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Sympathetic Guitar: Humans Respond Socially to Interactive Technology in an Abstract, Expressive Context

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Abstract
There seems to be an inherent sociality of computers which is somehow related to their interactivity. However, existing research on this topic is limited to direct interaction, semantic information, clear goals and the visual modality. The present work replicates and extends a previous study on human politeness toward computer systems using a different interaction paradigm involving indirect remote sensors in the context of expressive musical performance with a guitar. Results suggest that the quality of interactivity of a system contributes to its sociality, demonstrating the relevance of an existing body of literature on social responses to technology to the aesthetic of abstract, expressive systems such as video games, artistic tools, ambient systems, media art installations, and mobile device applications. Secondary findings suggest the possibility of manipulating the inherent social presence of an interface through informed design decisions, but a direct investigation is needed on this issue.

Categories and Subject Descriptors (according to ACM CCS): H.5 [Information interfaces and presentation]: User Interfaces--theory and methods, user-centered design; Sound and Music Computing.

1. Introduction

Developments in human-computer interaction seem to be growing toward simulating human-human interaction. Systems that 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 [Tor09], to robots designed specifically for social interaction [Bre04, YM09]. These systems are embodied with human and animal characteristics, enabling interactions which elicit expressions of thought, feeling, and experience from users [Dou01, Gre07, Pic00]. We are exploring this theme by expanding previous investigations on social responses to interactive media.

Even relatively simple computer systems have been shown to elicit pre-conscious social behaviour from users [RN98]. However, there is not yet a clear understanding of which specific elements are resulting in such social responses. If we travel through the history of computation, moving from a paper and pencil, to an abacus, continuing through ENIAC and Engelbart's "Online System" to contemporary technology, it seems hard to imagine a single discrete point where the computer "becomes" social [Roj01]. Instead, this development was more likely a gradual appropriation of several different factors which human psychology typically attributes to social entities.

In exploring these factors, research tends to study the context of information-focused media involving direct interaction with visual information [RN98, Nas10]. However, many interactions occur on video game consoles, creative suites, mobile devices, digital musical instruments, interactive art installations, and other contemporary media which are often used for abstract and expressive purposes. This development raises a question: is direct interaction and a focus on semantic and verbal information required to elicit these social behavioural effects, or would remote, indirect, and expressive technological artefacts also elicit the same effect? If true, designers and artists could apply a vast literature on social forms of technology toward the aesthetic of contemporary interaction design and media arts. The present work uses an augmented guitar interface to investigate this question by exploring how previous findings manifest with an indirect, abstract, and expressive interaction paradigm.

2. Background Literature

As background for our investigation, we will first contextualize the present experiment in the realm of computer-mediated communication, exploring whether a computer system can have its own implicit social presence. Second, we will explore previous research on factors contributing to social technology and how the present work was designed to explore a specific facet of this ongoing

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dialectic. Finally, we explore the theoretical underpinnings of the *Sympathetic Guitar:* the prototype we used to broaden our understanding of social technology.

2.1 Mediated Communication and Social Presence

"Social" interactions take place in the context of one's awareness or knowledge of another sentient being. In computer-mediated communication, this is known as **social presence**. Although explicit definitions of social presence are nebulous, a loose definition lies in the mediated experience of another sentient being. A robust theory would include both a psychological component and a technological component, rendering it open for application to a wide range of research from psychology to technological design [BHB03]. On the psychological side, researchers can use the study of interactive media to understand how the human mind appraises socially-relevant stimuli (an approach not unlike [Nas10]). On the technological side, one can study the social presence involved in experiencing different media to gain insight toward improvements for future interaction designs. For example, a chat-room experience would likely be rated as more socially present than an e-mail, a finding we could investigate psychologically or technologically. Not only is it worth knowing what elements of the medium are generating a social response, but we can also investigate how the human user is using mediated information to form a theory of mind for their conversation partner.

For our purposes, the significance of Biocca et al.'s [BHB03] analysis is their rejection of the idea that social presence is entirely a property of the medium: *"social presence is a feature of the communication interaction with the individual's perception determining the extent to which it exists, and the medium is one causal variable shaping that social interaction."* It seems that many elements, including psychological factors, interpersonal relationships, interface attributes and context, can give rise to social presence. However, with the appropriate interface attributes and context, is a second sentient being even necessary for a medium to generate social presence? Consider a chat client with a bug which falsely depicted a friend as currently "online". In this example, context and expectation alone seem to lead a simple icon to generate a small level of social presence with no second sentient being directly involved. This may also be possible through the medium alone (a social optimization of Biocca et. al.'s "*one causal variable*"). A standalone computer system designed specifically to maximize social presence may do so without connecting users to any second sentient being at all.

Friendly robots aside, could we compare an automated chat partner (like Google's Aardvark or a successful Turing Test candidate) with a computationally-generated e-mail digest in terms of social presence? In both cases, there is no second sentient being involved, but would users report some difference in social presence due to the immediacy and responsiveness of the AI chat-room? If so, how we can understand these contributing factors and apply them to manipulate the sociality of other interaction designs? Not only could this invoke the personal attachment, intimacy, engagement, cognitive immersion and fluidity of interaction associated with interpersonal relationships, but it could also help reduce the social quality of critical interfaces which require unbiased, emotionless control (i.e. weapons systems or health databases).

2.2 Factors Contributing to Social Interfaces

The natural solution to creating a socially active human-computer interface is to give it the likeness of a social animal [FZMK07]. When referring to humans, this factor is known as *anthropomorphism*; using animal-like traits is known as *zoomorphism*. For simplicity, we shall refer to anthropomorphism and zoomorphism together under the term **zoomorphism**: a simplification which aligns with the post-humanist idea that we are social animals [Bro11, Wol10].

In studying zoomorphic effects in technology, Koda found that a human-like face increased enjoyment of a poker game [Kod03]. However, zoomorphism does not always have a positive effect, as it depends on design context. Often, zoomorphic interfaces can generate unrealistic expectations in users' minds; human-like appearance can lead users to anticipate a full range of human-like behaviour (discussed in [Pic00]). The infamous example of Microsoft's *Clippy* demonstrates that in some circumstances, using zoomorphism in design can have drastic negative effects on users' subjective response [Nas10]. This variability in the effects of zoomorphism on human perceptions of interfaces suggests it as only one contributing factor to the sociality of technology.

A second, less obvious method to using human social tendencies to improve human-computer interactions is to design with respect to emotions. **Affective computing** involves taking cognitive models of human emotional behaviour and applying them to computers [Pic00]. Affective computers recognize and respond to human emotions in a way that simulates emotional interactions shared between people. For example, a particular affective alarm clock bears no resemblance to a human or animal, but it allows for expressive manipulation to control the alarm time, and responds to that emotion through its choice of alarm sound [WOD00]. As it is theoretically impossible to tease the concept of emotion from social and cultural influence [Lup98], affective computing contributes to the sociality of human-computer interfaces. This factor is especially interesting as it connects a system's behaviour directly to its social perception.

Artefacts which maximize sociality by combining both zoomorphism and affective computing - like the Haptic Creature [YM09] or Cynthia Breazeal's Kismet [Bre03] - may lead one to believe that these are the only key factors involved in social technology. However, experiments from Stanford [Nas10; NMC99; RN98] suggest other factors by showing that even non-anthropomorphic, non-affective interfaces are treated as if they were social entities. Several experiments were conducted exploring human socio-cognitive biases in the context of "*text on a computer, a computer-controlled home theatre, small and large televisions, voices in a multimedia tutorial, and motion in political advertising*" [RN98]. These studies consistently show that humans behave toward such media as they would with a fellow human being.

Nass describes a few possible reasons as to why humans naturally treat computers socially: "*although there has been no systematic investigation of this point, there are a few characteristics that distinguish computers from most other technologies and are closely associated with the human 'prototype': (1) words for output; (2) interactivity, that is, responses based on multiple prior inputs; and (3) the filling of roles traditionally filled by humans*" [NM00]. This assessment suggests three more factors contributing to the sociality of a technological artefact, discrete from Picard's affective computing paradigm and the aforementioned effects of zoomorphism [FZMK07, Pic00]. Since this argument, Nass & Brave have published an entire book on the first theory suggesting that the use of words is indeed a third factor contributing to social responses to technology [NB05]. The present work investigates Nass & Moon's second theory concerning interactivity. As a **first hypothesis**, if interactivity truly leads to pre-conscious social behaviour, then any interaction paradigms, no matter how abstract and indirect, should show some level of the same experimental results. As a **second hypothesis**, if we alter the interactivity of a given interface by varying its temporal responsiveness, we should see a correlative change in users' social behaviour (a less interactive system should be somehow less social). In the present work, we validate these claims by replicating an existing study in a vastly different design context, pushing for a more complete view of social technology.

2.3 Finding a Suitable Prototype

Simply testing a Kinect or iPhone equipped with some abstract, expressive application will lead to confounds involving prior knowledge about the system. These devices are already well-known for their use in entertainment and communication. This will hinder their perception as a truly abstract and expressive interface. A clearer test of whether users respond socially to more than just information-centric, direct, verbal and visual systems would involve enhancing a well-known non-verbal, expressive interface with indirect, remote sensors and having users explore freely. This keeps the participant comfortably using a proven expressive interface in a familiar context with attentive focus and abstract goals. If we add an indirect, parallel system which responds to interactions with that expressive interface in an equally abstract way, we can target our experimental goal: do people still respond socially after indirect interaction with a system in an expressive and abstract context?

Tangible interaction [HB06] 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*" [HB06], can be exploited to produce embodied interactive systems which seamlessly integrate with the physical world [Dou01]. While Ullmer and Ishii [UI00]'s seminal model depicts a narrow view of tangible interfaces, Hornecker et. al.'s more inclusive definition of tangible interaction [HB06] broadens the perspective, allowing us the freedom to explore less direct and goal-oriented forms of interactivity. Our prototype concept came from attempts to find a prevalent, physically expressive interface and augment it for tangible interaction to enable the effective study of users' social response to interactivity.

The guitar is an engaging and persistent interface which naturally places emphasis on the expressive relationship between the guitarist's physical input and the guitar's sound output. By 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* in [HB06]). 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 this will help in our efforts to measure participants' social response to abstract, expressive human-computer interfaces; the aesthetic of the prototype will ensure participants' general interest, comfort and engagement in exploring the interactivity of our prototype and participating in the experiment.

3. Methods

3.1 Apparatus: 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 main design goal was to explore the expressive relationship between a guitarist and a sound-producing computer without any direct interaction or a focus on semantic information. The instrument is played exactly as one would play a normal guitar; however, hand positions are passively monitored using sonar signals and light detection to modulate a deep, progressive sitar 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 participants' interaction with the guitar proceeds as normal, an ambient interaction occurs with the sound-generating computer system. The guitarist never touches the computer. While there is certainly information passing between the guitarist and the computer, the interaction does not center on exchanging or manipulating semantic information. Instead, the process is expressive and users' goals are abstract, aligning with many socially unexplored examples of contemporary technology. As opposed to adding new controls or features to the guitar's interaction paradigm, or allowing the guitarist to tweak and alter the computer's sound, we were instead focused on tying a sonic response to sensors which gather additional information about hand positions and performance dynamics from typical interactions (*performative action* in [HB06]). As opposed to providing affordance for new or direct interaction modes, the unaltered basic interaction guarantees a comfortable and expressive experience, leaving interpretation of the system entirely in the participants' hands.

While much work has been done on technologically augmented instruments (see [Mac04], for a well-known example, or [KSB*07] 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 to be specifically minimalist to test users' social response.

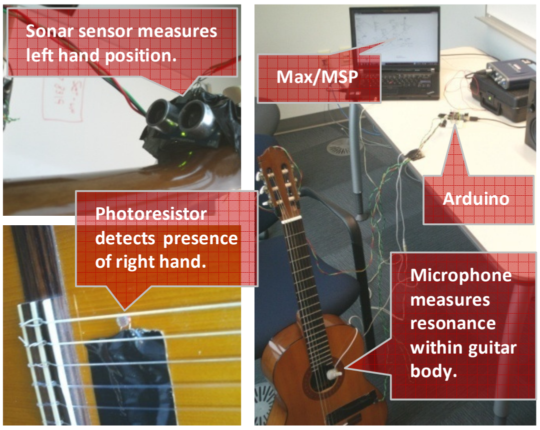

Figure 1: *The Sympathetic Guitar consists of three sensors which measure guitarist movement and action in order to modulate the sound of a sitar drone.* **Video demonstration:** *http://www.vimeo.com/17421550*

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. In this way, our experimental results on social response can be clearly separated from the basic guitar-playing action, as the traditional experience remains unaffected. In Heidegger's terms, we were designing for the standard guitar to be *ready-at-hand* while the added drones are experienced as *present-at-hand* [Hei62]. This is of key importance, as we do not fully understand the psychological relationship between a musician and instrument. While there is likely a social component (people often name their guitars), and the psychology of the interaction is likely quite complex, these confounds are mostly avoided by leaving the musician-instrument interaction as is. We are simply studying the relationship between human users and a sound-generating computer in the context of guitar performance.

3.2 Experimental Design

Before diving into experimental details, it is important to understand the study we have replicated. Nass et. al. [NMC99] had participants engage with a personal computer for a tutoring session. After being tutored, participants filled out a questionnaire which evaluated the help provided by the computer system. The study showed a significant positive boost on evaluations obtained through the very same computer which tutored participants, relative to evaluations obtained from a second computer or a piece of paper. In other words, people inflated scores when completing evaluations "to the face" of the very computer they were evaluating, a bias which is normally shown socially for the sake of politeness. As the qualitative dimension of the study revealed that participants were not aware or intentionally producing this effect, the experimenters concluded that polite social behaviour towards interactive media seems to be automatic and pre-conscious. Being critical for Reeves and Nass' "media equation" [RN98], this study gives us a tool with which we can measure the pre-conscious social response to an interface; one can assume that such a politeness effect implies a pre-conscious social response.

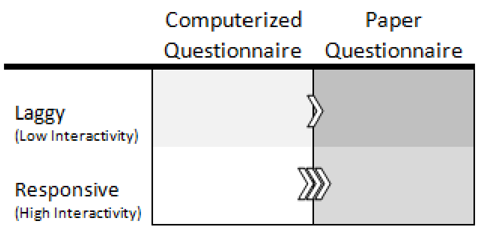

Figure 2: *Our 2x2 experimental design explores politeness toward abstract, expressive systems, and also whether its magnitude varies with interactivity.*

In adapting this methodology to study the Sympathetic Guitar, we were able to investigate if an indirect, expressive, abstract interface demonstrated the same pre-conscious social response from the original study; this would support the conclusion that interactivity relates to the inherent sociality of an interface. As elaborated earlier, we also intended to vary the temporal responsiveness of the guitar in order to investigate differences in effect size. If people are less polite to a temporally delayed (or "laggy") version of the guitar, we can further support this conclusion. Our adaptation of Nass' experimental design [NMC99] manifests as the 2x2 design depicted in *figure 2*, where the two questionnaires are referring to Nass' conditions, the interactivity dimension refers to the responsiveness of the guitar interface, and the white arrows indicate hypothesized effect sizes. Note that we only had two questionnaire conditions, as Nass showed user response to an "other computer" condition was no different than that to a paper questionnaire. All trials were counterbalanced.

3.3 Participants

Fourteen guitarists were recruited through Craigslist for two 30-minute sessions a week apart. Despite receiving interest from almost 30 participants, more than half were turned away due to a lack of sufficient guitar skill. Since novice guitarists tend to play memorized and rehearsed music, participants' guitar abilities were screened through a self-evaluation to ensure they were comfortable enough with the guitar to at least "explore new ideas and improvise," (verbatim) allowing them to fully explore the system's interactivity. Due to difficulty in finding suitable candidates, a random and balanced recruitment was impossible, limiting the power of our findings. The study involved 12 males and 2 females. 10 participants were below the age of 30.

Due to difficulty in recruiting talented guitarists, we used a split plot design: while the interactivity dimension was between-subjects, the questionnaire medium was varied within-subjects. Not only does this maximize use of each guitarist, but this alteration also removes between-subject variability from Nass' experimental design [NMC99]. Put simply, if a given participant has two identical sessions a week apart and still tends to demonstrate the politeness effect, an argument for the sociality of human-computer interfaces becomes more compelling. With this reduced variability, we were able to institute very tight criteria for outliers. Since each participant performs the exact same session with the same questionnaire a week apart, we removed all questionnaire data from any participants who were beyond 1.5 standard deviations from the mean with the assumption that they were not providing accurate responses; this would be much too great a difference for any subtle politeness effects. This proved effective, as this formula detected three clear outliers who not only were inconsistent, but also seemed to misunderstand the session for other reasons (two had inadequate guitar skill and one expressed a lack of sobriety).

3.4 Procedure

Participants entered their first session, signed a consent form, and were read a standard instruction sheet. They sat in front of a laptop computer with two speakers in close proximity; this was done intentionally to ensure the participants considered the computer and speakers as a single unit. Participants had no direct interaction with the computer other than glancing at a large timer for their session. Instead, they picked up the guitar and began exploring; their immediate comfort with playing the guitar was a testament to our iterative design efforts and informal usability testing to ensure sensors and electronics were not too salient or distracting.

Once the 15 minute timer was complete, a sound was played to get the user's attention, and the screen instructed users to put down the guitar and complete a questionnaire either on-screen or paper, depending on the experimental condition. Participants were asked to rate a series of positive adjectives on a scale from 1 to 10, mostly taken from Nass' study with a few alterations to adapt to the guitar context [NMC99]. Responses were summed for a measure of overall valence. Other experimental details and procedures were carried out exactly as in Nass' original experimental design, including a subtle indication of the system as accompanist, ensuring that all participants would similarly orient a positive valence. Put simply, knowing that the system's goal is to accompany the guitarist guides any politeness effects which may be found to push valence scores in the same direction. If those scores are significantly more positive with the on-screen questionnaire, our **first hypothesis** of a politeness effect is confirmed. If this politeness effect is greater in the more responsive condition, our **second hypothesis** is confirmed.

In order to supplement the original experimental design to investigate conscious social perceptions of technology, the study included an adaptation of Burgoon & Hale's relational communication questionnaire [BH87] (a similar approach to that recently used by Nowak & Biocca [NB11]). This particular questionnaire is interesting due to its focus on interpersonal conversation [BHB03]. Burgoon & Hale's questions were adapted to refer to the computer instead of a conversation partner; questions which were rendered absurd by this change were removed. While questions like "*I felt the computer was similar to me as a musician*" seem quite leading in their suggestion of a social relationship, this could not affect our behavioural data as the questionnaire was completed at the very end of the second session. By including a conscious, self-reported questionnaire established to measure the quality of relationships between two people, we hope any significant differences between conditions will give us insight toward implicit social presence of the system. Finally, we conducted informal exit interviews focused on the participants' point of view and debriefed them.

4. Results

We analyzed participants' overall valence toward the session using a Factorial Mixed ANOVA with the questionnaire medium (paper vs. computer) as a repeated-measures factor and interactivity (responsive vs. laggy) as a between-subjects factor. Participant evaluations of the session had a significant positive boost when performed on the sound-generating computer itself relative to the paper questionnaire ($p = 0.011^*$). Although there was also a significant positive effect on valence in the more responsive condition ($p = 0.032^*$), there were no interaction effects between medium and interactivity ($p = 0.658$). These significances are visible on both axes of *figure 3*, and the lack of interaction effect can be discerned by the fairly consistent slope of both lines.

Responses to our adapted version of Burgoon & Hale's relational communication questionnaire [BH87] were analyzed with respect to the responsive and laggy conditions using a series of t-tests on mean responses to specific questions, specific factors, and the entire questionnaire. As a whole, responses to the questionnaire were significantly higher in the more responsive condition ($p = 0.037$*). Unpacking this result using the factors detected in Burgoon & Hale's meticulous analysis shows the "Receptivity/Trust" factor as highly significant ($p = 0.001$*). Further, the "Immediacy/Affection" and "Similarity/Depth" factors were approaching significance ($p = 0.081$ and $p = 0.068$, respectively), while the "Composure", "Dominance" and "Task Orientation" factors were not significant ($p = 0.511$, $p = 0.840$, and $p = 0.333$, respectively). While these factors are complex, the important finding here is the significance we see when grouping the same three factors which Burgoon & Hale's analysis grouped together as an overarching factor called "Intimacy" ($p = 0.005$*). In summary, the questionnaire showed significant differences between the responsive and laggy conditions due to more participant agreement to statements about the intimacy of their experience with the responsive interface.

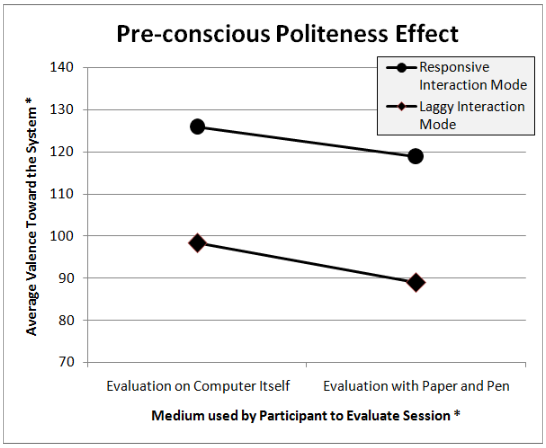

Figure 3: *Politeness toward an indirect, expressive, interactive system. Asterisks indicate significance.*

5. Discussion

When experienced guitarists sit down and play an acoustic guitar while a computer somehow responds with a modulated sitar sound, they pre-consciously behave politely toward that computer as if it were a social entity. They do not directly interact with the computer. They do not have any kind of semantic or verbal informational dialogue with it. The guitar simply responds by interactively altering the parameters of a peaceful sitar drone. Yet, participants automatically employ social behaviours toward the sound- generating system. These social behaviours were consistent in both responsive and laggy versions of the Sympathetic Guitar system, supporting our **first hypothesis** while contradicting our **second hypothesis** (varying temporal responsiveness of interactions will change pre-conscious social response to the interface).

In an earlier section of this paper, we mentioned Kismet and the Haptic Creature as social technologies which combine affective sensibility and zoomorphism [Bre03, YM09]. Research from Stanford seemed to suggest that these factors were amplifying or adding to other factors which contribute to social technology such as use of language and interactivity [NM00]. However, the majority of previous research was conducted on information-centric systems with direct interaction and a visual focus [Nas10, RN98]. While further research has supported social responses to language [NB05], the main thrust of the present experiment demonstrates that interactivity also contributes to users' social response. The Sympathetic Guitar is an indirect and expressive interaction paradigm with emphasis in the auditory modality, and it still clearly elicits pre-conscious social responses from users, presumably due to its interactivity.

The conflict between these findings and our lack of significance in varying temporal responsiveness can be resolved by considering confounds in our study of the secondary hypothesis. While a musical context was perfect for our first hypothesis which required instituting indirect tangible interaction in a familiar expressive interface, it was problematic with respect to our secondary goal of controlling for responsiveness; there is a lot we do not yet understand about music. Although participants rated the responsive sessions with more positive valence, people might interpret delayed responses as more polite in the context of music. Such hypothetical scenarios demonstrate potential problems with our measures of sociality when varying interactivity in the context of the abstract interaction paradigm of music: a less responsive mouse cursor is obviously cause for negative valence, but music may be more complicated.

The lack of significance with respect to pre-conscious social behaviour between temporal responsiveness conditions was juxtaposed with our observation of a clear significance on a conscious measure of sociality: a self-reported questionnaire. People consciously reported sessions with the more responsive interface as more intimate and socially present using a scale designed to study human-human relationships, while simultaneously displaying no pre-conscious behavioural differences. While absolute quantities are irrelevant with this study design, this finding is strengthened by many participants making post-experimental comments which suggested some form of conscious social perception of the system:

"You know when you play with someone else and ... [you're] feeding off each other? That's sort of what I felt with this [guitar]" –JA

"*It felt like there was someone else there with me, another sound, another instrument, so I didn't feel so alone.*" –JL

Taken with the questionnaire results, these comments help demonstrate that a standalone system can have social presence without any other sentient being involved. While many factors may have an influence, this finding also suggests it feasible that altering the quality of interactivity of a medium may be able to influence this social presence. However, a formal and direct investigation triangulating multiple measurements is needed to confirm this finding and clarify the distinction between pre-conscious and conscious social responses to technology.

The present experiment not only implies interactivity's contribution to the basic sociality of technology, but also loosely suggests that it may not simply be a static element. Preliminary findings of the current study suggest that - much like zoomorphism, language use and affective computing – the quality of interactivity could be a configurable factor which alters the way a system is consciously appraised as social by human users. Further work toward understanding whether this factor affects conscious and pre-conscious social responses would open a door toward socially-relevant technology which is not held back by the moral and ethical pitfalls of affective computing or the unrealistic expectations generated by zoomorphism. Even the most conservative systems (information archives, office software, operating systems, etc.) could be manipulated in terms of quality of interactivity. On the other hand, an elegant design which embodies this factor in concert with other proven factors, combining affective computing, zoomorphism, quality of interactivity, language use, and more, could lead to new heights of social technology. If an interactivity factor can contribute to understanding and generating profoundly social technologies which elicit powerful responses from human users in any way, it would be an important step toward seamless social embodiment [Dou01], therapeutic human-computer interaction and levels of technological engagement and immersion which parallel human social interaction.

6. Conclusion

The first clear finding of this study lies in its replication of Nass et. al.'s politeness effect [NMC99] with an abstract, expressive interface. This suggests an entire body of literature from Stanford's *Social Response to Communications Technology* project [Nas10, NMC99, RN98, etc.] as relevant for new technologies which use remote sensing interfaces for abstract and expressive contexts: media art installations, video games (Kinect, Wii, etc.), ambient visual displays, digital musical instruments, and even mobile device applications which use accelerometers and GPS. Even without direct interaction or a clear information-based goal, people behaved toward the Sympathetic Guitar's sound-generating computer as if it were a social entity. Further, the majority of interaction occurred in an audio modality, another difference from previous studies in this realm. Given this example of "the media equation" [RN98] in an expressive context and new modality using remote sensors without a direct focus on semantic or verbal information, the assertion that users' pre-conscious social behaviour toward technology is influenced by the quality of interactivity seems more compelling. Despite being very different from systems used in previous experiments, interactivity still led to automatic pre-conscious social behaviour in users. When creating systems for personal use, information management, expressive performance, aesthetic installation, or any other interactive purpose, it seems a well-informed artist or designer should take time to consider the interaction paradigm from a social perspective to ensure aesthetics, engagement and fluidity.

A second goal of this study was to vary interactivity and measure any changes in social response. While our hypothesized change in the extent with which participants behaved socially toward the computer based on responsiveness was not observed, a difference on a self-reported social presence questionnaire was found instead. As there are many variables at play here and many potential confounds, a more controlled study needs to be done to validate whether varying temporal responsiveness, or perhaps some other estimation of interactivity, can affect the social salience of a human-computer interface. Such a direction will help us further define whether the quality of interactivity is truly a configurable factor contributing to the sociality of technology (along with zoomorphism, use of language, and affective computing), and whether it has effects consciously or pre-consciously.

A greater understanding of factors which contribute to whether interfaces are deemed social by users will enable us to manipulate these elements through better informed design decisions. In the same way that Koda was able to influence user response by adding a human face to a poker game [Kod03], we may eventually be able to alter the quality of interactivity to influence social response (linearity, responsiveness, modality, etc.). Given the recent work suggesting that humans are fundamentally social animals [Bro11, Gal09], such manipulations will likely have profound effects on attachment, engagement, subjective preference, fluidity of interaction and more.

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