of socially responsible and culturally sensitive design (Satyanarayan and Jones 2024). In this present project, we propose to develop an experimental interface to empirically demonstrate the feasibility of such human-centered design approaches, and in so doing, further advance the interdisciplinary integration of our respective fields: linguistic anthropology and human computer interaction (HCI).

Research Design and Objectives	GenAI is facilitating a shift from closed design spaces with preconfigured affordances to more open ones. In open design spaces, each time a user performs a task, they can flexibly vary the role they wish to play and have the AI responsively modulate its role to match. Open design spaces herald an era of personalized interfaces, where users are able to shape the interface in an ongoing interaction with an AI agent to match the kind of involvement they prefer for a given task at a particular point in time. Such open design spaces reflect the way cooperative interactions between human co-agents naturally occur. Open design spaces do not obviate the role of designers. Rather, they shift the focus of designers' attention. We expect that focusing on the representations that users and GenAI trade back-and-forth will offer designers a more expressive yet structured approach for opening design spaces: the degrees of freedom by which a design space can be opened map to the semiotic characteristics of these representations. Within the ongoing workflow of Dr. Satyanarayan's lab, we will stand up a research team consisting of: a postdoc recruited from anthropology, computer science, or a related field such as cognitive science; a graduate RA from EECS or TPP; and 1-2 undergraduate UROPs and, ideally, 1-2 MSRP fellows. Following procedures that we have already implemented with current postdoctoral researchers, we will develop a novel experimental interface for simulating open-ended use scenarios in which human test subjects collaborate with an AI agent to complete a series of tasks or solve a series of problems that involve coordinating successive steps. Social psychologists have frequently conducted such experiments to determine how human subjects develop shared understandings and provisional representations to more efficiently solve problems. By modulating the semiotic repertoire available for coordinating joint activity, we should be able to both quantitatively and qualitatively assess how different categories of signs factor into establishing common ground in human-AI collaboration, contributing to more or less efficient and satisfactory task completion.

Description of Multidisciplinary Collaboration	Multidisciplinary collaboration between a qualitative social science such as anthropology and a quantitative, technical field such as computer science holds tremendous potential for bettering MIT and the world. Make no mistake: realizing that potential through substantive interdisciplinary dialogue is a long and laborious process that must begin with a sustained examination of each constituent discipline's underlying assumptions, gradually building toward shared vocabulary and methods. It cannot happen overnight and has significant start-up costs on all sides. Since 2020, the co-PIs have effectively given each other one-on-one tutorials in their respective fields: Satyanarayan has taught Jones not only about the history of HCI and AI, but also schooled him in the associated approaches to design. Jones has helped Satyanarayan become conversant in linguistic anthropology, and familiar with some of the allied fields relevant to this collaboration, notably sociolinguistics and conversation analysis. During this time, we have collaborated closely in multiple capacities. We co-advised HASTS doctoral student Crystal Lee, who since joined the faculty as Assistant Professor in CMS-W. We currently co-mentor one postdoctoral fellow in Anthropology, Dr. Michelle Morgenstern. We have also worked together with three other postdocs, including two supervised by Dr. Satyanarayan, Drs. Vineet Pandey and Amy Fox, and one based in STS, Dr. Shai Satran. We have applied for and received multiple grants, including: a 2022 Bose Research Fellowship for our work on trust in visual information; a 2023 Generative AI Impact Award for our work on agentive AI; and a 2024 CAST Visiting Artist Fellowship for our work on with magician Jeanette Andrews on trust in information. In the process, we have generated multiple research outputs, including an award-wining 2021 paper on scientific misinformation (Lee et al. 2021). As our most recent programmatic publications suggest, this process has been not only a matter of mapping out common ground at the intersection of our respective fields, but also of propounding what practically amounts to a new field. This has been possible because we share a common background in distributed cognition, a branch of cognitive science that concerns the way cognitive achievements such as navigating a ship or piloting a plane involve individual minds, collective institutions, and mediating tools. To put it schematically, it might be said that Dr. Satyanarayan approaches our work as someone who makes the tools—specifically information visualizations—to support cognitive tasks, while Dr. Jones studies the way the culture of collective institutions shapes knowledge and expertise. The overarching preoccupation of our work is to model complex interactions between culture and technology to better describe and evaluate computational tools for improved social impacts.

Anticipated Deliverables and Research Dissemination Plan	Concretely, we anticipate this project will result in the advanced training of a postdoc, an MS student, and several undergrads in interdisciplinary research methods. It will lead to at least one (though probably more) research publications that will demonstrate the empirical validity of theoretical frameworks we have previously described. It entails the creation of an experimental platform and protocol that may serve as the basis for future experiments in coming years. Ultimately, both the methods and results may help revolutionize the way future generations conceptualize the nature of anthropology, design, and the relationship between them.
Potential Impacts	Our work has direct implications for the near-term development of GenAI systems, but its broader implications have to do with a transformation of the relationship between humanism and engineering. Anthropologists frequently decry the negative downstream social impacts of technologies but have little opportunity for involvement in design processes that might produce more desirable outcomes. At the same time, it is not uncommon for designers to be surprised by unforeseen impacts of technologies in real-world social settings that are too complex to model in laboratory experiments. In this context, Drs. Satyanarayan and Jones have been developing new ways of integrating social scientific insights and methods into design practices, offering new approaches to both applying linguistic anthropology to solving design problems and applying design research to advancing anthropological understandings of human visual communication. We are hopeful that our work will eventually culminate in a 21E major in user experience (UX) that with permanently cement this interdisciplinary partnership in the MIT curriculum. We have laid the conceptual foundation for such an interdisciplinary major and are convinced of its viability. The next logical step is developing a research and design protocol for both technological and pedagogical applications. We reasonably expect that any research advances we make will have direct implications for innovative interdisciplinary curriculum that can transform education in both computer science and anthropology, for MIT and the world.

Title

Material and Acoustic Studies of Historic Musical Instruments

11/22/2024

id. 48895993

by **Mark Rau** in **MITHIC SHASS+ Connectivity Fund**

Original Submission

11/22/2024

Project Name	Material and Acoustic Studies of Historic Musical Instruments
Name of SHASS PI/Project Lead	Mark Rau
SHASS PI/Project Lead Unit	Music
Name of Non-SHASS PI/Project Lead	Antoine Allanore
Non-SHASS PI/Project Lead DLCI	Center for Materials Research in Archaeology and Ethnology (CMRAE)
Other Collaborators	Dr. Benjamin Sabatini; CMRAE Prof. Richard Newman; CMRAE, Museum of Fine Arts, Boston; Dr. Jared Katz; Museum of Fine Arts, Boston

Research Statement	This project aims to develop a new framework for studying historic musical instruments by including X-ray Computed tomography (CT), vibration and acoustic measurements, finite element modeling (FEM), numerical sound synthesis, and fabrication methods. The project is a collaboration between the Center for Materials Research in Archaeology and Ethnology (CMRAE) in the Department of Materials Science and Engineering (DMSE), Music Technology in Music and Theater Arts (MTA), and the Museum of Fine Arts (MFA) Boston. The combination of musical, archeological, materials science, vibration/acoustics, and electrical engineering skills needed for this project make MIT a unique location for this research to be possible.
Research Design and Objectives	X-ray Computed tomography (CT) is an undeniably valuable tool for documenting and researching irreplaceable pieces of cultural heritage non-destructively, including ancient and historic instruments; however, cost and access restrictions to it have historically prevented all but a handful of studies. Fortunately, we find ourselves at a convergence, at a uniquely positioned institution, where all the necessary resources are at hand, allowing us to pursue interdisciplinary research leveraging CT in music technology and materials science. Unlike previous studies that have relied on costly medical-grade and custom-built apparatuses, this project will employ high-resolution industrial CT scanners developed by Lumafield, a local company founded by a group of MIT alumni, including a former SHASS student who has supported projects at the Center for Materials Research in Archaeology and Ethnology (CMRAE). The Museum of Fine Arts (MFA), with its collection of over 1300 ancient and historic instruments from around the world, will support this venture by granting access to its collections and a home for the CT scanner. We intend to purchase and place a scanner at the MFA, allowing us to perform scans onsite at dramatically less cost and with far fewer logistical hurdles than transporting and insuring the instruments to offsite locations. Over half of the MFA's instrument collection is in off-site storage, so we will begin by focusing on easily accessible instruments, with the possibility of expanding to additional instruments as the project progresses. To start, we will focus on struck percussion instruments made primarily of metal. Metal percussion instruments are an ideal initial test case as the Allanore research group

specializes in metal characterization, manufacturing, and systems modeling. Following this work, we hope the project will continue and that collaborative projects will be conducted between the MFA, CMRAE, and SHASS, scanning other instruments and artifacts. In addition to our immediate research goals, the opportunity to scan these and other museum objects will revolutionize and reinvigorate the humanities and archaeology, providing faculty, researchers, and students at MIT, the MFA, and throughout CMRAE and SHASS with a combination of opportunity and expertise unheard of elsewhere. Housing the scanner at the museum will provide these institutions and their members with years of unique and impactful research and discoveries.

For the immediate project, we plan to conduct non-invasive vibration and acoustic measurements of the instruments, including laser Doppler vibrometry, a non-contact surface vibration technique that can provide vibrational frequencies and mode shapes. Acoustic measurements will be made with a microphone array to capture their sound radiation profiles, and the CT scans will provide accurate geometry and density information. Combined, these data will allow numerical simulations using FEM (finite element method). The vibration and acoustic measurements can be used to verify FEM simulations and to gain further insight into the materials by optimizing the models to material properties. Additionally, the vibration and acoustic measurements and simulations will be used to create real-time synthesis models of the instruments, allowing for interactive digital copies.

The scans have even more potential, as they can be 3D printed, allowing us to create 1:1 or scaled replicas. The replicas can be used as negatives for casting metal recreations in the same alloys, which can then be worked, and the sound profiles compared to the originals, providing insight into the manufacturing processes and the influence to sound imparted by metal properties such as grain structure and imperfections. Combined with FEM, the recreations can be used for publications, exhibitions, educational settings, and future research. Through our efforts in measuring and creating the models and replicas, the information can be applied to a broader range of research questions while making these objects more accessible to the public.

Description of Multidisciplinary Collaboration	This project is assuredly multidisciplinary, spanning fields throughout SHASS and the School of Engineering (SoE) at MIT and with the curators and scientific researchers at the MFA. Mark Rau is a new Assistant Professor of Music Technology with a joint position between Music and Theater Arts (MTA) and Electrical Engineering and Computer Science (EECS). Mark's work focuses on the acoustics of musical instruments, particularly vibration and acoustic measurement, combined with numerical modeling and sound synthesis. Antoine Allanore is a Professor of Metallurgy in the Department of Materials Science and Engineering (DMSE) and the director of CMRAE. He is best known for his work in electrochemistry, metallurgy, and process engineering. Benjamin Sabatini is a Senior Postdoctoral Associate in DMSE and CMRAE, specializing in archaeomaterials, thermodynamic modeling, and CT. At the MFA, this project will collaborate with Jared Katz, the Pappalardo Curator of Musical Instruments, and Richard Newman, the head of Scientific Research, a CMRAE representative, and professor of art history at Boston College.
Anticipated Deliverables and Research Dissemination Plan	This project will produce articles for top-tier journals, submit papers to conferences, and engage in public outreach through interviews and blog updates on the CMRAE and SHASS websites. For publication, we primarily aim for high-ranking interdisciplinary journals such as Nature Reviews Materials and Plos One, where we could showcase our work to a large readership and audiences knowledgeable in materials and acoustics. We will also aim to publish in the Journal of the Acoustical Society of America and Archaeometry or similar, depending on the results of our research and the publisher's expertise. Dissemination of our results is of the utmost importance, so we plan to present at conferences such as the Acoustical Society of America, International Symposium on Musical Acoustics, Forum Acusticum, the Archaeological Institute of America (AIA), Archaeometry, especially sessions on archaeomusicology, the European Association of Archaeologists (EAA), and others in the humanities such as the Society for Cultural Anthropology and the Society for American Archaeology. In addition to the academic community, we intend to present the results of this project to the general public. We will create an interactive exhibit at the MFA in the musical instrument gallery, including synthesized sound and physical models of struck percussion instruments, allowing museum patrons to experience historic instruments beyond simply viewing them behind glass. Displays and descriptions of the scientific methods and key points in our research process will accompany the exhibit. We also hope that MIT students and faculty will be interested in incorporating our models and recreations into their performances. These models would allow them to play accurate copies of historic instruments or even hyper-instruments that augment their typical performance range but are designed based on scientifically measured and recreated originals.

Potential Impacts	This project's scope is ambitious, incorporating CT scanning, materials science, archeology, vibration and acoustic measurements, numerical modeling, sound synthesis, and the production of accurate recreations. We believe this research will revolutionize the way historic instruments are studied, preserved, and interacted with by the public at large. This all-encompassing framework will provide conservationists with invaluable information, helping preserve our irreplaceable cultural heritage. In particular, using sound measurements and models combined with CT and materials analysis will provide a standardized framework for analyzing historic instruments, framing them as continuously playable rather than purely objects for study. We hope our results spark curiosity and further investigation by ethnomusicologists and archeologists, who have not had, but sorely want, the information this project will provide. The Music Technology and Computation Graduate program at MIT will begin accepting students in the Fall of 2025, and this project will undoubtedly be attractive to them while providing a long-term research direction for Professor Rau's group. We foresee this project leading to the development of an enhanced curriculum in multidisciplinary music technology, history, and archaeology. It would contribute to currently planned course offerings, including those proposed by Professor Rau and envisioned at CMRAE. The timing is fortuitous, as CMRAE is expanding its research group and course offerings. A project of this scale and scope would be ideally positioned to benefit archaeology, music technology, and the Institute through inspiring and unique research and education. Doctor Sabatini plans to offer a class in advanced materials studies at CMRAE that will incorporate CT in addition to materials and modeling, statistics, and directed student projects. This can all be realized by placing a CT scanner at the MFA since it would allow us to study any object/artifact in the museum that can fit in the device chamber. Of note, the chamber dimensions are more suitable for musical instruments and artifacts than a medical-grade scanner, and for larger objects, the scans can be performed in sections and joined in software. In addition, CMRAE is a consortium of member institutions from the greater Boston area, including Harvard, Boston University, Tufts, Wellesley College, the University of Massachusetts, Brandeis, and the MFA. With the support of MIT and the similarly focused goals of these institutions, we can all but guess that this project will garner interest both here and internationally. Public outreach is a necessary aspect of this project. We intend to install a semi-permanent exhibit in the musical instrument gallery at the MFA. This exhibit will include information about the materials, the sound of the instruments with downloadable digital copies, and, above all, information on our research and research collaborations at MIT. To attract students to archaeology and music technology, we will prepare and present our work and potential projects at venues such as the DMSE expo, SoE UROP mixer, and music technology events.