MULTIMODAL COMMUNICATION IN AMBIENT INTELLIGENT ENVIRONMENTS: USING GESTURES IN TRANSACTIONAL HUMAN-SYSTEM COMMUNICATION.

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ABSTRACT

Technology is moving beyond the screen. The new technological landscape integrates and connects technology with everyday objects, which rapidly decreases its visibility to the human eye. This connected universe calls for a change in how researchers perceive human-computer interaction, as human beings will no longer interact with a single device, but with a complex web of devices and information systems. As such, research must answer the question: when technology is invisible, how can humans communicate with information systems while maintaining an interactive and symbiotic relationship with technology? Studies have already detected that computers are social actors and anthropomorphized for humans to adapt and identify with the system. It naturally follows that technology should strive to incorporate all natural communication methods like nonverbal, verbal, written and visual communication to shift the burden of interpretation to the system and create intuitive experiences for its users. Multimodal communication is a broad field, and in an effort to carve out a small piece of the pie, this study focuses on gestural communication modalities in transactional human-system communication (HSC) in ambient intelligent environments.

Keywords: communication, ambient intelligence, kinesics, gestures, ASL, natural language

INTRODUCTION

Current technology is divisive, not only in terms of class and access (aka: wealth), but also in terms of ability and knowledge. Today communication with systems is limited in the way information is input (e.g., typing on a keyboard) and users are required to understand how systems work in order to accomplish a specific goal; placing the burden of knowledge on the user. Over the years, companies have shifted their priorities to create more natural user interfaces, but the steps taken still require people to use only one mode of communication (e.g., voice) and limit the experiences to the confines of a device (e.g., screen or robot). Screens do vary in size and information is now carried between devices, but people still continue to move between two worlds: a digital world and a physical world.

The current technological trajectory will merge both the digital and physical world into an integrated world, where people will exist in physical space with multiple digital layers. The new world is comprised of individual or community-based environments, which perceives and responds to the presence of each person and presents unique images, characters, temperatures, colors and scents based on the user's preferences, learned organically over time. This concept is referred to as "ambient intelligence" and is characterized by five individual constructs: embedded, context aware, personalized, adaptive and anticipatory (Aarts, Harwig, & Schuurmans, 2001). Ambient intelligence and networked devices (Internet of Things) are working together to remove the device from center stage. The human body and mind can abandon the false barriers of keyboards and mice to return to the physical nature of the world. The one caveat for this shift requires a significant change to how humans interact with invisible systems.

Science has been using the ideas found in nature as inspiration for technology, creating flexible and intuitive systems that can adapt and learn over time. The same idea of finding communication tools already in practice should be studied when developing interactions between humans and systems. Creating and advancing research in multimodal communication inputs for systems allows users the flexibility of engaging the entire body in communication, pushing the burden of interpretation on a system that can process and predict information quickly and efficiently. Shifting the cognitive load from the user to the system opens the possibility of returning to a natural communication pattern; the way humans send and receive communications. This study focuses on gestural communication modalities in transactional human-system communication (HSC) in ambient intelligent environments.

LITERATURE REVIEW

Developing the appropriate communication systems must begin with how humans interact with technology. Research in the early 1990s suggests humans automatically apply social rules, like politeness and social voice recognition to their interactions with computers (Nass, Steuer, & Tauber, 1994) and that people have a tendency to connect with and assign human qualities to objects regardless of the complexity of the interaction (Reeves & Nass, 2006). In fact, in Reeves and Nass' study, they discovered people need very few social cues from computers to respond socially and do not even realize their response is based on the interaction with the object. This indicates human beings are patterned to respond socially, even if the interaction is with an object. The idea behind social responses is the mindless tendency to anthropomorphize computers. This phenomenon was analyzed in a study where participants interacted with a human-like virtual agent on a health website. Kim suggested mindless social responses are triggered by cues in the interface and result in the automatic assignment of human traits to virtual agents along with use of the appropriate social norms (Kim & Sundar, 2012). Another recent study looks into the differences in social responses. One condition used a remote control and the other used voice control when watching television. The study revealed voice control when paired with a cartoon-like agent produced a negative user response and when paired with a realistic image of an agent, produced a positive response. This uncovered a new potential factor that could influence a positive social response: matched or paired input modalities (Sah & You, 2014). However, this study may not take into consideration the "uncanny valley" factor, which hypothesizes that humans are repulsed by images that look, move and respond too closely to the real humans (Mori, 1970) and further investigation into the negative responses to the realistic image should be explored. However, paired modalities add an additional component to selecting the appropriate communication tool and play an important role in our future interaction paradigms.

Another field of exploration in communication is inspired by the general principles of nature: movement based on insects (Full, Kubow, Schmitt, & Koditschek, 2002), robots mimicking empathy (MIT Media Lab) and progressive learning techniques (iCub, 2010). The field of robotics is working towards a literal translation of nature making it easy to relay the concept that communication with systems can incorporate more than text. But robots are solving different problems. The ability to interact with visible objects is the reverse of what ambient intelligence is attempting to accomplish and may be geared towards a class of people where there is adequate square footage/meters to accommodate additional objects. The importance of the work in robotics signifies the trend in creating more natural interfaces; and an increase in the understanding of the human body and human response mechanisms. The human mind collects and processes large amounts of data, using filters and channels to maintain the attention to the needed area (Broadbent, 1982). Much like the human mind, data processing requires a highly complex system to collect, filter and analyze data. Since storage capacities have increased and the size of hardware has decreased, the potential for information processing has grown to include all aspects of the human body: facial expressions, body language, gestures, sounds, symbols and directional gaze. The entirety of the human communication model can be captured, stored and analyzed to communicate between human and system. In addition, the mass amount of data collection and repetitive instances allows systems to progressively learn context and eliminate the need for human beings to explicitly state each step in the process, placing the burden of information processing and interpretation on the system. One example of this concept in reality is a thermostat that gathers data based on current temperature, user proxemics, Internet data and user history to monitor and manage the household environment (Nest). In this example, Nest bears the brunt of information processing and interpretation and reduces the need for users to program or control the temperature.

But Nest is a quiet device nestled on a wall, dependent on pre-programmed data collection with a single goal: control the temperature. The whole system can only perform a single task, which is not to discount its importance, however a system that is built to understand complex ideas cannot remain a silent partner. It will need to engage the user in a way that compliments the interaction. Human beings will mindlessly engage in social practices when presented with images of people on a screen, but people will also imagine a virtual partner when confronted with text (Clark, 1999) and when interacting with a disembodied voice (Lee & Nass, 2004). These findings bode well for screen-free human-system interactions and the user's ability to adapt to invisible technologies, whose communication output is likely to be disembodied.

Multimodal communication engages the idea of social presence, which describes the extent to which a computer is perceived as sociable when it is used to interact with others (Lombard & Ditton, 1997). When communicating between humans and computers, studies have reported an increased perception of social presence in audio-conference conditions than in text-chat conditions (Sallnäs, 2005), indicating that audio is more likely to engage the idea of social presence in the minds of the user.

One possible theoretical model in explaining the human-system interaction is the Interaction Adaptation Theory (IAT), which explains how dyads coordinate communication and adapt to individual communication styles. According to IAT, people respond to each other in complementary ways, adhering to a norm of reciprocity (Burgoon, Stern, & Dillman, Interpersonal Adaptation: Dyadic Interaction Patterns, 1995). In multimodal communication between humans and systems, the system would be required to take on the burden of coordinating its communication style with the person and attempt to uncover the individual's requirements, expectations and desires in order to create a dynamic, dyadic relationship. This natural style of communication means systems would need to interpret and respond to changes in human beings' cognitive load by switching between communication modes as the task increases in complexity (Oviatt, Coulston, & Lunsford, 2004). Natural language demands that systems interpret multiple inputs from speech, gestures, facial expressions, touch and text.

Psychologists have been working on the meaning and significance behind facial expressions, body postures, body position and location in a room. Everything we do has meaning and technology is on the cusp of being able to identify key behaviors and adapt to individual user behavior over time. Incorporating multimodal communication permits several natural human communication inputs to be interpreted by systems. Among the myriad of ways humans communicate with one another, one primary area of natural communication is the language of gestures.

SIGNED LANGUAGE AND GESTURES

Any language serves two purposes: (1) to symbolize a thing and (2) communicate the relationship between things (Armstrong, Stokoe, & Wilcox, 1995). Visible gestures have meaning, whether they are constructed or simply a supplementary part of expression. All cultures use gestures to communicate; in North America, if we raise our middle finger and collapse the remaining fingers, we are expressing anger. We extend our index finger, we are indicating direction. We wave our hands to say hello and goodbye and spread our fingers and push our hand out forcefully to indicate stop. If technology is going to expand our idea of human-computer interaction beyond the screen, researchers must evaluate how best to communicate in this new physical space. This study is an exploration of two very distinct types of North American gestural categories: the first is signed language (ASL) and the second is supplementary gestures as typically combined with verbal speech. Regardless of the type of language, spoken language, signed language or supplementary gestures, like voluntary gestures and gesticulation accompanying speech, they each serve people to facilitate social interaction.

SIGNED LANGUAGE

Sign language is a natural language, meaning it arises unpremeditated in the human brain. Deaf babies start learning language by babbling with hand gestures (Levine & Munsch, 2010), and hearing babies will often use gestures prior to speech and then combine both gesture and speech to communicate more complex ideas (Volterra, Caselli, Capirci, & Pizzuto, 2005). This clearly indicates gestures are a significant part of language development regardless of one's ability to hear. However, the two languages diverge after the initial development stage.

Signed language has its own unique syntax and uses all three dimensions to communicate (Emmorey, Kosslynb, & Bellugi, 1993), relying on the use of (1) configuration, (2) location and (3) action or performance of the hands (Armstrong, Stokoe, & Wilcox, 1995) to communicate complex thoughts. The difficulty with spoken language is its linear nature; requiring a story to unravel as speech continues. For example, the phrase "slammed on his brakes" takes four words to speak, but only one sign. This makes signing an efficient and complex communication tool.

Scientists have learned a lot about the relationship humans have with computers over the past few decades. Part of what makes the communication effective on the computer is the matched modalities: we type text on a keyboard and receive text back to read. We speak into a microphone and we hear an audio response. A mismatch in communication modalities reduces the task outcome (Burgoon, Bonito, Bengtsson, Cederberg, Lundeberg, & Allspach, 2000), suggesting that matching modalities becomes increasingly important for positive task outcomes. In an ambient intelligent environment the interaction takes place in a physical space and has the potential to support multiple modes of communication, which could indicate the need for communication to use the physical space and the human body as the affordance. For instance, in a smart home the user could ask the system to close the blinds. This could be accomplished with (1) a voice command with the input modality being verbal and the output being a closed blind, (2) a sign for “blinds close”, in which the input is a signed language and the output is a closed blind, and (3) a gesture for “blinds close”, in which the input is a gesture and the output is a closed blind.

Signed language could also support new interfaces that don’t rely on the keyboard input. Imagine trying to crop a photo on your computer. The user uses a pad or a mouse to drag the cursor to the desired tool, clicks on it and then drags the cursor to the photo, makes the edit, moves the cursor again to select file, then save as, then types in the name of the file, chooses its location and the task is complete. In a world of multimodal communication with signed language, the user could use a voice command like, “modify photo”, to open the photo, manipulate their fingers into an already constructed vocabulary for communicating the concept of crop/cut (e.g., scissors). The user would indicate when the modifications were complete, verbally name the image and the file would be automatically saved. The user could choose to specify the location or use a default folder for file storage. Ideally the system would create tags relevant to search and having user-generated information architecture and taxonomy would not be a supplemental task. Relying on text-based or voice commands alone for each step is not practical and prohibits the user from becoming fully immersed in both the physical space and the task.

The issue with signed language is similar to spoken language: each region has a specific syntax and culturally specific signs, meaning there are multiple signed languages. As such, ASL follows a North American signed vocabulary, syntax and visual expressions. It relies on the hands to communicate the words, motion to provide meaning and context and facial expressions to convey emotion and linguistic structures (Liddell, 1984).

Studies today focus on how systems recognize sign language from an accessibility viewpoint. In the late 1990s, researchers worked on wearable solutions to recognize and translate American Sign Language (Starner, Weaver, & Pentland, 1998). This recognition and translation work continues in 2011 with sensory gloves (Oza & Leub, 2011). While this research is imperative for the future of gesture recognition, it is solving an accessibility issue; not a global input system. It is not known yet whether signed language is the appropriate modality for communication in a physical space and needs to be studied as a possible global input modality for interaction with ambient intelligent environments.

SUPPLEMENTARY GESTURES

Supplementary gestures at a high-level use the same principles of configuration, space and motion, but it lacks the predictability of an official language. Early research suggests that we use our hands in physical space to help convey thoughts. As children develop, the act of pointing one's finger is viewed as the royal road to language development as it serves three purposes: (1) requires someone else's attention, thus dialogic, (2) serves to single something out, and (3) provides directional guidance (Butterworth, 2003). Pointing symbolizes direction and communicates the relationship between the thought and the object, replacing formal language. In the beginning stages of development hearing children will combine gestures (e.g., point) and speech (e.g., 'eat') to aid in communicating complex thoughts and sentence structures.

Early childhood development is a positive starting point in developing a system for human-system interaction because it's this innate function of communication that will be reinforced and persistent throughout life, thus making it easier for adults to incorporate this natural communicative expression.

But all gestures are not as simple as pointing towards an object. Gestures can be complex, such as an open right hand moving diagonally left and clasping the left index finger. The meaning behind this gesture could be an illustration of an animal pouncing on prey, a shark attack or any number of imaginative responses. Gestures are singular and live on the same plane (not in a hierarchy), they are context-sensitive and different combinations of gestures provide different meaning (McNeil, 1992). But these meanings can be challenging to unpack, since they rely so heavily on spoken language to provide context for the gesture. What gestures do well is communicate simple directional guidance and potentially some emotion (Armstrong, Stokoe, & Wilcox, 1995).

If technology is moving towards building ambient intelligent environments, the appropriate foundation work for discovering the potential between human and system interactions. Science must not limit themselves to only understanding the limitations of our culture today, but work towards creating a system wherein the next generations can take advantage of complex communication with systems in a natural, non-programmatic way.

RESEARCH METHOD PROPOSAL

EXPERIMENTAL DESIGN

Using an experimental research method, this study will focus on gestural communication modality in ambient intelligent environments. Participants are in an empty room by themselves with two pieces of visible technological equipment: a single screen and a web camera. The screen will only display progress of the transactional commands and the camera is used to stream visual information to the 'ambient system'. As access to an ambient system is limited, an ASL-fluent person would act in place of the ambient system and is tasked with interpreting the gestures from the user in several conditions. As the interpretation is key, the 'ambient system' will be recorded for future research interest in this process.

ACTIVITY

The goal of the participant is to stack ten to thirty colored blocks in the fewest number of steps, in the least amount of time and leave with an increased feeling of satisfaction/liking towards the system.

CONDITIONS

The experimental study will be broken into six specific conditions: (1) verbal only, (2) ASL only, (3) gesture only, (4) multimodal: verbal and signed language, (5) multimodal: verbal and supplementary gestures; and (6) multimodal: free-form using all available communication modalities

	Verbal	Signed Language	Supplementary Gestures
Condition 1	x		
Condition 2		x	
Condition 3			x
Condition 4	x	x	
Condition 5	x		x
Condition 6	x	x	x

HYPOTHESIS

H1: Individuals who complete a task in the fewest number of steps and in the least amount of time will express more liking towards the "system".

H2: Multimodal communication systems will be significantly correlated with "liking" of the system.

H3: ASL-fluent + verbal participants in any multimodal condition will be significantly correlated with the fewest number of steps, the least amount of time and an increased "liking" of the system.

H4: Liking of the system will be mediated by social presence and trust.

PARTICIPANTS

The participants are broken out into three specific categories: those with low or no ASL experience, some ASL experience and a lot of ASL experience. Each group will be assigned to a ten, twenty or thirty block scenario and all would be subjected to differentiating between at three colors, black, white and red, to accommodate for anyone with color blindness.

At the beginning of each ASL session, the researcher will review the required signs required to complete the task and each participant will be given ten minutes to practice. A piece of paper with the commands will be in the participants view to enable continuous access to information. In the gesture-only conditions the system is required to learn the gestures and is relying on the participant to image the gestures required in communication.

MEASURES

Social Presence (Gefen & Straub, 2003)

- I felt a sense of human contact with the system.
- I felt a sense of personalness in the system.
- I felt a sense of human warmth in the system.
- I felt a sense of sociability in the system.
- I felt a sense of human sensitivity in the system.

Trust (Wang & Benbasat, 2007)

- The system was competent.
- The system performed its role of building the house very effectively.
- Overall, the system was capable of understanding my commands.
- I believe that the system's dealings with me were in my best interest.
- The system's dealings with me felt like that it would do its best to help me.
- The system's dealings with me felt like that it was interested in my well being; not someone else's.
- I would characterize the system's responses with me as honest.
- The system appeared unbiased.

Satisfaction/Liking (Koufaris, 2002)

- Interacting with the system is enjoyable.
  Interacting with the system is exciting.
- Interacting with the system is pleasant.
- Interacting with the system is interesting.
- Interacting with the system is fun.

DISCUSSION

Spoken communication is steeped in cultural complexities, grammatical challenges and is fully dependent on context to establish meaning. But language can be simplified and adapted to suit the growing technological world. Ajit Narayana discovered people convert multidimensional thought into speech by answering only a handful of basic questions: who, what, when and where (Narayanan A. , 2013). Drawing from the very basics of language, he created a universal pictorial language to help autistic children communicate complex thoughts. He even hopes to use this system to revolutionize the way we learn languages – not as translated from the mother tongue, but from a tabula rasa state, as though we are learning a mother tongue. In the same vein, McWhorter is illuminating how texting has evolved the written word through communicating complex thoughts through abbreviations, acronyms and shorthand – essentially using speech to inform the way we write (McWhorter, 2013). Both of these examples speak to how people are adapting language to communicate complex thoughts in ways that align with the technological environment. If spoken language can be converted into pictures and shorthand text while maintaining the complexities of a typical communication exchange, using the fundamentals of ASL can drastically change the way we envision the future of communication with ambient intelligent environments.

In short, limiting the use of sign language to address an accessibility challenge for the hearing impaired misses the opportunity to use a primary language designed to create meaning within a physical space. These qualities alone elevate the importance of considering sign language as a fundamental human communication language with systems.

WORKS CITED

Aarts, E., Harwig, R., & Schuurmans, M. (2001). Ambient Intelligence. In P. J. Denning, *The Invisible Future: The Seamless Integration of Technology into Everyday Life* (pp. 235-250). New York, NY, USA: McGraw-Hill.

Armstrong, D. F., Stokoe, W. C., & Wilcox, S. E. (1995). *Gesture and the Nature of Language.* Great Britian: Cambridge University Press.

Broadbent, D. (1982). Task combination and selective intake of information. *Acta Psychologica* , 253–290.

Burgoon, J., Bonito, J., Bengtsson, B., Cederberg, C., Lundeberg, M., & Allspach, L. (2000). Interactivity in Human-Computer Interaction: A Study of Credibility, Understanding, and Influuence . *Computers in Human Behavior* , 553-572.

Burgoon, J., Stern, L., & Dillman, L. (1995). *Interpersonal Adaptation: Dyadic Interaction Patterns.* New York: Cambridge University Press.

Butterworth, G. (2003). Pointing is the royal road to language for babies. In S. Kita, *Pointing : Where Language, Culture, and Cognition Meet* (pp. 9-33). Mahwah, N.J.: L. Erlbaum Associates.

Clark, H. H. (1999). How Do Real People Communicate With Virtual Partners? *AAAI Technical Report.*

Ekman, P., & Rosenberg, E. L. (2005). *What the Face Reveals: Basic and Applied Studies on Spontaneous Expression Using the Facial Action Coding System (FACS).* New York: Oxford University Press.

Emmorey, K., Kosslynb, S. M., & Bellugi, U. (1993). Visual imagery and visual-spatial language: Enhanced imagery abilities in deaf and hearing ASL signers* . *Cognition* , 139-181.

Full, R., Kubow, J., Schmitt, P. H., & Koditschek, D. (2002). Quantifying dynamic stability and maneuverability in legged locomotion. *Int. & Comp. Biology* , 149-157.

Gefen, D., & Straub, D. (2003). Managing User Trust in B2C E-Services. *e-Service Journal , 2* (2), 7-24.

iCub. (2010). *iCub*. Retrieved 06 21, 2014, from iCub: http://www.robotcub.org/

Kim, Y., & Sundar, S. S. (2012). Anthropomorphism of Computers: Is it Mindful or Mindless. *Computers in Human Behavior* , 241-250.

Koufaris, M. (2002). Applying the Technology Acceptance Model and Flow Theory To Online Consumer Behavior. *Information Systems Research , 13* (2), 205-233.

Lee, K. M., & Nass, C. (2004). The Multiple Source Effect and Synthesized Speech: Doubly-Disembodied Language as a Conceptual Framework. *Human Communication Research , 30* (2), 182-207.

Levine, L. E., & Munsch, J. (2010). *Child Development: An Active Learning Approach.* London: Sage Publications.

Liddell, S. (1984). Think and Believe: Sequentiality in American Sign Language. *Language* , 372-399.

Lombard, M., & Ditton, T. (1997). At The Heart of it All: The Concept of Presence. *Journal of Computer Mediated Communication , 3* (2).

McNeil, D. (1992). *Hand and Mind: What Gestures Reveal About Thought.* University of Chicago Press.

McWhorter, J. (2013, 02). *Txtng is killing language. JK!!!* Retrieved 07 22, 2014, from Ted Talks: http://www.ted.com/talks/john_mcwhorter_txtng_is_killing_language_jk

MIT Media Lab. (n.d.). *MIT Media Lab*. Retrieved 06 01, 2014, from Leonardo: http://robotic.media.mit.edu/projects/robots/leonardo/socialcog/socialcog.html

Mori, M. (1970). The Uncanny Valley. *Energy , 7* (4), 33-35.

Narayanan, A. (2013, 02). *A Word Game to Communicate in Any Language*. Retrieved 07 22, 2014, from Ted: https://www.ted.com/talks/ajit_narayanan_a_word_game_to_communicate_in_any_language

Narayanan, A., Manuel, D., Ford, L., Tallis, D., & Yazdani, M. (1995). Integration of Natural Language and Vision Processing. *Artificial Intelligence Review , 9* (2-3), pp. 215-235.

Nass, C., Steuer, J., & Tauber, E. R. (1994). Computers are Social Actors. *Human Factors in Computing Systems* (pp. 72-78). Boston: CHI94.

Nest. (n.d.). *Nest*. Retrieved 06 01, 2014, from Nest: https://nest.com/

Oviatt, S., Coulston, R., & Lunsford, R. (2004). When Do We Interact Multimodally? Cognitive Load and Multimodal Communication Patterns. *ICMI'04.* Pennsylvania: State College.

Oza, C., & Leub, M. C. (2011). American Sign Language word recognition with a sensory glove using artificial neural networks. *Engineering Applications of Artificial Intelligence , 24* (7), 1204-1213.

Pütten, A. M.-v., & Krämer, N. C. (2014, July). How Design Characteristics of Robots Determine Evaluation and Uncanny Valley Related Responses. *Computers in Human Behavior* , 422-439.

Piaget, J. (1971). *The theory of stages in cognitive development.* New York: McGraw-Hill.

Reeves, B., & Nass, C. (2006). *The Media Equation: How People Treat Computers, Television, and New Media Like Real People and Places.* Stanford: CSLI.

Sah, Y. J., & You, S. (2014). Talking to an Agent in Smart TV: Effects of Modality Matching in Human-TV Interaction on Viewing Experience. *ICA'14* (pp. 1-28). Seattle: ICA'14.

Sallnäs, E.-L. (2005). Effects of communication mode on social presence, virtual presence, and performance in collaborative virtual environments. *Presence: Teleoperators and Virtual Environments , 14* (4), 434–449.

Starner, T., Weaver, J., & Pentland, A. (1998). A wearable computer based American sign language recognizer. In V. Mittal, H. Yanco, J. Aronis, & R. Simpson, *Assistive Technology and Artificial Intelligence: Applications in Robotics, User Interfaces and Natural Language Processing* (pp. 84-96). Springer Berlin Heidelberg.

Volterra, V., Caselli, M., Capirci, O., & Pizzuto, E. (2005). Gestures and the Emergence and Development of Language. In M. Tomasello, & D. I. Slobin, *Beyond Nature Nurture* (pp. 3-40). Mahwah, NJ: Lawrence Erlbaum Associates.

Wang, W., & Benbasat, I. (2007). Recommendation Agents for Electronic Commerce: Effects of Explanation Facilities on Trusting Beliefs. *Journal of Management Information Systems , 23* (4), 217–246.