Sympathetic Guitar: Can a Digitally-Augmented Guitar be a Social Entity?

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CHI 2011, May 7–12, 2011, Vancouver, BC, Canada.
ACM 978-1-4503-0268-5/11/05.

Abstract
Previous work suggests that people treat interactive media as if they were social entities. By drawing a parallel between socio-cognitive theory and interface design, we intend to experimentally determine whether deliberate design decisions can have an effect on users' perception of an interactive medium as a social entity. In this progress report, we describe the theoretical underpinnings and motivations which led to the design and implementation of the *Sympathetic Guitar*: a guitar interface which supplements standard acoustic sound with a spatially-separate audio response based on the user's hand positions and performance dynamics. This prototype will be used for investigating user response to a specific, socially-relevant design decision.

Keywords
Social, communication, interaction, design, musical instrument, sound, performance, expression, tangible.

ACM Classification Keywords
H.5 [Information interfaces and presentation]: User Interfaces--theory and methods; Sound and Music Computing.

General Terms
Algorithms, Design, Experimentation, Human Factors

Introduction

Developments in human-computer interaction seem to be growing toward simulating human-human interaction. Systems which attempt to detect, model and respond to the inner states of users are prevalent. Examples range from adaptive, personalized interfaces which attempt to tailor the user experience [12], to robots designed specifically for social interaction [2, 5, 14]. The process behind these systems is similar to human social interaction, where we use another person's expressions to understand their thoughts, feelings, and experiences [6]. We are exploring this theme by investigating how one might be able to enable people's social response to media through informed interaction design. This direction is especially plausible considering that even relatively simple computer systems seem to naturally elicit a social response from users [11]. However, there are not yet design guidelines to manipulate such social responses. For example, a designer cannot systematically enhance children's social response to an online tutoring system, or minimize errors caused by social biases toward critical information systems. Granting design control of an interface's ability to present itself as a social entity is a key step toward improving socially embodied systems which are "embedded in a set of social and cultural practices that give them meaning" [3].

Determining a Socially-Relevant Design Dimension for Experimental Purposes

As opposed to philosophizing whether computers can be truly social on the same level as humans, it is more practical to explore how users respond to systems which are designed specifically to activate human social responses. In pursuit of this approach, we applied a cognitive theory of human-human interaction to vary a relevant design element. We intend to measure any resulting differences in users' social responses. This experiment will help us explore the idea that manipulating the sociality of a technological interface is, in fact, possible (Nass, personal communication).

We started by selecting an applicable facet of a leading socio-cognitive theory: Mitchell Green's description of how humans perceive *self-expression* [6]. In the context of one human determining the inner state of another from his/her self-expression, Green distinguishes two strategies of perception. ***Part-whole perception*** represents the process where an observer determines the existence of an artifact from the direct perception of a characteristic part of that artifact. In the realm of physical objects, perceiving light reflecting off one face of an apple is enough for a typical observer to determine the existence of the entire apple. Green argues that, through a similar process, we are able to directly perceive the inner states of other humans through the detection of a characteristic component of that state; for example, directly perceiving the facial signature of anger can allow us to infer the full emotional state of anger in the same way we perceive only one side of an apple.

Green's theory [6] continues by suggesting a second way we detect the inner states of others, which he calls ***perceiving-in***: the inference of the existence of an inner state through indirect factors. Just as I can infer the existence of a horse through its reflection in a mirror or its footsteps in the dirt, I can detect another person's inner state through a more complex interpretation of non-characteristic factors. While shifting eye gaze, nervous twitches, and slumped body posture may communicate a certain discomfort, none of these factors are individually necessary or characteristic; instead, they are all considered together in some complex, non-linear way. It is essential to note that Green's perception modes are not objective. The observer subjectively determines how each cue is constructed into a holistic percept of an inner state, and whether or not each cue is considered a characteristic component of that state.

While some interactive media elicit and detect user input and map it linearly to virtual counterparts (i.e. a web browser displaying most-visited websites), others use a more complex evaluation of various elements in an attempt to extract higher-level parameters (i.e. Apple's *iTunes Genius* predicting songs you may like). ***Linear mapping*** can be conceptualized in the language of Green's part-whole perception [6]: the system has been programmed to consider user input as *characteristically* related to its digital representation, and thus manifests an appropriately direct response. ***Non-linear mapping*** is akin to perceiving-in, as both employ more complex inferences in their integration of input. As such, non-linear mapping results in less predictable responses to user input, as the system has been programmed to infer indirect parameters from the analysis of multiple inputs. The social relevance of this design dimension (linearity of mapping algorithm) makes it an excellent candidate for our exploration of the relationship between interface and social response.

Research Questions and Intentions

While previous work demonstrates that people respond socially to interactive media [11], our aim is to eventually equip creators of technology with the ability to manipulate this social response with deliberate, non-anthropomorphic interface design decisions. We will use functional prototypes to study how people react differently to interfaces which vary in specific design dimensions inspired by socio-cognitive theory. While a computer science approach could quantify such dimensions with algorithmic detail, we will first establish a foundation by testing extreme cases using a user-focused, psychological approach rooted in HCI and design. Standard controlled experiment designs will be used to investigate the social quality of users' responses, using both qualitative and quantitative methods to answer the following research questions:

Does the application of a socio-cognitive theory to the design of an interactive system influence users' perception of that system as a social entity? This work reflects a first step toward understanding whether cognitive models of human-human interaction can serve as design tools for embedding interfaces in the social realm of the user. For example, does interaction with a system which uses non-linear mapping lead to stronger effects on human social response to technology than direct linear mappings? Do users describe their experience with more complex systems more like interaction with an autonomous social agent? If so, such a result would be an important step forward for social approaches to interaction design, such as those presented by Dourish, Reeves and Nass [3, 11].

How does the linearity of mapping between input and output affect user behaviour and response to a system? As "versatile interpreters" [1], people are eager to mentally model any new system [4]. We predict that linear mappings will enable users' quick understanding of the system's underlying model, and non-linear mappings will extend the period of discovery as users hermeneutically explore interaction with the system.

Any behavioural findings which result from this difference may have implications for many goals of contemporary technological design, including usability, engagement, performance and expressivity.

Selecting the Context for Experimentation

Attempting to study specific design decisions in some novel, abstract medium would be ambiguous, as cognitive and behavioural effects may be attributable to any feature of the interaction paradigm. To minimize confounds and focus on user responses to linearity of mapping algorithms, our prototype needs to involve a novel enhancement situated within a familiar context for users. This approach will focus user response on the enhancement as opposed to basic functionalities.

Hornecker et. al.'s *tangible interaction* [8] is a human-computer interaction paradigm whose focus on bodily movement, space and materials seems to lend itself well to our purpose; there is no more familiar context than the physical world. The stated characteristics of tangible interaction, "tangibility and materiality, physical embodiment of data, embodied interaction and bodily movement as an essential part of interaction, and embeddedness in real space" [8], can be exploited to produce interactive systems which seamlessly integrate with the physical world [3]. Further, our focus on varying algorithmic mapping strategies between input and digital representation also aligns directly with the first characteristic of Ullmer and Ishii's seminal "MCRpd" model of tangible interfaces: "Physical representations are computationally coupled to underlying digital information" [13]. While Ullmer and Ishii's other characteristics depict a narrow view of tangible interfaces, Hornecker's more inclusive definition of tangible interaction [8] broadens the perspective, allowing us more design freedom. Our prototype concept came from attempts to find a prevalent physical interface and augment it for tangible interaction in a way which would enable the effective study of differences in user response between linear and non-linear mapping algorithms.

The guitar is an engaging and persistent interface which naturally places emphasis on the relationship between the guitarist's physical input and the guitar's sound output. In technologically augmenting the interface of an acoustic guitar, we intended to alter this relationship in a way which would likely draw the attention of guitarists, due to its familiar affordance for their expertise (*tailored representation* [8]). Further, digitally enhancing the interactions between human and guitar using technology has been a well-accepted phenomenon in pop culture since the first electric guitar. As such, it is not very likely to trigger negative, knee-jerk reactions from guitarists. In fact, we anticipate the sonic aesthetic of the prototype will help maximize feedback from guitar-playing participants, who will likely feel comfortable and curious.

Introducing the Sympathetic Guitar

The *Sympathetic Guitar* (fig. 1) is a novel digital musical instrument which uses sensor technology to augment the sonic output of an acoustic guitar with a synthesized sitar drone. The instrument is played exactly as one would play a normal guitar; however, hand positions are monitored using sonar signals and light detection to modulate a deep, progressive drone emanating from a Max/MSP patch connected to an Arduino microcontroller. The drone is further modulated by a microphone within the body of the guitar which measures performance dynamics from the guitar's inner resonance, creating a digital metaphor for the sympathetic strings of an Indian sitar.

While much work has been done on technologically augmented instruments (see [10] for a well-known example, or [9] for an example involving Indian music), it is important to note that this project is not a specific attempt toward some novel or useful musical instrument. Instead, this prototype was designed for correlating users' social response with mapping algorithms. As such, its software operates in two modes: one mode which linearly maps each sensor to a particular attribute of the emitted drone, and a second mode which uses a non-linear algorithm to vary the sound based on multiple guitarist behaviours over time. The former condition seems more like a simple controller, while the latter is less predictable and direct.

The main design goal of the Sympathetic Guitar was to build upon the relationship between a guitarist and his/her instrument without altering the basic interaction. As opposed to adding new controls or features to the guitar's interaction paradigm, we were instead focused on tying a sonic response to simple, well-placed sensors which gather additional information about hand positions and performance dynamics from typical interactions (*performative action* [8]). In this way, the system aligns with Green's aforementioned theory in that it "perceives" the user's typical self-expression with the guitar, as opposed to providing affordance for new interaction modes [6]. The unaltered basic interaction paradigm leaves interpretation entirely in the participants' hands; it will be interesting to see if the linearity of mapping affects whether they feel they are controlling the additional sound themselves, or whether the computer seems to

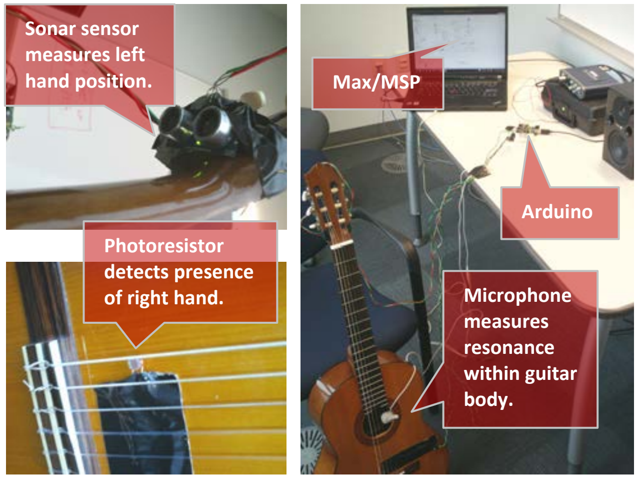

figure 1. The *Sympathetic Guitar* prototype consists of three sensors (shown above) which measure guitarist movement and action in order to modulate the sound of a sitar drone. **Video demonstration:** http://www.vimeo.com/17421550

be improvising along with the music as an external agent which is reacting to their behaviour.

A second design goal was to focus user reactions toward the relationship between their own behaviour and its digital representation. Despite our first sketches involving an electric guitar which modulated its own sound output, we instead decided to add a second, perceptually-distinct sound source to an acoustic guitar. This design further preserves the standard interaction between the musician and acoustic guitar, facilitating our investigation by drawing users' attention and feedback to the novelty of our digitally-added sitar drone. In Heidegger's terms, we are designing for the standard guitar to be *ready-at-hand* while the added drones are experienced as *present-at-hand* [7].

Informal Evaluation

The initial design involved attaching electronics to the pick. However, this was found to be problematic during a series of informal usability sessions. With an electronically enhanced guitar pick, participants' first impression of the interface was one of novelty and adaptation. As this impression contradicted our main design goal, we decided to remove the pick from the interface; as expected, users became much more comfortable with it, treating it more like a typical guitar. After this change, informal tests saw first impressions of genuine interest and exploratory interaction, as opposed to confusion or learning. In more recent sessions, the prototype has been effective in inviting guitarists' existing skills: within seconds of holding the Sympathetic Guitar, participants start to play comfortably. We plan to continue such testing with each additional implementation until we are ready to perform the experiment.

Acknowledgements

Thanks to Aaron Levisohn for technical help, SIAT and SFU for supporting this work, and ACM SIGCHI for providing opportunities to discuss and evolve our ideas.

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