

Adversarial Uses of Affective Computing and Ethical Implications

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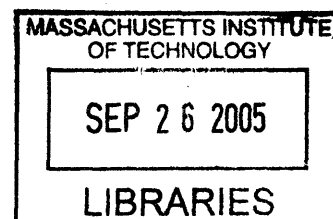
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Abstract

Much existing affective computing research focuses on systems designed to use information related to emotion to benefit users. Many technologies are used in situations their designers didn't anticipate and would not have intended. This thesis discusses several adversarial uses of affective computing: use of systems with the goal of hindering some users. The approach taken is twofold: first experimental observation of use of systems that collect affective signals and transmit them to an adversary; second discussion of normative ethical judgments regarding adversarial uses of these same systems. This thesis examines three adversarial contexts: the Quiz Experiment, the Interview Experiment, and the Poker Experiment. In the quiz experiment, participants perform a tedious task that allows increasing their monetary reward by reporting they solved more problems than they actually did. The Interview Experiment centers on a job interview where some participants hide or distort information, interviewers are rewarded for hiring the honest, and where interviewees are rewarded for being hired. In the Poker Experiment subjects are asked to play a simple poker-like game against an adversary who has extra affective or game state information. These experiments extend existing work on ethical implications of polygraphs by considering variables (e.g. context or power relationships) other than recognition rate and using systems where information is completely mediated by computers. In all three experiments it is hypothesized that participants using systems that sense and transmit affective information to an adversary will have degraded performance and significantly different ethical evaluations than those using comparable systems that do not sense or transmit affective information. Analysis of the results of these experiments shows a complex situation in which the context of using affective computing systems bears heavily on reports dealing with ethical implications. The contribution of this thesis is these novel experiments that solicit participant opinion about ethical implications of actual affective computing systems and dimensional metaethics, a procedure for anticipating ethical problems with affective computing systems.

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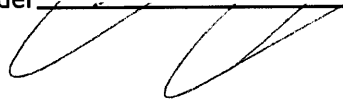
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Table of Contents

Acknowledgments	15
1. Affective Computing Used Adversarially	17
Motivating Examples	17
Panopticon / Panemoticon	18
Hypotheses	21
Outline	22
2. What Is an Ethical System?	23
Ethical Reasoning Performed by Humans Concerning Computers	23
3. Methods Used Across Experiments	27
Overview	27
Participants	27
Recruitment	27
Participant Scheduling	27
Demographics	28
Apparatus	30
Experiment Location	30
Pressuremouse	31
HandWave	37
Experimental Affective System with MixedEmotions Display	43
Questionnaire Materials	46
4. Poker Experiment	49
Poker Experimental Design	49
Poker Results	66
Poker: Charity Gains	67
Poker: Charity Loses	68
Poker: Other Analyses	71
5. Interview Experiment	73
Interview Experimental Design	73
Interview Results	84
Interview: Control	86
Interview: Charity Gains	90
Interview: Charity Loses	94
Interview Experiment Discussion	98
6. Quiz Experiment	99
Quiz Experimental Design	99
Control	102
No Effect on Charity, Charity Gains, and Charity Loses Motivators	113
Quiz Results	116
Quiz: Control Motivator	116
Quiz: No Effect on Charity	121
Quiz: Charity Gains	121

Adversarial Uses of Affective Computing and Ethical Implications

Quiz: Charity Loses	125
Quiz Experiment Discussion	125
7. Discussion	127
Ecological Validity and the Expression of Opinion	127
Pooled Results	128
Same System But Different Evaluation	129
Different Social Dimensions	129
Effects of Motivators	134
Revisiting Hypotheses	134
Performance and Ethical Reports	135
Ability to Interpret Affective Information	137
Gender Differences	137
The Employee Polygraph Protection Act	139
What Can We Conclude?	139
Future Work	140
Reference List	141
Appendix A	147
Experiment Registration System	147
Appendix B	153
Means and Standard Deviations of Experimental Data	153

List of Figures

1.1. Bentham's Panopticon (1787)	18
1.2. A modern prison design that mirrors the Panopticon	19
3.1. Histogram of study participant ages	29
3.2. Office used for subjects in sensor conditions or their control analogs	30
3.3. Office used for subjects in conditions receive affective sensor information or their control analogs	31
3.4. Pressuremouse prototype board	32
3.5. Cheesemouse visualization	33
3.6. Printed circuit board prototype	34
3.7. Current data acquisition board	35
3.8. Current mouse appearance	36
3.9. Current mouse sensor arrangement	37
3.10. Relax to Win: video game where relaxation determines the winner	39
3.11. HandWave, revision 5 electrical schematic	40
3.12. HandWave Bluetooth skin conductance sensor, orb prototype	41
3.13. HandWave Bluetooth skin conductance sensor, wrist prototype	42
3.14. HandWave Bluetooth skin conductance sensor, version used in experiments	43
3.15. MixedEmotions displays the sensor data to certain experiment participants	45
3.16. Introduction to questionnaire	46
3.17. Questionnaire	47
4.1. Initial page of the Poker Experiment	51
4.2. Sensor preparation information (disadvantage)	52
4.3. Your task (disadvantage, Charity Loses motivator)	53
4.4. Your task (advantage, same across two motivators)	54
4.5. Your task - sensors (advantage)	55
4.6. Your task - sensors (advantage)	56
4.7. Dealer's initial screen	57
4.8. Non-dealer's initial screen	59
4.9. Your bet screen	60
4.10. Bet called screen	61
4.11. Shuffling deck screen	62
4.12. Dealer's initial screen for actual game	63
4.13. Bet screen for dealer's opponent	64
4.14. Fold screen for dealer's opponent	65
4.15. Follow up question	66
4.16. Final page	66
4.17. With sensors that collect information about emotion vs. task for Charity Gains motivator	68
4.18. With sensors question	69
4.19. Performance of disadvantaged players with sensors vs. their advantaged opponents for Charity Loses motivator	70

Adversarial Uses of Affective Computing and Ethical Implications

5.1. Initial page of the Interview Experiment	76
5.2. Sensor preparation information (interviewee)	77
5.3. Your task (interviewee - Charity Loses motivator)	78
5.4. Your task (interviewer)	79
5.5. Your task - sensors (interviewer)	80
5.6. Your task - sensors (interviewer)	81
5.7. Your task (interviewer)	82
5.8. Interview questionnaire (situation)	83
5.9. Follow up questions	83
5.10. Final page for all subjects who were not hired	84
5.11. Ethical vs. interview role for Control motivator	86
5.12. Ethical question	86
5.13. Respectful vs. interview role for Control motivator	87
5.14. Respectful question	87
5.15. Uncomfortable vs. interview role for Control motivator	88
5.16. Uncomfortable question	88
5.17. Immoral vs. interview role for Control motivator	89
5.18. Immoral question	89
5.19. Performance vs. sensors for Control motivator	90
5.20. Uncomfortable vs. interview role for Charity Gains motivator	91
5.21. Uncomfortable question	91
5.22. Immoral vs. interview role for Charity Gains motivator	92
5.23. Immoral question	92
5.24. Unfair vs. interview role for Charity Gains motivator	93
5.25. Unfair question	93
5.26. Ethical vs. sensors for Charity Loses motivator	94
5.27. Trustful vs. interview role for Charity Loses motivator	95
5.28. Trustful question	95
5.29. With or without sensors vs. condition for Charity Loses motivator	96
5.30. With sensors question	96
5.31. With sensors that collect information about emotion vs. interview role for Charity Loses motivator	97
5.32. With sensors question	97
6.1. One of the 30 squares used in the quiz experiment. Participants were asked to find the pair of numbers that sum to 10	99
6.2. Initial page of the Quiz Experiment (tailored for each participant)	102
6.3. Initial questions for the Quiz Experiment for all conditions	103
6.4. Sensor preparation information	104
6.5. Instructions: practice quiz (Control motivator)	105
6.6. Instructions: 5 minutes are up	106
6.7. Practice quiz score (Control motivator)	106
6.8. Instructions: real quiz	107
6.9. Compensation	108

Adversarial Uses of Affective Computing and Ethical Implications

6.10. Complete the real quiz	108
6.11. Instructions: 5 minutes are up	109
6.12. Your score	110
6.13. Quiz questionnaire (situation)	110
6.14. Quiz questionnaire (questions)	111
6.15. Determining your compensation	112
6.16. Final page	113
6.17. Please shred your quiz	114
6.18. Compensation (No Effect on Charity, Charity Gains, and Charity Loses Motivators)	115
6.19. Ethical vs. sensors for quiz Control motivator	117
6.20. Ethical question	117
6.21. Respectful vs. sensors for quiz Control motivator	118
6.22. Respectful question	118
6.23. Immoral vs. sensors for quiz Control motivator	119
6.24. Immoral question	119
6.25. Trustful vs. sensors for quiz Control motivator	120
6.26. Trustful question	120
6.27. Respectful vs. sensors for Charity Gains motivator	121
6.28. Respectful question	122
6.29. Hindrance vs. sensors for Charity Gains motivator	122
6.30. Hindrance question	123
6.31. Immoral vs. sensors for Charity Gains motivator	123
6.32. Immoral question	124
6.33. Trustful vs. sensors for Charity Gains motivator	124
6.34. Trustful question	125
7.1. Histograms of no opinion vs. sensors, grouped by variable	127
2. The poster used to solicit subjects on the MIT campus.	147
3. Initial page of experiment registration system.	148
4. Demographics page of experiment registration system.	149
5. Calendar page of experiment registration system.	149
6. Reminder page of experiment registration system.	151

List of Tables

4.1. Poker conditions	49
4.2. Poker p-value summary: participants with sensors vs. paired opponents	67
4.3. Poker p-value summary: disadvantaged participants using sensors vs. disadvantaged participants with No Sensors or Visible Card	67
5.1. Interview conditions	73
5.2. Interviewees with sensors vs. paired interviewers p-value and r-value summary	85
5.3. Interviewees with sensors vs. interviewees without sensors p-value summary	85
5.4. Hiring rates of conditions in the Interview Experiment	85
6.1. Quiz conditions	100
6.2. Quiz compensation	100
6.3. Sensors vs. no sensors p-value and r-value summary	116
7.1. Social dimensions relevant to evaluation of systems that mediate the communication of affect (a non-exhaustive list)	130
7.2. Assumptions in the Poker Experiment	132
7.3. Assumptions in the Interview Experiment	132
7.4. Gender pooled sensors vs. no sensors p-value summary	138
5. Poker experiment: mean (μ) and standard deviation (σ) summary for disadvantaged participants using sensors vs. disadvantaged participants with No Sensors or Visible Card	153
6. Poker experiment: mean (μ) and standard deviation (σ) summary for participants with sensors vs. paired opponents	154
7. Interview experiment: mean (μ) and standard deviation (σ) summary for interviewees with sensors vs. interviewees without sensors	155
8. Interview experiment: mean (μ) and standard deviation (σ) summary for interviewees with sensors vs. paired interviewers	156
9. Quiz experiment: mean (μ) and standard deviation (σ) summary for sensors vs. no sensors	157

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Chapter 1. Affective Computing Used Adversarially

Systems that are capable of detecting information related to emotion have many beneficial uses and also many frightening misuses. While often these frightening misuses may work to the benefit of a particular individual, in many cases they cause harm to others. As such, many of these frightening uses are adversarial in nature.

Motivating Examples

When individuals oppose one another their relationship can be described as adversarial. For instance, if an individual's goal is to hinder another person by speaking against them, acting against them, or behaving in a hostile manner then this individual may be described as the other person's adversary.

Individuals may behave adversarially not just through actions or spoken words, but through artifacts such as letters, legislation, weapons, or technologies. Information technology is already used in some adversarial ways:

- The TALON robo-soldier, a tracked robot equipped with machine gun [fostermiller2005]. Current research efforts are developing robots capable of full autonomy that will "be equipped with a pump-action shotgun system able to recycle itself and fire remotely" [stamant2004].
- Uncontrollable haptic devices used to explore the theme of "human-machine conflict" [schiessl2003].
- The "fruit machine," a device developed in Canada for the purpose of identifying homosexuals. "The fruit machine was employed in Canada in the 1950s and 1960s during a campaign to eliminate all homosexuals from the civil service, the RCMP, and the military." It worked by measuring pupil dilation, perspiration and pulse for arousal [sawatsky1980].
- The polygraph or lie detector is a device designed to detect deception. Polygraphs have been used in criminal investigations and by intelligence agencies to screen employees [ota1983].
- "Integrated System for Emotional State Recognition for the Enhancement of Human Performance and Detection of Criminal Intent," is the subject of a recent DARPA SBIR [darpa2004]. This initiative emphasizes technologies that can be used without the consent or knowledge of users.

Existing work has observed and analyzed adversarial relationships. Cohen et al. performed ethnography investigating the "phenomena of adversarial collaboration" in work-flow systems used in a law firm [cohen2000]. Applbaum provides an ethical analysis of adversarial roles [applbaum2000].

Panopticon / Panemoticon

Affective computing is "computing that relates to, arises from, or deliberately influences emotion" [picard1997]. This thesis examines use (or misuse) of affective computing in adversarial contexts.

Individuals often view their emotions to be especially sensitive and private matters. As such, adversarial uses of systems that sense and communicate affect are especially interesting as a domain of inquiry. The problem that this work is addressing is the lack of information concerning user responses to affective communication systems in an adversarial use context. The approach taken to this problem is to repeatedly induce situations that are adversarial and then collect performance and survey data in an experimental context. The idea is to use this information to inform design of future systems that sense and transmit information related to emotion in ways that are ethical.

Panopticon / Panemoticon

As an example of a system that uses affective computing in an adversarial manner let us first consider Bentham's Panopticon and then a hypothetical system called "Panemoticon" that seeks to observe information related to emotion from a large number of people.

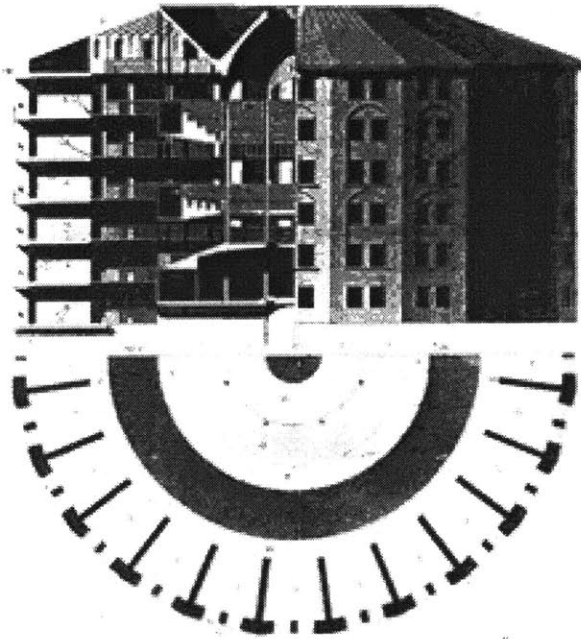


Figure 1.1. Bentham's Panopticon (1787)

Bentham took an utilitarian perspective on ethics and also sought to improve prison conditions [bentham1787]. His conception of an ideal prison was a "surveillance machine" allowing an

Panopticon / Panemoticon

inspector to watch prisoners without being seen. It was his contention that the mere possibility of surveillance would induce prisoners to mend their ways. The Panopticon places an inspector in a privileged centralized position in the architecture of the prison, as a sort of all-seeing-eye. The Panopticon thus enforces a power relationship between the inspector who is in a dominant position and the prisoner who is in a submissive position [foucault1975].



doug duBois & jim goldberg NYTimes 9-22-2002

Figure 1.2. A modern prison design that mirrors the Panopticon

Foucault argued that "power somehow inheres in institutions themselves rather than in the individuals that make those institutions function" [felluga2002]. He cited the Panopticon as a way to illustrate his point about how power can become invested in artifacts: "it automatizes and disindividualizes power."

Panopticon / Panemoticon

Affective computing systems used adversarially also have the capability of automatizing and disindividualizing power. A pervasive network of sensors that observe emotional states and uses them to watch for criminal intent takes a process that was once limited (interrogation and observation of affective cues by individuals) and automatically reproduces the interrogative process on a larger scale and more frequent basis. While such a state of affairs seems rather far-fetched consider the title of a recent DARPA research solicitation: "Integrated System for Emotional State Recognition for the Enhancement of Human Performance and Detection of Criminal Intent" [darpa2004].

The nightmarish world of Orwell's *1984* portrays a dystopia where pervasive communication of affect to a dominant party is realized [orwell1949]. Orwell's fiction elaborated on Bentham's Panopticon, with the introduction of pervasive telescreens. Orwell's narrator comments "There was no place where you could be more certain that the telescreens were watched continuously." In doing so he echos the goal of the panopticon, that is constant pervasive and internalized surveillance.

In the excerpt below we see how the telescreens in Orwell's *1984* capture many pieces of information related to emotion and some that have already been used in the development of affective computing systems.

He took his scribbling pad on his knee and pushed back his chair so as to get as far away from the telescreen as possible. To keep your face expressionless was not difficult, and even your breathing could be controlled, with an effort: but you could not control the beating of your heart, and the telescreen was quite delicate enough to pick it up. He let what he judged to be ten minutes go by, tormented all the while by the fear that some accident — a sudden draught blowing across his desk, for instance — would betray him.

Later the protagonist Winston comments on how subtle and unconscious facial movements are dangerous to exhibit in a society with pervasive monitoring:

Your worst enemy, he reflected, was your own nervous system. At any moment the tension inside you was liable to translate itself into some visible symptom. He thought of a man whom he had passed in the street a few weeks back; a quite ordinary-looking man, a Party member, aged thirty-five to forty, tallish and thin, carrying a brief-case. They were a few meters apart when the left side of the man's face was suddenly contorted by a sort of spasm. It happened again just as they were passing one another: it was only a twitch, a quiver, rapid as the clicking of a camera shutter, but obviously habitual. He remembered thinking at the time: That poor devil is done for. And what was frightening was that the action was quite possibly unconscious.

Many systems exist that allow Internet users to observe activity of individuals on the Internet. "AIM Sniffers" for instance allow an individual to monitor and archive Internet chatting activity

Hypotheses

[aimsniiff2003]. IMWatching furthermore allows users to track presence information of chat users [harfst2004].

Such systems are a special variety of more generalized network sniffing and logging software. The UNIX program tcpdump allows systems to programmatically filter and store TCP/IP network traffic [richardson2004]. A Windows version of this software also exists called WinDump [windump2004]. Additionally the library libpcap can be used to develop applications that capture TCP/IP traffic [richardson2004]. While there are many legitimate and ethically acceptable uses for such libraries (e.g. debugging, firewalls) there are also many malicious and potentially ethically unacceptable uses (e.g. stealing passwords or credit card information).

Imagine an internet application that uses such technologies to detect information related to emotions; one might call it "Panemoticon." Panemoticon could employ sniffing techniques and feed this data to systems that classify the emotional orientation and valence of observed words. Panemoticon could then construct graphical displays of the affective content of communication of networked users over time. Panemoticon does not exist; however, it could be built. As a thought experiment it provides a context for discussing the problems with unchecked affect sensing.

Such a system might be desirable to mid-level managers concerned with employee morale and alertness. It might however, be seen as adversarial by employees. It is these types of uses for which we would like to begin ethical inquiry.

Hypotheses

It is one thing to speculate about potentially unpleasant uses of affective computing technology and another altogether to witness actual reactions to such systems. In order to have a better understanding of adversarial uses of affective computing I undertook the design of several experiments with the following properties:

- use of live affective computing systems to communicate information related to emotion
- empirical observation of adversarial situations
- solicitation of participant opinions about the ethical implications of their experience with affective computing systems in adversarial situations

The majority of the research described in this thesis takes the form of a series of experiments designed to induce adversarial situations and to compare control conditions with treatment conditions that make use of systems that sense and transmit information related to emotion.

The primary hypothesis is that in a variety of situations participants who are using systems that sense and transmit information related to emotion will view the situation they are placed in as more unethical, invasive, uncomfortable, hindering, immoral, suspicious, and unfair when compared to a control. It is also hypothesized that participants will express a preference for

Outline

systems without sensors and that those with sensors will not perform as well on tasks when compared to a control. To provide a variety of situations, three distinct circumstances are considered in the experiments. These include quiz-like situation, a job-interview situation, and a poker-like situation.

Outline

In order to provide a background and context for this work, the next chapter will discuss related work in computer ethics. Following this will be a description of the apparatus used in several experiments that seek to induce adversarial situations. Next will be detailed descriptions of the protocol of the so-called poker, interview, and quiz experiments. Discussion of the results of these experiments is presented, together with the thesis conclusion.

Chapter 2. What Is an Ethical System?

Ethical Reasoning Performed by Humans Concerning Computers

Picard anticipated "ethical and moral dilemmas" posed by technology specifically designed to sense emotions [picard1997]. Picard and Klein also described several theoretically unethical uses of affective systems [picard2002]. But these unethical uses were not wholly investigated. Following this work were preliminary forays into investigating the privacy consequences of this technology [reynolds2004CHI]. However, privacy is only a single dimension of ethical import.

Value-Sensitive Design [friedman2002] articulates many dimensions that are relevant to systems that mediate the communication of affect. Value-Sensitive Design (VSD) is "an approach to the design of technology that accounts for human values in a principled and comprehensive manner throughout the design process." It considers Human Welfare, Ownership and Property, Privacy, Freedom From Bias, Universal Usability, Trust, Autonomy, Informed Consent, Accountability, Identity, Calmness, and Environmental Sustainability as values that may be of ethical consequence. Friedman and Nissenbaum applied VSD to evaluation of bias in computer systems [friedman1997]. VSD has been applied by others to problems such as online privacy [agre1997] universal usability [thomas1997], urban planning [noth2000], and browser consent [friedman2002HICSS]. The Tangible Media Group has considered various ambient displays that support the something akin to the VSD notion in their research on computer-supported cooperative work and architectural space [wisneski1998]. VSD does not directly address variables relating to the use context of a system (e.g. what is at stake to users) but instead focuses on important values that should be accounted for during the design process. VSD does not directly address how the same technology can be perceived differently when motivators or context vary.

In "It's the computer's fault: reasoning about computers as moral agents," Friedman also considered how people evaluate the ethical and moral consequences of computer programs [friedman1995]. In interviews with computer-science students, Friedman found that 75% attributed "decision-making" to computers. But only 21% held the computer "morally responsible" for errors. These results indicate that the majority of the interviewees thought a computer could make decisions but a minority blamed the computer for the consequences of bad actions. One participant was quoted as saying "the decisions that the computer makes are decisions that somebody else made before and programmed into the computer..." Friedman concludes by noting that "designers should communicate through a system that a (human) who and not a computer (what) - is responsible for the consequences of computer use." This work suggests deeper questions about the possibility of a computer having ethical behavior.

But what does it mean for a computer to be ethical? Does the rule-following of an artificially intelligent chess program count as moral behavior? Perhaps one of the first individuals to explore these questions was Asimov. His fictional work on robot ethics has made the topic interesting and accessible to a wide audience [asimov1956]. In "I, Robot" Asimov described "Three Laws

Ethical Reasoning Performed by Humans Concerning Computers

of Robotics" that sought to constrain harmful behavior, but then proceeded to show some of the limitations of such rules.

Lacking free will, Turing Machines do not make moral choices between "good" and "bad." Instead, they largely carry out their designer's choices. This means that if a designer makes "bad" choices from the user's perspective, the resulting interaction could be viewed as unethical. As such, computers without free will do not have the capability to perform their own ethical deliberation.

Moor, in the classic article "What is Computer Ethics?" [moor1985] conceptualizes computer ethics as dealing with the policy vacuums and conceptual muddles raised by information technology [bynum2001]. This definition does not address an important area of debate: the foundation of computer ethics. Floridi and Sanders categorize different types of foundations that have been used as a basis for ethical arguments about computers [floridi2004]. Many topics have been analyzed from the standpoint of computer ethics: privacy, crime, justice, and intellectual property [brey2000]. Of these, privacy is a value that is directly linked with communication systems.

Palen and Dourish define privacy to be a "dynamic boundary regulation process" in an extension of Altman's theory [palen2003]. Their view of privacy is as a dialectic process between "our own expectations and experiences" and others with whom we interact. Privacy has also been considered in value-sensitive design methodologies [friedman2002]. Friedman et al. also worked on the impact of informed consent in the domain of web browsers [friedman2002HICSS]. Bellotti and Sellen examined privacy in the context of ubiquitous computing. Their studies took place in the context of pervasive sensors (microphones and video cameras). They found that "feedback and control" were two principles that were important in the design of acceptable environments with sensing [bellotti1993]. Mann found that the notion of symmetry in surveillance can help balance inequities that cause privacy problems [mann1996]. Lederer, Mankoff and Dey studied location-sensing technology and determined that "who" is asking for information is an important factor for those determining preferences or policies for access to private information [lederer2003]. Hong also discussed context fabric as an architecture that provides support for privacy in ubiquitous computing systems [hong2004].

Outside of a narrow focus on privacy, there have also been some unusual approaches to considering computers and ethics. Weld and Etzioni worked to include the notion of "harm" into a planner to create ethical "softbots" [weld1994]. Eichmann proposed an ethic for Internet agents and spiders to limit bandwidth abuse [eichmann1994]. Allen et al. suggest a "moral Turing test" as a method to evaluate the ethical agency of artificial intelligence [allen2000]. Wallach also proposes the research and development of "robot morals" [wallach2002]. Brey proposes "disclosive computer ethics" as a methodology for maintaining human values [brey2000].

After all these different uses of the term "ethics" readers might ponder exactly "what is ethics?" It is beyond the scope of this proposal to answer this question. But those seeking more information might consult MacIntyre's *A Short History of Ethics* [macintyre1967]. A gentler intro-

Ethical Reasoning Performed by Humans Concerning Computers

duction for non-specialists is also provided by *Introducing Ethics* [robinson2001]. Additionally, Sher has collected an anthology of readings related to ethics and moral philosophy [sher1989].

A question that is within the scope of this thesis is: "what do you the author mean by ethical?" Ethics [fieser1999] is often divided into:

- applied ethics (such as Medical Ethics or Environmental Ethics)
- normative ethics ("moral standards that regulate right and wrong conduct")
- metaethics (argumentation about basic issues that often serve as a foundation for ethical theory).

What I mean by ethical is the application of ethical theory stemming from commitments to a metaethical position. In plain English, something is ethical if we can explain how we arrived at it being "good" (by relying on a framework). An example might help elucidate these somewhat cryptic explanations.

Consider the contractualist metaethical position. Contractualism founds ethical evaluations on a hypothetical or real contract formed between groups or individuals. An enormous amount of metaethical philosophy can be termed contractualist including the work of Hobbes, Rousseau, Rawls, and Gauthier.

Cudd describes the contractual macroethical position in the following manner: "Contractualism, which stems from the Kantian line of social contract thought, holds rationality requires that we respect persons, which in turn requires that moral principles be such that they can be justified to each person." [cudd2000]. Thus, we should offer our moral decisions in public and seek to justify them to each user.

In "Affective Sensors, Privacy, and Ethical Contracts," Reynolds and Picard discuss the application of contractualism to problems involving hypothetical systems that sense and communicate affect [reynolds2004CHI]. Specifically, they find that participants who did not have an ethical contract viewed hypothetical systems as significantly more invasive of privacy when compared with those who did receive an ethical contract. This finding was used to shape some of the experimental designs that appear in chapters 6, 7, and 8. Following this, Reynolds and Picard discuss the relationship between contractualism and the value-sensitive design development of informed consent [reynolds2004AD]. Both of these papers make metaethical commitments and then proceed by applying relevant ethical philosophy to problems related to the design of affective computing systems.

Chapter 3. Methods Used Across Experiments

Overview

The next four chapters will describe a series of experiments I conducted to help investigate the ethical implications of adversarial uses of affective computing. This chapter describes methods that were common to these experiments including participant information, apparatus, and materials. Following this individual chapters will describe the poker, interview, and quiz experiments.

Participants

Recruitment

Participants in the three experiments conducted for this thesis were recruited from around the Boston area using two methods. Posting were made to craigslist.org, a community website, seeking individual interested in "participating in an exciting experiment." Additionally, recruitment posters were placed on college campuses around the Boston area.

Participant Scheduling

After signing up using the experiment scheduling system described in Appendix A, participants arrived at the Media Laboratory. Participants were asked to choose a time slot from a calendar of available sessions Monday through Friday from 10 AM to 5 PM on the hour (except for noon). If the slot they had chosen was empty they were either randomly assigned to the Interview Experiment or the Poker Experiment (experiments that required two people to show up before they could be run). In the case that someone had already taken a spot in the slot, they inherited this partner's experimental task.

Midway through the experiment (on May 13th) a system of assigning extra subjects was implemented to offset the rate at which subjects were not showing up for scheduled sessions. This system assigned a "spare" subject with each pair. I found empirically that the attendance behavior of experimental subjects can be roughly modeled as a coin flip. For any given subject there is a 50% chance of actually appearing. This meant that for pairs of subjects, there was a 1 in 4 chance of a pair actually appearing. Consequently, I implemented an over-scheduling system to place spares and increase the odds of actual pairs appearing.

The first participant to arrive was greeted and asked to wait for another subject to appear. They were told that if the another subject didn't appear by 15 minutes after the hour, then I would run them individually (which meant they would be reassigned to a third experiment — the Quiz experiment — which required one person to be present). If a second participant appeared, then I would escort both of them to the pair of offices used for the experiment. In the unlikely case

Demographics

that three subjects appeared, I would compensate the last subject to arrive \$5 and ask them to reschedule for another time.

The experimenter was never blind to the condition to which participants had been assigned. A stronger future version of this experiment could involve another person who was blind to the hypothesis to perform tasks involving interacting with participants such as attaching sensors. However, the majority of the experiments were designed to be run completely by the computer, to minimize the contact with the experimenter in all but one case, which will be discussed later.

Demographics

Approximately 560 participants registered for the experiments conducted. Only those subjects who arrived for their scheduled experimental session and (when paired) arrived at the same time as their partner were included in the study. In some small number of cases (less than 10) participants were not able to complete the experiment due to computer problems or interference with the experimental apparatus. These subjects were compensated, but their data was not used. This reduced the number to $N=390$ individuals who completed the actual experiment. Subjects who completed the experiment had to be able to make their way through all of the web pages associated with their experiment.

Demographics

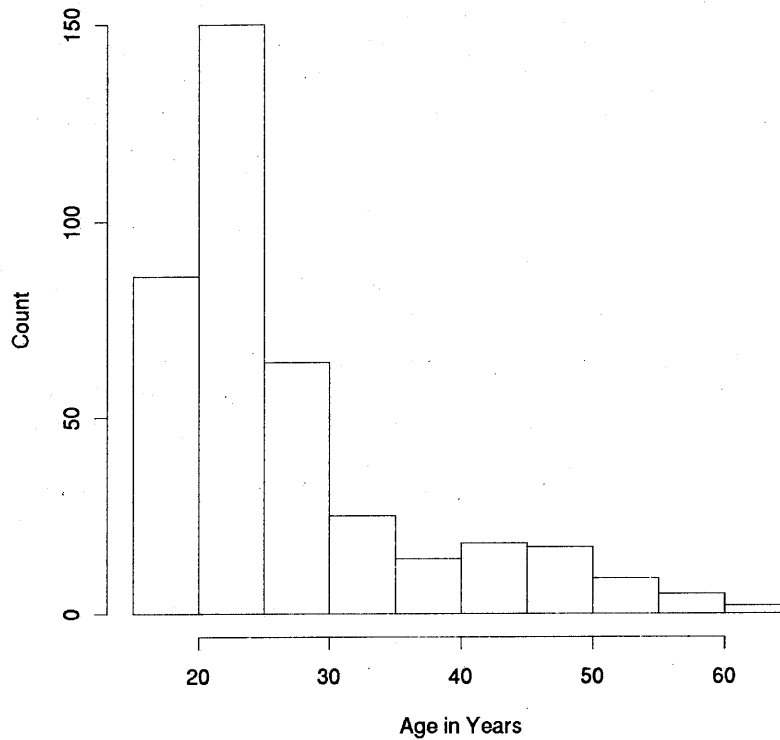


Figure 3.1. Histogram of study participant ages

The median age reported for the dataset was 24, the mean was 27.27 with a standard deviation of 9.61. The figure above shows a histogram of the ages of the participants.

There were 199 female and 191 male participants in the dataset for all three experiments, 51% of the subjects were female and 49% of the subjects were male.

With respect to nationalities, 38 countries were represented. The largest majority (78%) were from the United States, distantly trailed by India (2%), Germany (1%), with the others representing less than 1%.

With respect to education, the majority (61%) reported an undergraduate education, followed by 31% reporting post-graduate education, and 8% reporting secondary level. No distinction was made between some undergraduate and completion of undergraduate education.

Apparatus

Apparatus

Experiment Location

All of the experiments (described in the following chapters) took place in the same location: a pair of offices in Room E15-001 at the Media Lab. All of the subjects in conditions involving sensors were in office E15-120f, which is pictured below. Situated in this office were the affective sensors used to collect and transmit information related to emotions. Additionally, subjects who were the control analogs of the sensor conditions also used this office.

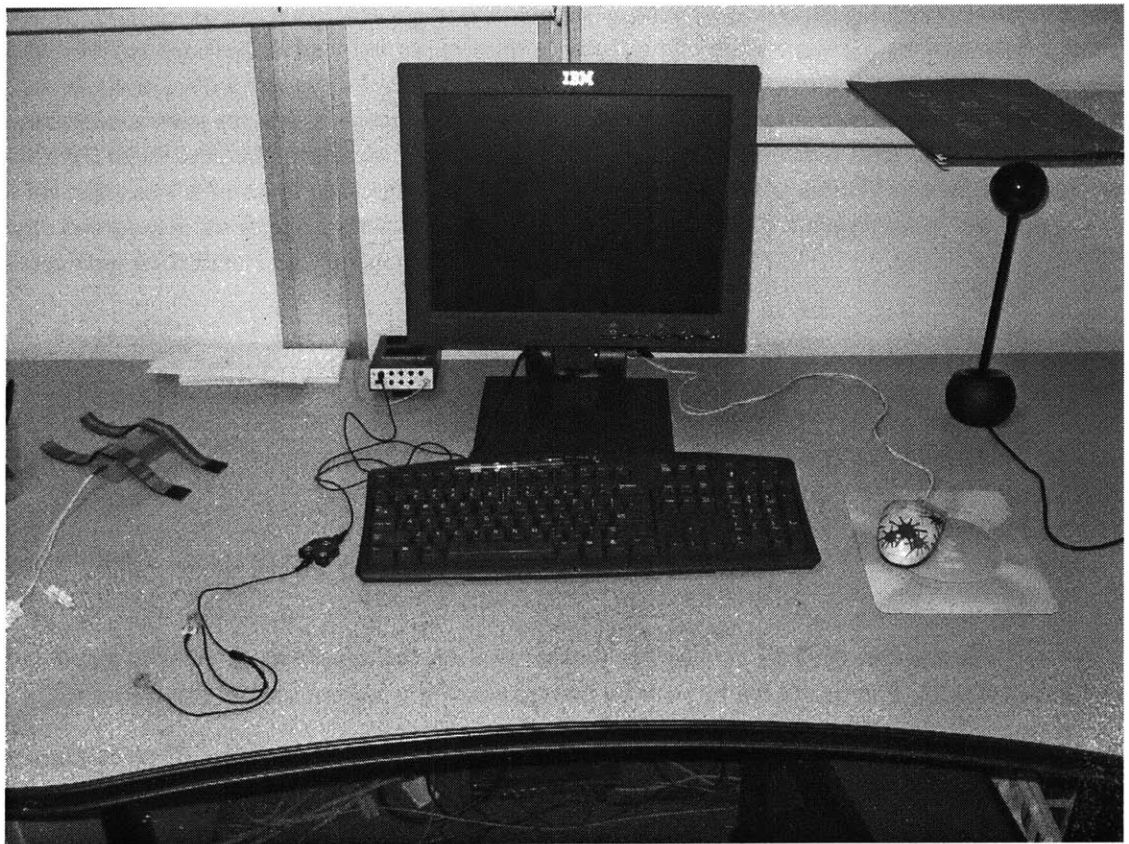


Figure 3.2. Office used for subjects in sensor conditions or their control analogs

Participants who received information from these sensors (but who did not use themselves wear or use sensors) sat in office E15-120g. Moreover, participants assigned to control analogs of the conditions receiving information from the sensors also used this office. Both of these offices were equipped with identical Dell computers running Windows XP.

Pressuremouse

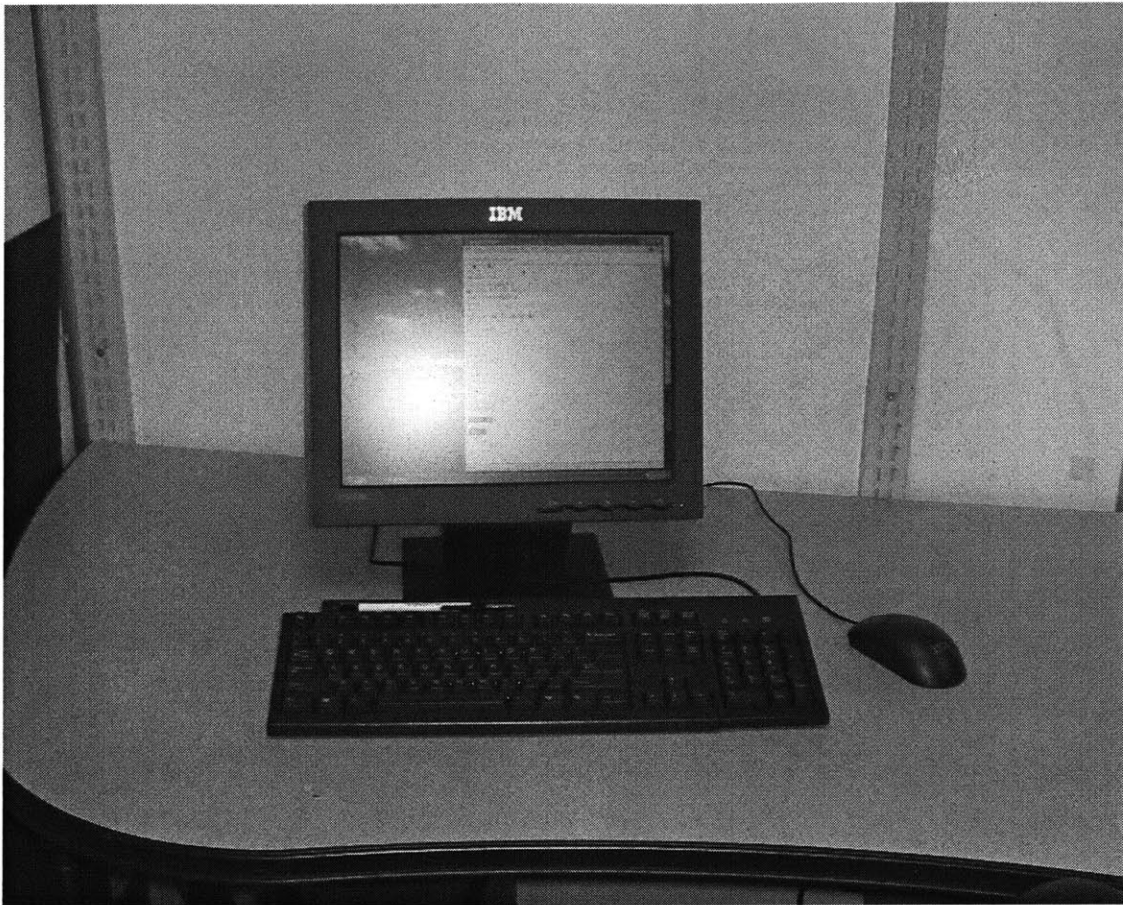


Figure 3.3. Office used for subjects in conditions receive affective sensor information or their control analogs

Pressuremouse

This section will detail the development of the Pressuremouse, which is used in each of the experiments described below. Pressuremouse is a standard computer mouse that has been augmented to capture information about grip force during interaction.

Pressuremouse

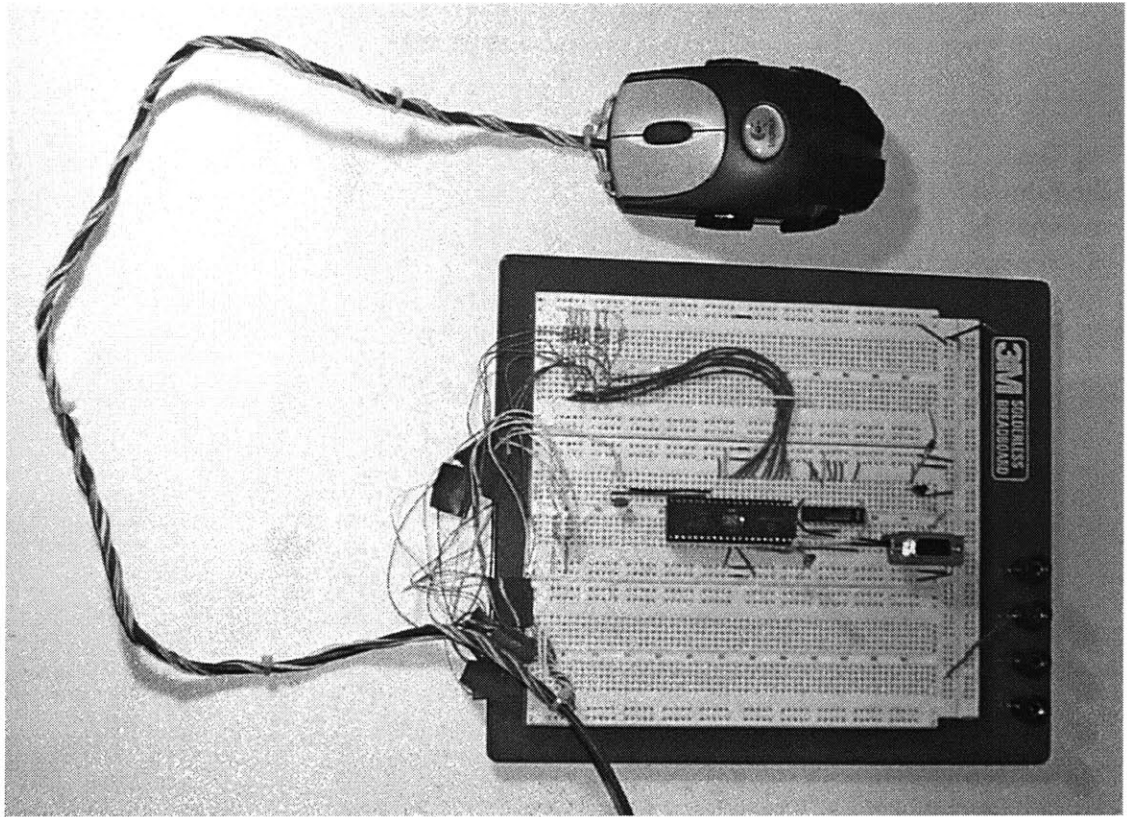


Figure 3.4. Pressuremouse prototype board

In exploring devices to sense behavior associated with frustration, one method that I explored was equipping a mouse with force sensors. At the outset of this work, I had already constructed a pressure-sensitive mouse that used 8 sensors covered with a conductive elastomer [reynolds2001].

To help better understand how individuals grip-force changes over time I developed a program called Cheesemouse. The program collected data from the surface of the Pressuremouse and rendered it upon a screen-capture video. This work builds off of Cheese [mueller2001].

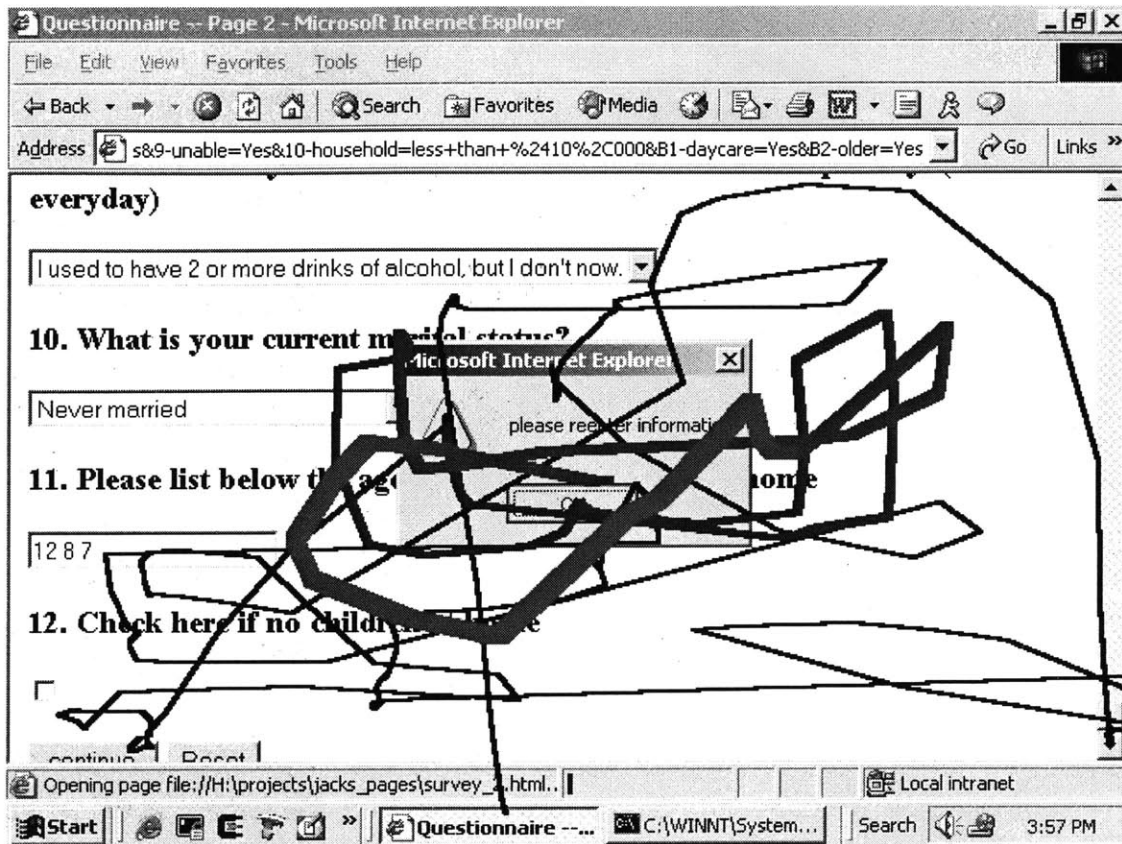


Figure 3.5. Cheesemouse visualization

The data acquisition board for the Pressuremouse was originally developed on a prototyping board. For day-to-day use this was found to be unstable and unreliable. Consequently, I undertook work to first reproduce the design as a printed circuit board (PCB) using the same dual-inline package components.

Pressuremouse

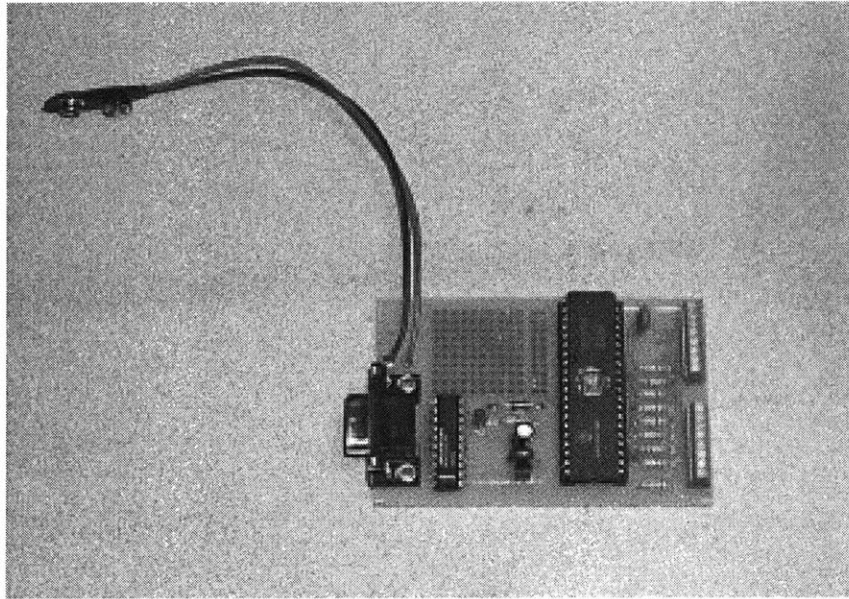


Figure 3.6. Printed circuit board prototype

Working with Keith Battocchi, this design was further reduced in size by switching to surface mount components. This led to a board that was small enough to be housed inside the mouse itself. The data acquisition board was also altered to parasitically draw power from the mouse.



Figure 3.7. Current data acquisition board

In order to produce a number of Pressuremouse prototypes, Manta Product Development was retained to revise the design. They suggested using off-the-shelf force sensitive resistors in six locations. They also suggested covering the mouse in a shrink-fitted shell that transmitted force to these points.

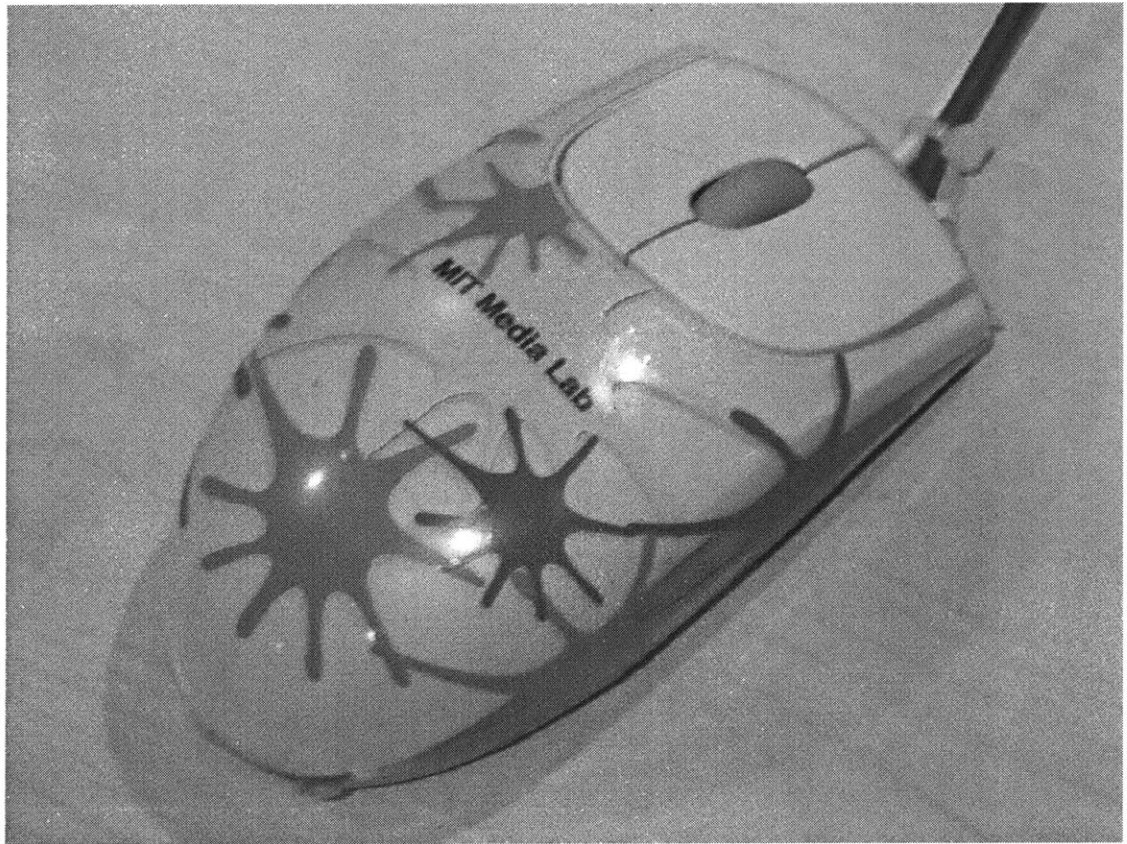


Figure 3.8. Current mouse appearance

This was in turn covered with a transparent shell with colored splotches which obscured the sensors. The current design looks and feels very much like a "normal" mouse but provides uncalibrated data relating to how much force is applied to the surface. The dynamic range of the sensor is tuned such that when normal use occurs, there is a low amount of force detected and when the user is over exerting their muscles the analog to digital converter reports a higher reading.

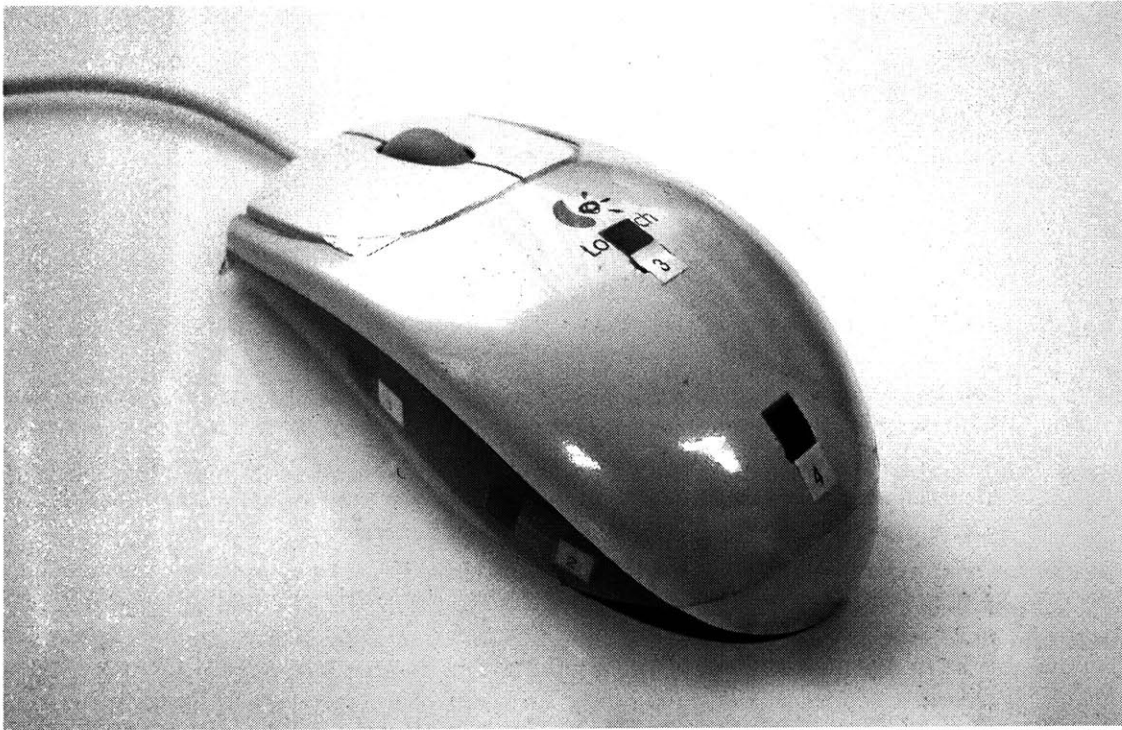


Figure 3.9. Current mouse sensor arrangement

In a collaboration with Jack Dennerlein of the Harvard School of Public Health the relationship between grip force and user frustration was explored. Participants in the study made use of a web form which I designed to be intentionally frustrating. Specifically, the form's design was mildly unusable and often forced the user to re-enter information. Initially, Jack's experiment tested the hypothesis that all subjects would exhibit more mouse force after frustrating stimulus. After observing no significant difference he then separated participants into high and low response groups depending on those who reported frustration after using this webpage. Using EMG sensors, the activity of several arm muscles was recorded. A force-sensing mouse was used to record grip force using miniature load cells. The study found that "force applied to the mouse was higher (1.25 N)" after frustrating stimulus when compared to interaction during control (0.88N) for the high response group ($p=0.02$) [dennerlein2003].

HandWave

This section will detail the development of the HandWave, which is also used in each of the experiments described below. HandWave is a wireless skin conductance sensor.

Galvanic skin response (GSR) is a term which is often used to describe the electrical activity which gives evidence of psychological changes [fuller1977]. Electrodermal Activity (EDA) is

HandWave

a broader term used by the psychophysiology community to describe the changes which take place on the stratum corneum in response to the sympathetic nervous system [malmivuo1995]. It is thought that the autonomic functions of the brain control the output of sweat glands and that electrodermal activity varies with psychological changes like increased arousal and anxiety [fenz1967].

Skin conductance is often measured using a bipolar electrode placement on the medial phalanx. Malmivuo and Plonsey suggest that a voltage of 0.5 V that is kept constant across the skin is present-day practice [malmivuo1995]. This is apparently because the of the conductance of the skin is linear for voltages under 0.7 V.

The skin conductance response consists of two components: the tonic and phasic [boucsein1992]. The tonic is slow moving, oscillating over the course of days. The phasic is fast moving, and spikes sharply when a person is startled, and generally increases when a person is psychologically aroused. Many skin conductance amplifiers include some adjustment so that the tonic portion can be removed and the phasic measured more accurately.

The current design for the galvactivator glove designed by Jocelyn Scheirer and her colleagues makes use of a "Darlington Pair" to amplify 6V dropped across the skin. A super-bright LED is lit in response and the circuit can be varied by adjusting a 500K Ohm potentiometer. This circuit was primarily designed to be inexpensive to reproduce. It however has several design flaws as a more clinical skin conductance design. Foremost, the circuit does not keep voltage constant by buffering it properly. Furthermore the circuit does not regulate voltage so that as the battery drains, the circuit can provide very different responses.

A more sophisticated and expensive design was developed by Blake Brasher. This design made use of a pair of Op Amps: one to buffer and a second to serve as a non-inverting amplifier. This design remedied many of the shortcomings in the original galvactivator circuit. For the problem at hand (use with Bluetooth wireless transmitters) however, this circuit still needs analog-to-digital (ADC) conversion.

A design by Brian McDonald of the Mindgames group provides a much more sophisticated skin conductance amplifier, but also introduces a Butterworth low-pass filter to address aliasing and noise issues. This design was interfaced with a PIC microcontroller which ran assembly ADC code.

McDonald's design was used for Relax-To-Win, a biofeedback game which makes use of skin conductance. The game takes the form of a race in which the players move faster when their skin conductance is lower relative to a baseline [bersak2001].



Figure 3.10. Relax to Win: video game where relaxation determines the winner

Over the course of nearly 2 years I experimented with a large number of circuits to amplify the skin conductance response and to pass this information to a host computer via Bluetooth. The later, more sophisticated designs made improvements over these previous designs by providing mechanisms to adjust automatically to skin resistance.

HandWave

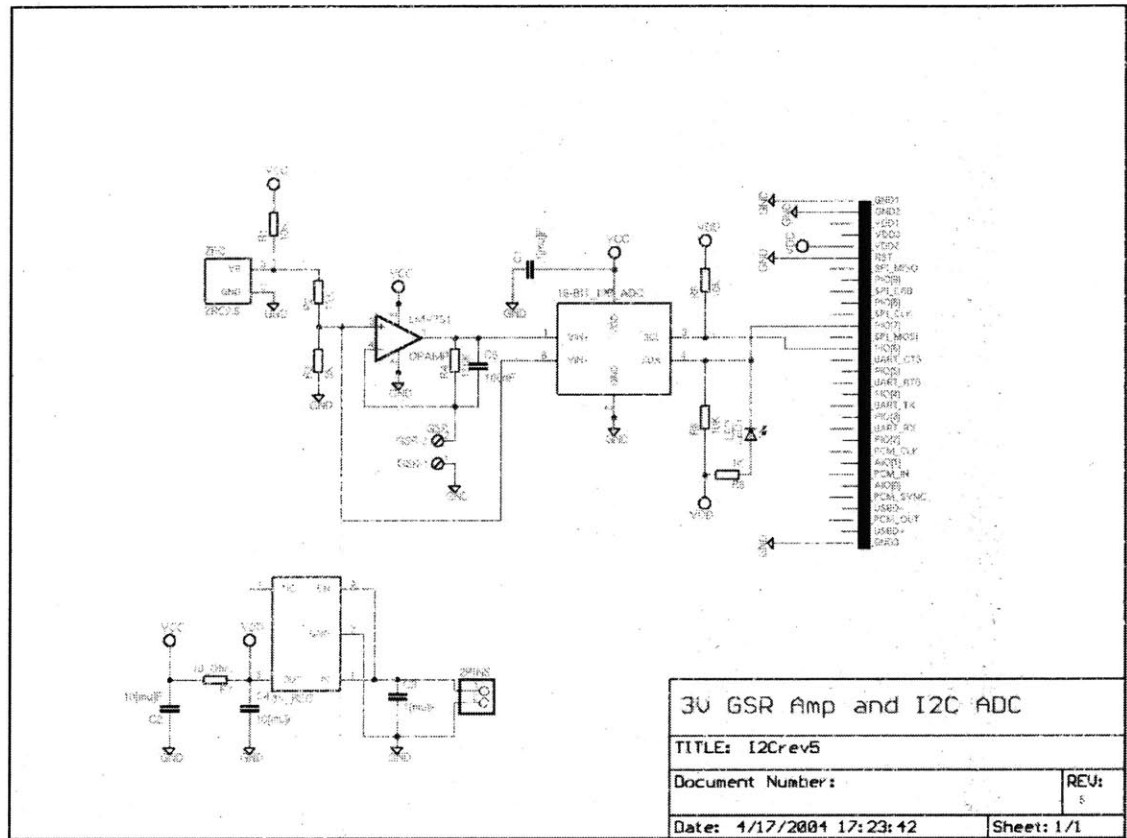


Figure 3.11. HandWave, revision 5 electrical schematic

The HandWave device combines analog circuitry to condition the signal collected from electrodes across the skin with an ADC and Bluetooth transceiver. The design pictured above incorporates a 16-bit ADC with enough resolution to ignore the tonic offset. The electrical schematic for this approach is considerably less complex than many of the other approaches tried, due mainly to the removal of the PIC microcontroller. The ADC chosen provides an inter-integrated circuit (I2C) bus which can be interfaced with wireless transmitters like the BlueCore 2.

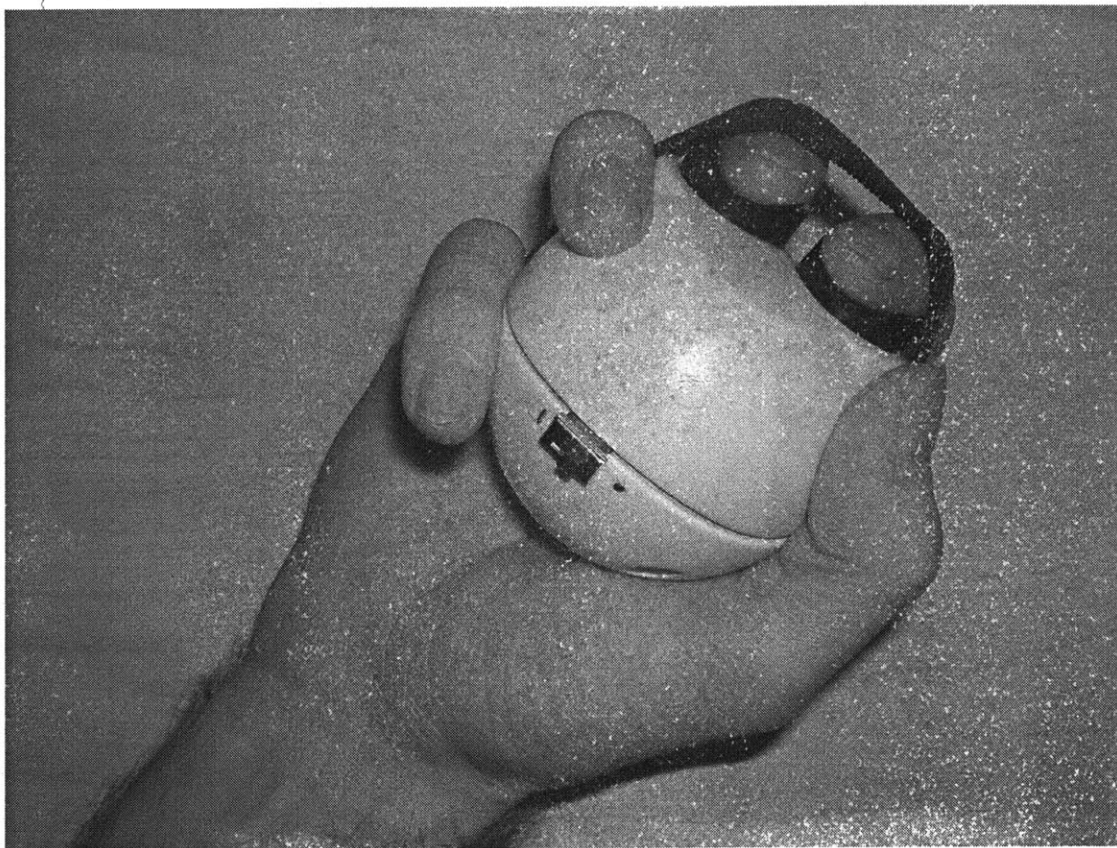


Figure 3.12. HandWave Bluetooth skin conductance sensor, orb prototype

A large number of different form factors were also experimented with. In collaboration with Marc Strauss, handheld orbs, and wrist-mounted versions of HandWave were tested for use. The most recent design, which is a wrist-mounted variety with large 9V battery, was selected for the experiment.

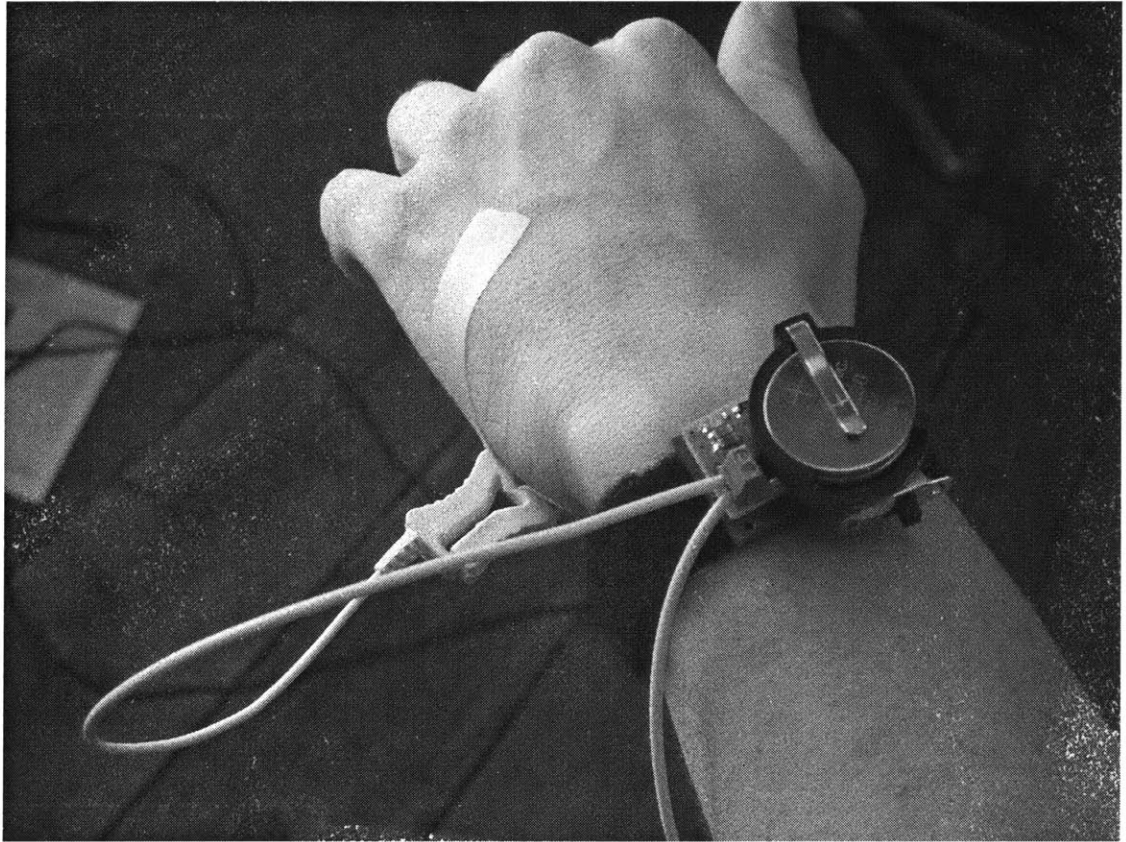


Figure 3.13. HandWave Bluetooth skin conductance sensor, wrist prototype

This design served as a starting point for a collaboration with Marc Strauss to redesign the HandWave device. The result is documented in his thesis, *HandWave: Design and Manufacture of a Wearable Wireless Skin Conductance Sensor and Housing* [strauss2005]. This more recent design uses an embedded microcontroller to improve the sampling rate achieved with the version discussed above. A larger wrist-mounted form factor was also used to accommodate a 9 volt battery.

Experimental Affective System with MixedEmotions Display

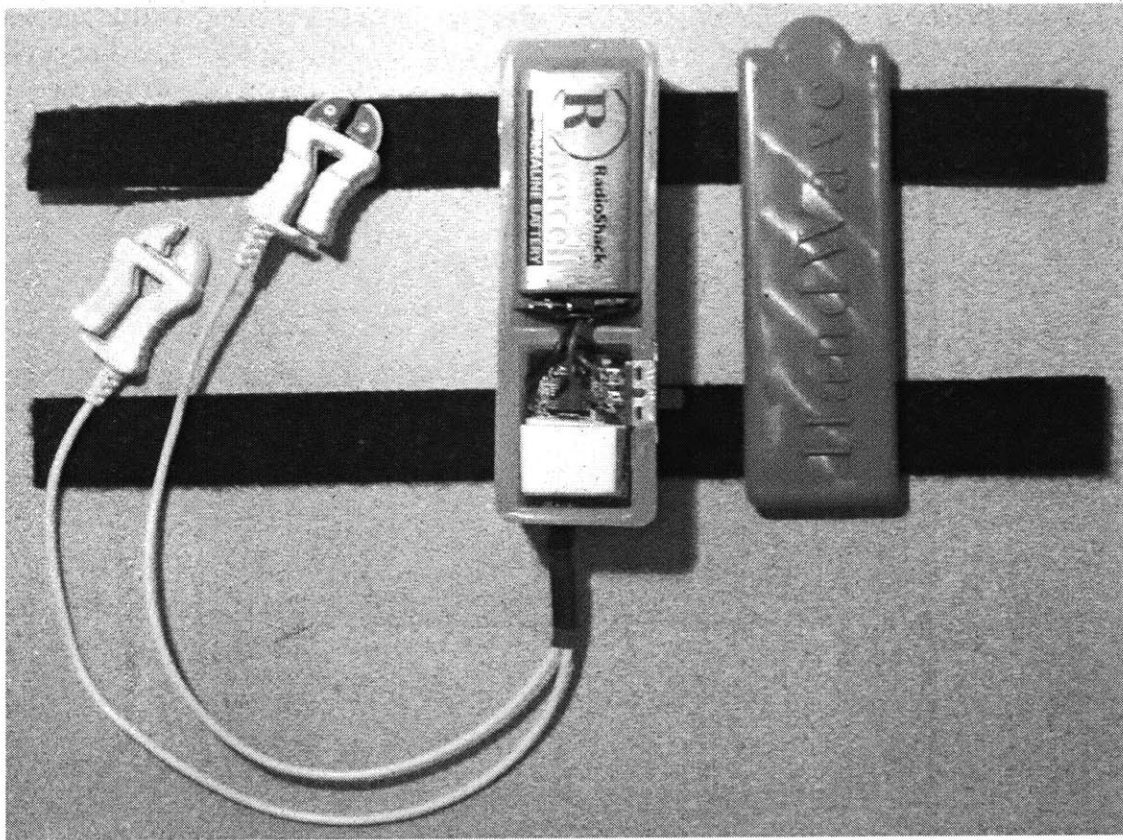


Figure 3.14. HandWave Bluetooth skin conductance sensor, version used in experiments

Experimental Affective System with MixedEmotions Display

For the actual experiments described below, HandWave (to collect electrodermal response (EDR)) and the Pressuremouse (to collect grip force) were used in conjunction with a ProComp+ sensor system (to collect electrocardiogram (EKG) information) and a face-tracking web camera. I wrote Python drivers to log the physiological data as well as keystrokes and mouse coordinates.

I wrote a second python program, called MixedEmotions to display the output of these sensor to other participants in certain experiments. This software connected to the sensor drivers via TCP/IP socket and then displayed the data collected as a video image and strip charts. The charts each showed 500 data points and were updated at various rates: the Force window at 40 Hz, the EKG window at 250 Hz, and the EDR window at 40 Hz.

Experimental Affective System with MixedEmotions Display

Participants in the sensor conditions described in the experiments below made use of the program MixedEmotions. This system recorded skin conductance, grip force, and electrocardiogram data, as well as video of the face. In some cases, this data was presented to an adversary.

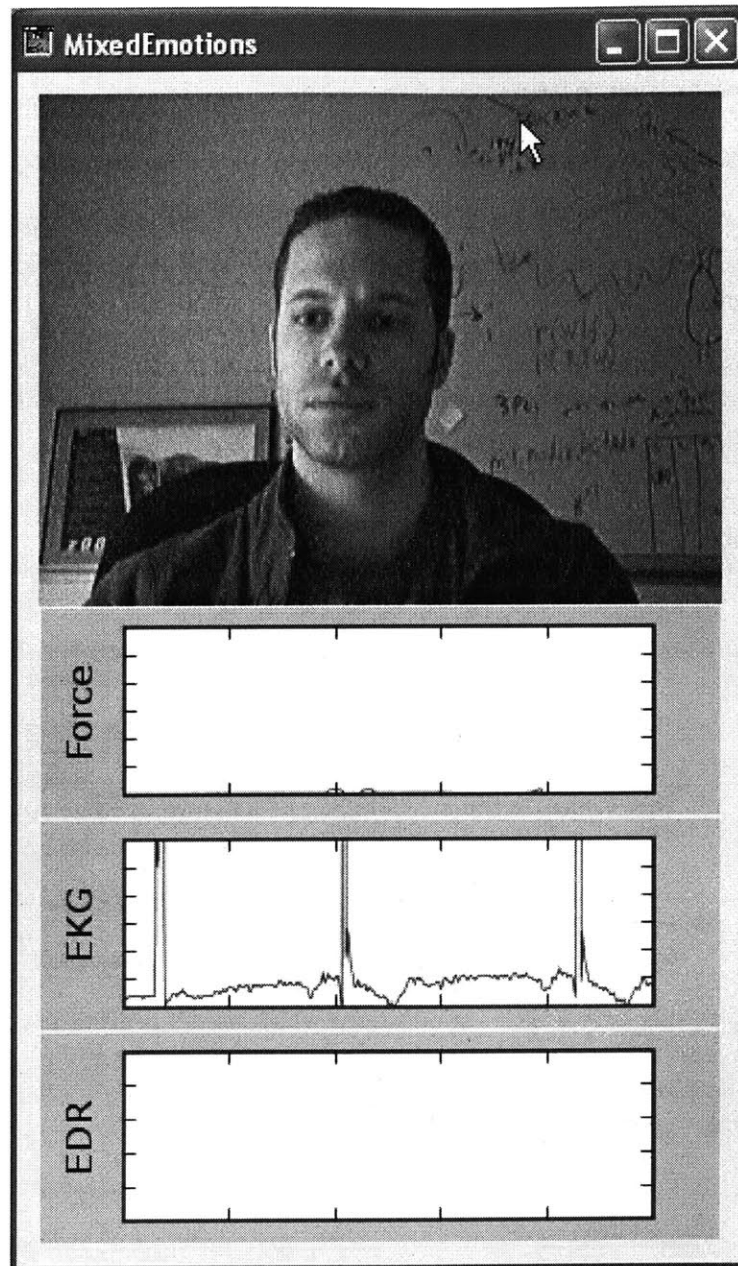


Figure 3.15. MixedEmotions displays the sensor data to certain experiment participants

Video from a face tracking camera had a prominent place in the MixedEmotions interface. Facial expression have long been recognized as important carriers of non-verbal information. Various

Questionnaire Materials

efforts to systemize facial expressions have reduced them to a two dimensional space [schlossberg1952] and a set of action units describing the movement of the muscles that control facial expressions [ekman1978].

Questionnaire Materials

Each of the experiments below shared a common questionnaire. This questionnaire was designed to help get evidence about individuals perceptions of several variables associated with ethical acceptability.

The questionnaire directed individuals to focus on the situation they were placed in and some particular aspects of this situation. Specifically "the methods of observation" they experienced in the experiment.

Questionnaire

Please fill out the following questionnaire before your compensation is determined.

Each of the following questions asks about the *situation* you encountered during the experiment. *Situation* refers to the methods of observation by the other individual or system with which you interacted. In the answers you give below, imagine you encountered this *situation* in everyday life.

Figure 3.16. Introduction to questionnaire

Following this were a series of questions which used 8 points Likert-scale questions. Using an 8 point scale forces choice between one of the two antipodes along which the scale varies. Participants could also select "No Opinion." Form validation code ensured that no questions were left blank.

Questionnaire Materials

Do you think the situation is:

Unethical ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Ethical

No Opinion ☐

Do you think the situation is:

Invasive ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Respectful

No Opinion ☐

Does the situation make you feel:

Comfortable ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Uncomfortable

No Opinion ☐

When performing the task was the situation a:

Help ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Hindrance

No Opinion ☐

Do you think the situation is:

Moral ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Immoral

No Opinion ☐

Which of the following does the situation make you feel:

Suspicious ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Trustful

No Opinion ☐

Do you feel the situation is:

Fair ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Unfair

No Opinion ☐

Given the choice between two situations you'd prefer the situation:

Without Sensors that
Collect Information
About Emotion ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ With Sensors that
Collect Information
About Emotion

No Opinion ☐

Figure 3.17. Questionnaire

Questionnaire Materials

The axes of the scales were devised by selecting pairs of opposite terms having to do with items related to the ethicality of the situation. Thus the questionnaire provides the pairs: Unethical...Ethical, Invasive...Respectful, Comfortable...Uncomfortable, Help...Hindrance, Moral...Immoral, Suspicious...Trustful, Fair...Unfair, Without Sensors that Collect Information About Emotion...With Sensors that Collect Information About Emotion.

Chapter 4. Poker Experiment

The purpose of the Poker Experiment was to create a game-like situation in which the players would be in an adversarial relationship. This situation was adversarial because success came at the cost of your opponent, namely in order to win one must beat one's opponent. Depending on condition, some players would use a system to communicate information related to emotion while others would have to show their opponent a card as a disadvantage. The design was asymmetric where only one player showed this information to the other.

Poker Experimental Design

In the "Poker Experiment," 144 participants played a simplified poker-like game in pairs. The games rules are as follows: first each player places an initial "ante" bet, next each player is dealt two cards, the players bet who has the highest card and are given the opportunity to fold. The players compete for a common pot and their implicit goal is to maximize their personal reward. Players play two rounds of the game, a practice and one which determines their compensation. In all cases, players make use of a web-based interface to play the game.

The 72 pairs of participants were divided into two groups of 36 depending upon the motivator to which they were assigned. These groups were evenly split between Charity Gains and Charity Loses motivators. In the Charity Gains motivator, a charity of the participants choice received a reward equal to the amount the participant won in the poker game. In contrast the Charity Loses motivator gave a reward equal to the amount the participant lost in the poker game. There were also 3 conditions: no sensors, a game involving sensors on one player, used to present information related to emotion to the other player, and a game in which one card was shown by one player to the other. The latter two conditions were deliberately designed to be unfair to one player.

Table 4.1. Poker conditions

	Charity Gains	Charity Loses
No Sensors (Control)	n=12 pairs	n=12 pairs
Sensors	n=12 pairs	n=12 pairs
Visible Card	n=12 pairs	n=12 pairs

As with the Quiz and Interview Experiments, in the Sensors condition one subject was wired using 3-lead electrocardiogram sensors and the HandWave skin conductance sensor. Additionally, mouse pressure and coordinates were collected. A face-tracking camera was also used to collect video of the participant's facial expressions. Participants with sensors in this condition also encountered an extra screen explained how the sensors would be attached. These subjects were

Poker Experimental Design

paired with a second interviewee subject who received information from these sensors using the MixedEmotions system described in the apparatus section.

The No Sensors and Visible Card conditions performed the same task and experienced the same questionnaire instruments as the Sensors condition. The difference was the absence of sensors and information related to attaching sensors.

In all conditions, participants were told: "You are about to play a poker-like game. You will begin with a practice round. Following this you will play a real round in which your compensation will be determined. The player who has the highest card wins (i.e. Ace beats King, Jack beats 10). If two players have the same high card, then the highest suit wins (Clubs beats Spades beats Hearts beats Diamonds). The winner gets the pot plus any of their own remaining chips which were not put into play. The loser gets only their own remaining chips which were not put into play. During the game players may: raise bets (counter an opponent's bet by betting more), call a bet (answer an opponent's bet by putting in an equal amount, ending the game), or fold (forfeit the game, keeping whatever chips were not put into play). Your goal is to win as much money as possible. When the game starts, each player automatically places \$1.00 into a common pot. In addition, you have \$5 to bet. You may bet as much or as little as you like, depending on the hand you are dealt."

Taking a pessimistic view, we will consistently call the player in the room with the sensors the "disadvantaged" player, even though there is no obvious disadvantage in the No Sensors condition when the player is merely accompanied by the sensing apparatus and not wearing it or communicating information through it. More disadvantage is hypothesized when that player is in the Sensor condition (communicating affective information to their opponent) and when that player is in the Card Visible condition, where the opponent can see one of their cards.

Disadvantaged participants in the Charity Gains motivator were additionally told that the charity of their choice "will be given funds that match your chips in the case that you are the winner." Disadvantaged participants in the Charity Loses motivator, on the other hand, were told that the charity of their choice "will be given funds that match your remaining chips in the case that you lose" and (as a consequence) nothing if they won. These motivators were identical in conditions both with and without sensors.

Disadvantaged players were placed in the office containing the sensing apparatus. The sensors were attached to participants only in the Sensors condition. Their opponent was seated in a similar office, but without any sensing apparatus. By asking the experimental subjects for their email address I was able to consult the random assignments of the experiment scheduling system, which had determined which subject should be seated in which office. At this point I would launch web browsers to view the experimental instructions.

Poker Experimental Design

Participant Demographics

step: 5
test: 1
nationality: United States
education: post-graduate
email: carsonr@media.mit.edu
slot: test
sessionId: V3Hj4iiGRbRA6XhU-o3gA
age: 30
gender: Male
experiment: 3
condition: 2
task: 2

Hand with which you use the mouse:

- ☐ Left
- ☐ Right

A favorite charity you'd like to see a donation made toward:

- ☐ Action Against Hunger
- ☐ American Red Cross
- ☐ American Jewish World Service
- ☐ AmeriCares
- ☐ Asia Foundation
- ☐ BAPS Care International
- ☐ CARE
- ☐ Direct Relief International
- ☐ GOAL
- ☐ Habitat for Humanity International
- ☐ International Federation of Red Cross and Red Crescent
- ☐ Islamic Relief Worldwide
- ☐ Karuna Trust
- ☐ Network for Good
- ☐ Oxfam International
- ☐ Quarters From Kids: Tsunami Relief and Rebuilding
- ☐ Sarvodaya
- ☐ Save the Children
- ☐ UNICEF
- ☐ World Food Programme (UN)
- ☐ World Vision
- ☐ Other Charity

[Next Page](#)

Figure 4.1. Initial page of the Poker Experiment

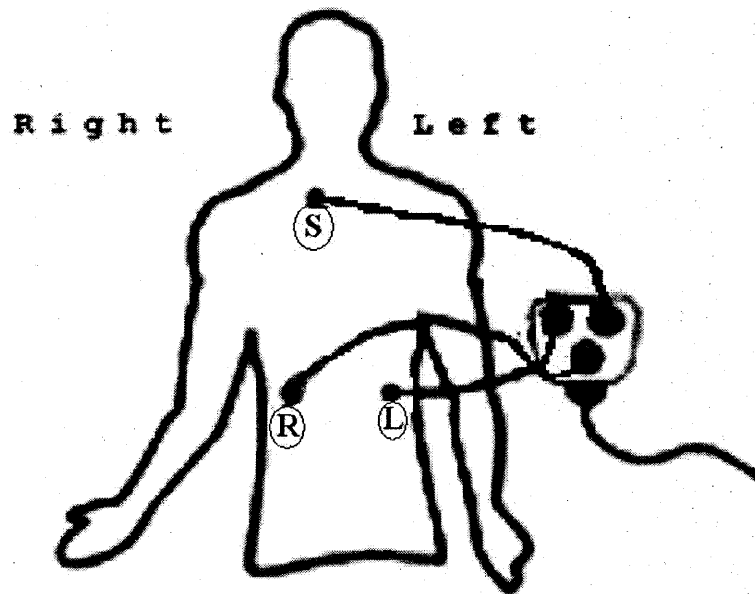
Poker Experimental Design

The first web page encountered by subjects in the poker experiment was used to verify their demographic information. Disadvantaged subjects were also asked to choose a "favorite charity you'd like to see a donation made toward." Subjects in the sensor condition were also asked to choose the "hand with which you use the mouse." After the consent form was signed and the identity of the participant verified, subjects were instructed to move on to the next page.

Sensor Preparation

The experimenter will now ask you to attach sensors. (You may go to the bathroom for privacy if you like.)

The sensors should be placed to match the following diagram:



The HandWave device will also be attached by the experimenter to your left hand.

[Next Page](#)

Figure 4.2. Sensor preparation information (disadvantage)

In the case that participants were assigned to a sensor condition, they were shown a page that informed them that sensors would be used. In the case that subjects were assigned to the No Sensors condition, the system skipped forward to a page showing the instructions for their task.

Poker Experimental Design

Your Task

- You are about to play a poker-like game.
- You will begin with a practice round.
- Following this you will play a real round in which your compensation will be determined.
- The player who has the highest card wins (i.e. Ace beats King, Jack beats 10).
- If two players have the same high card, then the highest suit wins (Clubs beats Spades beats Hearts beats Diamonds).
- The winner gets the pot plus any of their own remaining chips which were not put into play.
- The loser gets only their own remaining chips which were not put into play.
- During the game players may:
 - raise bets (counter an opponent's bet by betting more),
 - call a bet (answer an opponent's bet by putting in an equal amount, ending the game),
 - or fold (forfeit the game, keeping whatever chips were not put into play).
- Your goal is to win as much money as possible.
- When the game starts, each player automatically places \$1.00 into a common pot.
- In addition, you have \$5 to bet. You may bet as much or as little as you like, depending on the hand you are dealt.
- GOAL will be given funds that match your remaining chips in the case that you lose.

Next Page

Figure 4.3. Your task (disadvantage, Charity Loses motivator)

After viewing the sensor preparation information, a page displaying the instructions for the disadvantaged player was displayed. This page explained the game rules to participants and also the compensation they would receive (which was dependent upon their motivator).

Poker Experimental Design

Your Task

- You are about to play a poker-like game.
- You will begin with a practice round.
- Following this you will play a real round in which your compensation will be determined.
- The player who has the highest card wins (i.e. Ace beats King, Jack beats 10).
- If two players have the same high card, then the highest suit wins (Clubs beats Spades beats Hearts beats Diamonds).
- The winner gets the pot plus any of their own remaining chips which were not put into play.
- The loser gets only their own remaining chips which were not put into play.
- During the game players may:
 - raise bets (counter an opponent's bet by betting more),
 - call a bet (answer an opponent's bet by putting in an equal amount, ending the game),
 - or fold (forfeit the game, keeping whatever chips were not put into play).
- Your goal is to win as much money as possible.
- When the game starts, each player automatically places \$1.00 into a common pot.
- In addition, you have \$5 to bet. You may bet as much or as little as you like, depending on the hand you are dealt.

Figure 4.4. Your task (advantage, same across two motivators)

Individuals paired with participants at a disadvantage also received similar instructions on their task. The instructions differed by not including any information about a charity. This page also explained the game rules and compensation.

Poker Experimental Design

- You will see a program that gives you information about your opponent.
- A video stream of the candidates face is displayed along with mouse grip force, heart rate (EKG), and skin conductivity (EDR) information.
- A calm player, for instance might appear as follows:

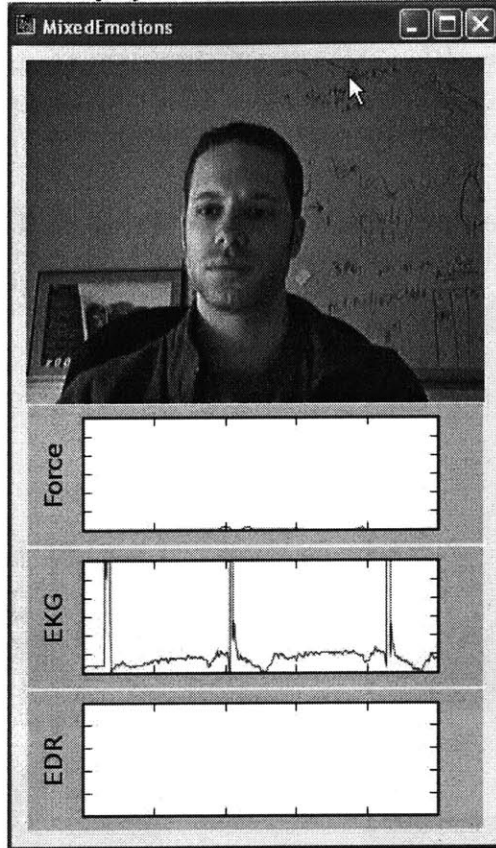


Figure 4.5. Your task - sensors (advantage)

In the case that the participant at an advantage was paired with a disadvantaged participant in the sensor condition, the participant with the advantage received additional information about how to interpret the data coming from MixedEmotions. This took the form of instructions comparing a "calm" state with a "stressed" state.

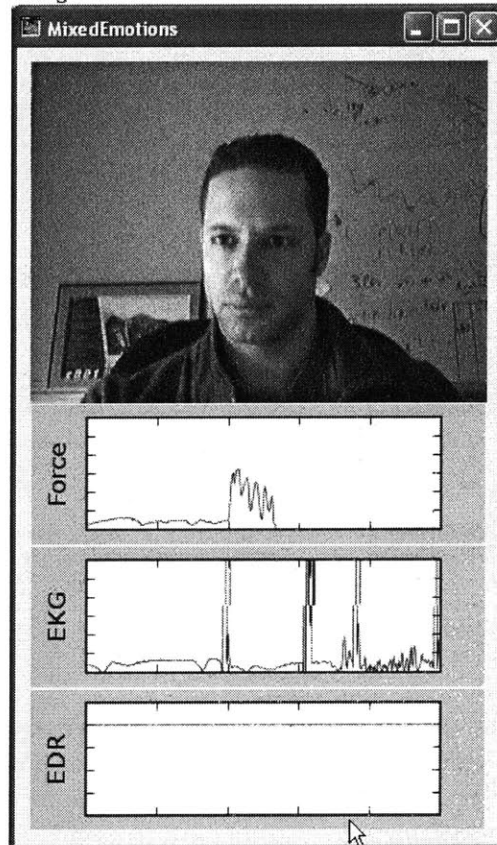
The goal of these instructions was to help the advantaged participant spot disadvantaged participants who might appear to be stressed. For instance, a participant who is bluffing about their cards might change facial expressions, exhibit irregular heart rate intervals, and an increase in skin conductance. In practice, many of these signals are noisy and even thoroughly trained polygraph tests may have difficulty perfectly interpreting such data.

Poker Experimental Design

Please note that there was an error in these instructions informing interviewers that candidates with "irregular heart rate" may be more stressed. Quite the contrary, normal resting individuals often show irregular heart rates. This should be corrected in future uses of this protocol.

The experimenter would then verbally verify that both participants had understood the instructions. The experimenter would also explain to both participants in their respective office how to contact the experimenter once the experiment was completed. At this point the experimenter would leave the participants to play the practice and real poker-like games.

- A player who is stressed may show increased grip force, irregular heart rate, and a rise in skin conductivity, as well as changes in facial expressions, as in the following image:



Next Page

Figure 4.6. Your task - sensors (advantage)

Poker Experimental Design

At this point, one of the two participants was randomly chosen as the dealer for both the practice and actual games. As per the rules of the game, each player places \$1 onto the table to form a pot to induce betting and bluffing. As with poker, this player would give out cards and then bet after the other player had bet. However, since this is an online game the action of giving out cards is automated, so the player first sees a status message saying "Waiting for your opponent..." and then after their opponent has read the instructions and clicked next page "Waiting for opponent's bet..." The dealer would bet following the other player's initial bet.

Waiting for opponent's bet ...

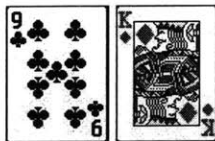
On table

\$ 2

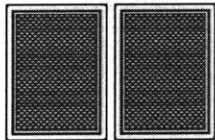
Your chips

\$ 5

Your Hand



Your Opponent's Hand



Your Opponent Sees

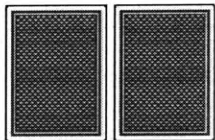


Figure 4.7. Dealer's initial screen

The player who is not chosen as the deal, on the other hand sees a screen showing their cards and the actions they can perform initially: "Place Bet" along with a drop down containing the

Poker. Experimental Design

amount of their bet and "Fold." Additionally, the current state of the pot "on table," "your chips," as well as any cards shown as part of a disadvantage associated with the visible card condition are displayed.

The poker screens are laid out as follows. In large text at the top is a title describing the action associated with the screen (i.e. "waiting for opponent's bet"). Below this is a section titled "on table" which shows the dollar value of the money at stake (which can increase following betting). Following this is a section entitled "your hand" which shows the two cards dealt to the participant. Below this is another section entitled "your opponent's hand" which shows the backs of the two cards dealt to the participant's opponent. In the case that the opponent is in the disadvantaged visible card condition, the participant would see the face of one of their opponent's cards. Below this is the "your opponent sees" section in which the backs of two cards are visible. In the case that the participant is assigned to a disadvantaged visible card condition then one of the two cards in their hand is shown here.

Practice: Your Bet

\$

Place Bet

Fold

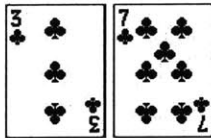
On table

\$ 2

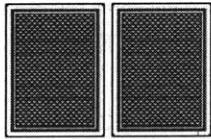
Your chips

\$ 5

Your Hand



Your Opponent's Hand



Your Opponent Sees

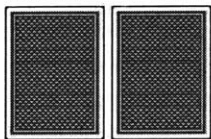


Figure 4.8. Non-dealer's initial screen

Suppose the non-dealer bets \$1, in this case the dealer will then see a screen stating this and allowing them to either "Raise Bet," "Call Bet (\$1)," or "Fold." In the mean time, their opponent would see a screen similar to the dealer's initial screen.

Practice: Your Bet

\$

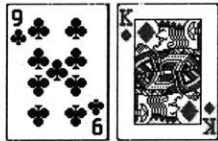
On table

\$ 3

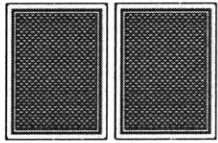
Your chips

\$ 5

Your Hand



Your Opponent's Hand



Your Opponent Sees

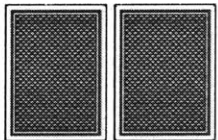


Figure 4.9. Your bet screen

If the dealer were to call the \$1 bet, they would see a screen revealing their opponent's cards and stating the outcome of the game. Additionally the screen informs the participant that the practice round is over and they will now play the actual round. Their opponent would see a similar screen relating complementary information (viz. Bet Called You Lose, in this case).

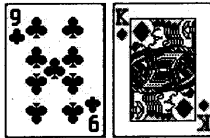
Bet Called, You Win

- This completes your practice round.
- You will now play a hand where the outcome determines your compensation.

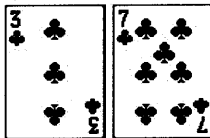
Your chips

\$ 8

Your Hand



Your Opponent's Hand



Next Page

Figure 4.10. Bet called screen

At this point both players would see a screen which re-iterated the rules of the game and would inform them that the "actual game" was commencing. This screen would also remind the players of the compensation scheme at work in the game. In the case that a participant was in a disadvantaged condition, they were reminded either that the charity of their choice "will be given funds that match your remaining chips in the case that you lose" in the Charity Loses motivator or "will be given funds that match your chips in the case that you are the winner" in the Charity Gains motivator.

In the sensor condition, the opponent in the non-sensor room (advantage) saw the MixedEmotions window on the computer, displayed side by side with the screens just described. In the visible card condition, the opponent in the room without sensors saw the first of the opponents cards face up on their screen.

Shuffling Deck, Preparing for Actual Game

- You will now begin actual play.
- The outcome of this hand will determine your compensation.
- A reminder of the game rules:
 - The player who has the highest card wins (i.e. Ace beats King, Jack beats 10).
 - If two players have the same high card, then the highest suit wins (i.e. Clubs beats Spades beats Hearts beats Diamonds).
- The winner gets the pot plus any of their own remaining chips which were not put into play.
- The loser gets only their own remaining chips which were not put into play.
- During the game players may:
 - raise bets (counter an opponent's bet by betting more),
 - call a bet (answer an opponent's bet by putting in an equal amount, ending the game),
 - or fold (forfeit the game, keeping whatever chips were not put into play).
- Your goal is to win as much money as possible.
- When the game starts, each player automatically places \$1.00 into a common pot.
- In addition, you have \$5 to bet. You may bet as much or as little as you like, depending on the hand you are dealt.

Next Page

Figure 4.11. Shuffling deck screen

The player selected as the dealer in the practice game remained the dealer in the actual game. So they would again see a webpage similar to "Dealer's Initial Screen" above, except with new cards.

Waiting for opponent's bet ...

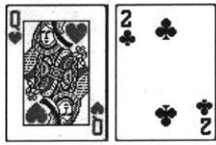
On table

\$ 2

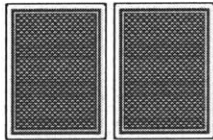
Your chips

\$ 5

Your Hand



Your Opponent's Hand



Your Opponent Sees

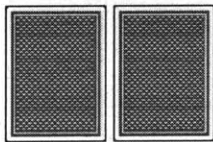


Figure 4.12. Dealer's initial screen for actual game

The dealer's opponent would again see a screen prompting them to bet. Since this is a new game, the pot on the table as well as the amount of chips each player has is reset. Namely, there is \$2 on the table as well as \$5 in chips.

Your Bet

\$

Place Bet

Fold

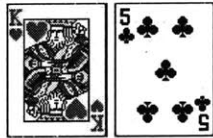
On table

\$ 2

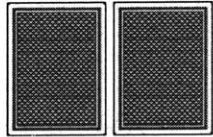
Your chips

\$ 5

Your Hand



Your Opponent's Hand



Your Opponent Sees

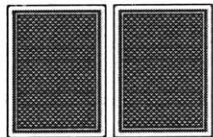


Figure 4.13. Bet screen for dealer's opponent

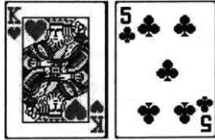
Suppose that in this situation, the dealer's opponent chooses to fold. The game would then display a fold screen with information about how many chips the player won.

You Fold

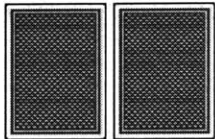
Your chips

\$ 5

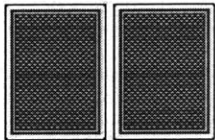
Your Hand



Your Opponent's Hand



Your Opponent Sees



Next Page

Figure 4.14. Fold screen for dealer's opponent

At this point both players completed the same questionnaire form as the participants in the Quiz and Interview Experiments (figure 3.17). As with the Quiz and Interview Experiments, the survey questions on this page were shown as eight-point Likert-scale questions with a "No Opinion" option. Each of the questions opposed a category related to an ethically positive term like "respectful" or "moral" against ethically negative terms like "invasive" or "immoral."

Following this was a brief page asking participants what "were the intentions with which you played the game." Participants were asked to choose between "Bad" and "Good." This question served as a manipulation check to see if the compensation structure induced intentions we had hoped. Note that the question is on a 7-point Likert scale without the no-opinion option. In future versions of the experiment to be consistent with the style of questionnaire used in other portions of the experiment, an 8-point Likert scale with no opinion ought to be used.

Poker Results

Follow Up Questions

Were the intentions with which you played the game:

Bad ○ ○ ○ ○ ○ ○ ○ Good

[Next Page](#)

Figure 4.15. Follow up question

Finally, participants encountered a page thanking them for participating. The page also prompted participants to contact the experimenter using an instant messaging client so that the experiment could be completed. Informal discussions about the purpose of the experiment were then conducted by myself.

Thanks

You have completed all of the information required. Please find the experimenter and let him/her know that you are finished. Thank you for participating!

You will receive \$5

Figure 4.16. Final page

Poker Results

This section performs data analysis comparing the questionnaire data measured between the no sensor, sensor, and visible card groups in the Poker Experiment. Statistical comparisons were performed using the Mann-Whitney test comparing variables between Sensors and No Sensors conditions that performed the same task. Additionally, paired Wilcoxon tests were conducted to look at differences between paired opponents. Effect sizes were calculated for significant values.

Poker: Charity Gains

Table 4.2. Poker p-value summary: participants with sensors vs. paired opponents

	Charity Gains	Charity Loses
Ethical	p=1.0	p=.39
Respectful	p=.59	p=.96
Uncomfortable	p=.33	p=.41
Hindrance	p=.25	p=.30
Immoral	p=.26	p=.35
Trustful	p=1.0	p=.56
Unfair	p=.28	p=.20
Sensors	p=1.0	p=.65
Performance	p=.52	p=.14

Table 4.3. Poker p-value summary: disadvantaged participants using sensors vs. disadvantaged participants with No Sensors or Visible Card

	Charity Gains	Charity Loses
Ethical	p=.82	p=.45
Respectful	p=.92	p=.33
Uncomfortable	p=.81	p=.71
Hindrance	p=.19	p=.71
Immoral	p=.18	p=.55
Trustful	p=.29	p=.62
Unfair	p=.82	p=.45
Sensors	p=.21	p=.09
Performance	p=.93	p=.41

Poker: Charity Gains

In the Charity Gains motivator, when a participant performed well a charity of their choice also benefited. There were no significant results from analysis of this motivator.

Poker: Charity Loses

Poker: Charity Loses

In the Charity Loses motivator, participants benefited at the expense of a charity. Participants were told "In addition, (charity) will win an amount of money. There were no significant results from analysis of this condition, but two interesting trends occurred.

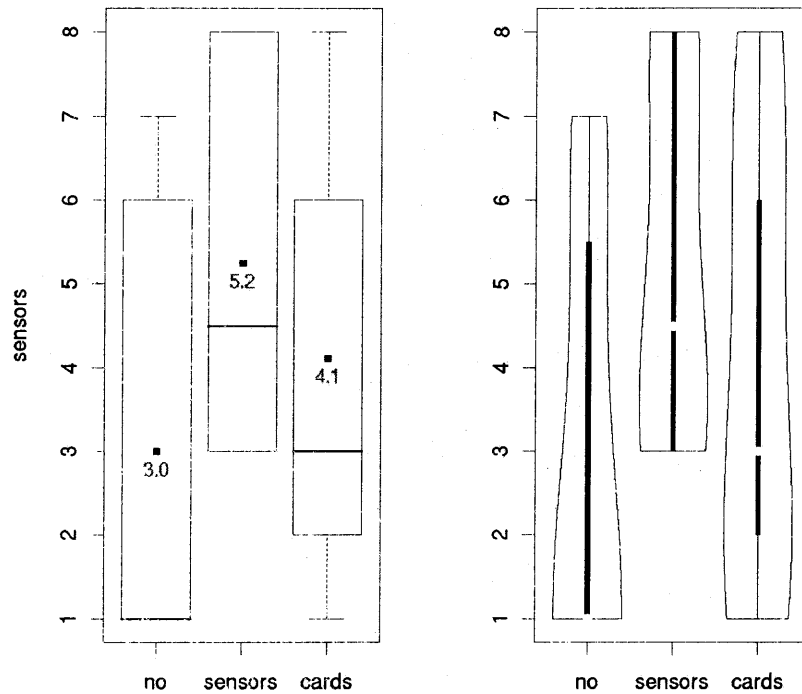
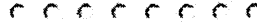


Figure 4.17. With sensors that collect information about emotion vs. task for Charity Gains motivator

Poker: Charity Loses

Given the choice between two situations you'd prefer the situation:

Without Sensors that
Collect Information
About Emotion



With Sensors that
Collect Information
About Emotion

No Opinion 6

Figure 4.18. With sensors question

A trend occurred showing participants with sensors expressed a preference for situations "with sensors that collect information about emotion" when compared with participants without sensors. A Mann-Whitney test shows that the difference is almost significant ($p\text{-value} = 0.0911$). A Kruskal-Wallis test comparing this same preference across all three conditions (No Sensors, Sensors, and Visible Card) finds no significant difference ($p\text{-value} = 0.1293$).

Poker: Charity Loses

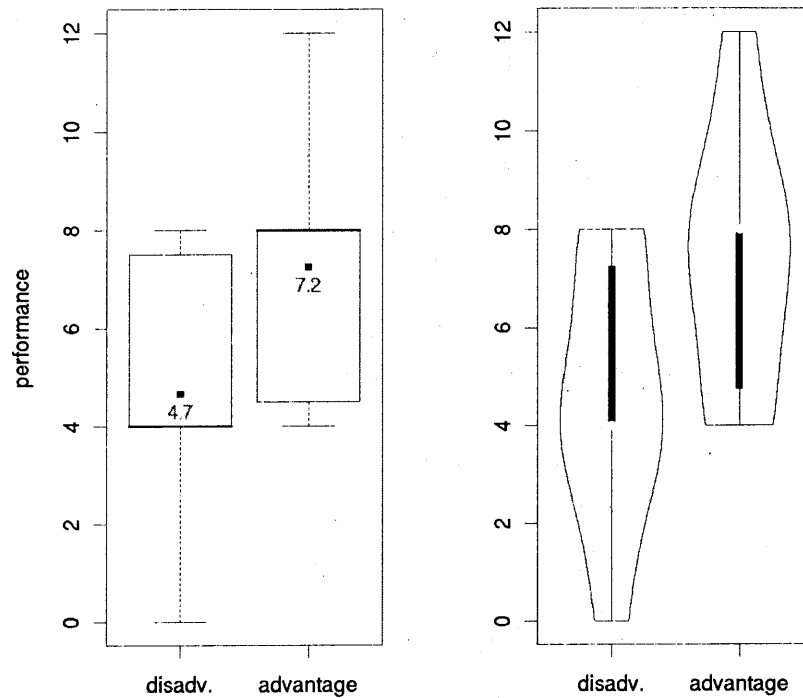


Figure 4.19. Performance of disadvantaged players with sensors vs. their advantaged opponents for Charity Loses motivator

A trend occurred showing that participants who were in the sensor condition performed worse than their paired opponents. The mean of the disadvantaged players with sensors was 4.7 dollars won compared to a mean of 7.2 dollars won by their opponents. A Mann-Whitney test shows that the difference is not significant (p-value = 0.1443).

Performance was also compared among all "disadvantaged" subjects from different motivators but the difference was found to be non-significant.

A manipulation check comparing participant reports good or bad intentions in the different motivators failed; it was non-significant.

Poker: Other Analyses

Additionally, some other analyses were performed to examine the disadvantaged participants in more depth. By grouping disadvantaged participants based upon their condition, additional Wilcoxon tests were performed.

We asked if people in one of the genuinely disadvantaged conditions (revealing a card or affect sensor data to their opponent) felt any different than their "disadvantaged" control, who just sat in the room where the sensors were located. There were no significant differences between these groups. However, there was a trend toward preferring sensors ($p=.08$) among those who had sensors or a card shown.

If instead a comparison is performed between disadvantaged participants who used sensors with participants having one of their cards shown to an opponent the following is observed. Participants having to show their card reported the situation to be significantly more unfair ($p=.05$) than those who had sensors.

These additional tests were performed after the original hypotheses the thesis set out to test were analyzed. Given that 54 individuals statistical tests were performed, it is entirely possible that the results reported in this chapter are entirely due to chance observation. Further discussion of these results occurs in Chapter 7.

Chapter 5. Interview Experiment

The purpose of the Interview Experiment was to simulate a job interview in which affective sensors would be used to aid the interviewer. An adversarial relationship was created between the interview and interviewer in the experiment by setting up goals that were at odds with one another (details below).

Interview Experimental Design

In the Interview Experiment, 144 participants were placed in a mock job interview. Half of the participants were randomly assigned to the role of interviewer for a fictional company. Interviewers were rewarded for hiring participants who work for "Good Company." Additionally, interviewers were rewarded for refusing to hire participants who work for "Bad Company." In contrast, the half of the subjects selected as interviewees were randomly assigned to have either "Good Company" or "Bad Company" as their existing employer. Interviewees were provided with a variety of motivators to try to get hired. One group of 24 were assigned to a Control motivator who used to work for Good Company and are rewarded for getting the job. The rest were assigned to have bad company as their previous employer, and then given one of two motivators to get hired: Charity Gains and Charity Loses. Both groups were told "You will need to convince the interviewer that you are from Good Company in order to get this job." Those assigned to the Charity Gains motivator were told that if they get the job then they will be rewarded and a reward will go to a charity of their choice. Conversely, those in the Charity Loses motivator were told that if they do not get the job a charity of their choice will be rewarded and if they get the job they will be rewarded instead.

Table 5.1. Interview conditions

	Control (Good Company)	Charity Gains (Bad Company)	Charity Loses (Bad Company)
No Sensors	n=12 pairs	n=12 pairs	n=12 pairs
Sensors	n=12 pairs	n=12 pairs	n=12 pairs

As with all experiments in this thesis, in the Sensors conditions one of the two subjects was wired using 3-lead electrocardiogram sensors and the HandWave skin conductance sensor. Additionally, mouse pressure and coordinates were collected. In this experiment (and in the Poker experiment) a face-tracking camera was also used to collect video of the participant's facial expressions. Participants with sensors in this condition also encountered an extra screen that explained how the sensors would be attached. These subjects were paired with a second interviewee subject who received information from these sensors using the MixedEmotions system described in the apparatus section. In addition, an instant messaging client was used by the subjects to communicate questions and answers during the interview. Thus, in the Sensors

Interview Experimental Design

condition, affective information was communicated asymmetrically, from the interviewee to the interviewer.

The No Sensors conditions performed the same task and experienced the same questionnaire instruments as the Sensors conditions. The difference was the absence of sensors and information related to attaching sensors. So, subjects in the No Sensors condition were asked to take part in a job interview mediated solely by an instant messaging client.

In all conditions, subjects acting as interviewers were told: "You are about to act as a recruiter for a job using an Internet application. Your goal is to hire candidates who used to work for Good Company and not hire candidates who used to work for Bad Company, a disreputable company. The interviewee is a former employee of either Good Company or Bad Company. In either case, however, the interviewee has been told to try to convince you s/he is from Good Company in order to get the job. If you choose to hire someone who used to work for Good Company, you will be paid a total of \$10, including \$5 for your participation. If you choose not to hire someone who used to work for Bad Company, you will also be paid a total of \$10, including \$5 for your participation. Otherwise, you will receive \$5 for your participation." In short, interviewers were rewarded for hiring candidates employees from "Good Company" and were punished for hiring deceptive candidates from "Bad Company."

Interviewees, on the other hand, were given one of three motivators: Control, Charity Gains, or Charity Loses. The following paragraphs provide details about exactly what these motivators entailed.

In the Control motivator subjects who acted as interviewees were told that they used to work for "Good Company" and told that they would receive a reward for being hired. They were paired with interviewers who were told that the participant may be from either "Good Company" or "Bad Company" and that they would be rewarded for hiring good company employees and penalized for hiring bad company employees.

In the Charity Gains motivator, when a participant was hired a charity of their choice also benefited. Participants were informed: "You are about to interview for a job using an Internet application. Your goal is to get the job. Your previous employer was Bad Company. The interviewer, however, has been told only to hire interviewees from Good Company. You will need to convince the interviewer that you are from Good Company in order to get this job. If you get the job, you will receive \$5 in addition to the \$5 you will receive for participating in this experiment. In addition, [the charity of the participant's choice] will receive \$5 if you get the job."

In the Charity Loses motivator, when participants were hired, money was taken from a contribution to a charity of their choice. Participants were told: "You are about to interview for a job using an Internet application. Your goal is to get the job. Your previous employer was Bad Company. The interviewer, however, has been told only to hire interviewees from Good Company. You will need to convince the interviewer that you are from Good Company in order to

Interview Experimental Design

get this job. If you get the job, you will receive \$5 in addition to the \$5 you will receive for participating in this experiment. [The charity of the participant's choice] will not receive any money if you get the job. If you do not get the job, you will not receive any money other than the \$5 you will receive for participating in this experiment. However, [the charity of the participant's choice] will receive \$5 if you do not get the job."

Interview Experimental Design

Participant Demographics

step: 5
test: 1
nationality: United States
education: post-graduate
email: carsonr@media.mit.edu
slot: test
sessionId: bL0--4xkAbRe5BhN8-k6w
age: 29
gender: Male
experiment: 2
condition: 2
task: 3

Hand with which you use the mouse:

- ☐ Left
- ☐ Right

A favorite charity you'd like to see a donation made toward:

- ☐ Action Against Hunger
- ☐ American Red Cross
- ☐ American Jewish World Service
- ☐ AmeriCares
- ☐ Asia Foundation
- ☐ BAPS Care International
- ☐ CARE
- ☐ Direct Relief International
- ☐ GOAL
- ☐ Habitat for Humanity International
- ☐ International Federation of Red Cross and Red Crescent
- ☐ Islamic Relief Worldwide
- ☐ Karuna Trust
- ☐ Network for Good
- ☐ Oxfam International
- ☐ Quarters From Kids: Tsunami Relief and Rebuilding
- ☐ Sarvodaya
- ☐ Save the Children
- ☐ UNICEF
- ☐ World Food Programme (UN)
- ☐ World Vision
- ☐ Other charity

Next Page

Reassign

Spare

Interview Experimental Design

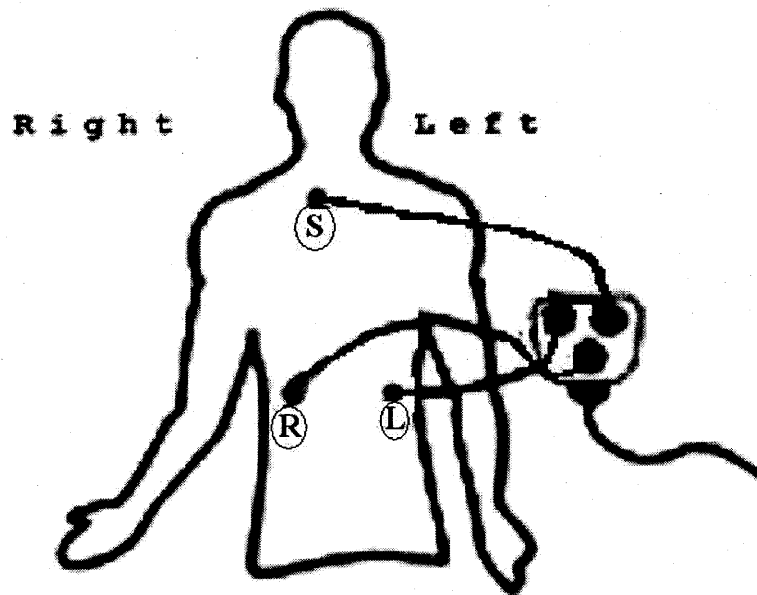
Figure 5.1. Initial page of the Interview Experiment

The first web page encountered by subjects in the Quiz Experiment was just used to verify their demographic information. In the sensor condition, subjects were also asked preliminary questions. After the consent form was signed and the identity of the participant verified, subjects were to move on to the next page. All participants acting as interviewees were placed in the office containing the sensing apparatus (regardless of whether they were assigned to the Sensor condition or No Sensor condition).

Sensor Preparation

The experimenter will now ask you to attach sensors. (You may go to the bathroom for privacy if you like.)

The sensors should be placed to match the following diagram:



The HandWave device will also be attached by the experimenter to your left hand.

[Next Page](#)

Figure 5.2. Sensor preparation information (interviewee)

Interview Experimental Design

In the case that an interviewee was assigned to a sensors condition, he or she was shown a page informing that sensors would be used. In the case that the subject was assigned to the no Sensors condition, the system skipped forward to a page showing the instructions for their task. Before leaving the room, the experimenter also told all subjects how to find them (if needed) during the experiment or once the experiment was completed. At this point the experimenter would leave the room.

Your Task

- You are about to interview for a job using an Internet application.
- Your goal is to get the job.
- Your previous employer was Bad Company.
- The interviewer, however, has been told only to hire interviewees from Good Company. You will need to convince the interviewer that you are from Good Company in order to get this job.
- If you get the job, you will receive \$5 in addition to the \$5 you will receive for participating in this experiment. Asia Foundation will not receive any money if you get the job.
- If you do not get the job, you will not receive any money other than the \$5 you will receive for participating in this experiment. However, Asia Foundation will receive \$5 if you do not get the job.
- The table below summarizes how money will be distributed based on the results of this experiment:

	You	Asia Foundation
Get Job	\$10	\$0
Don't get Job	\$5	\$5

- Please try your hardest to get this job!
- Please minimize this window and interview over the instant messenger client.
- Do not go to the next page until you have finished the interview.

[Next Page](#)

Figure 5.3. Your task (interviewee - Charity Loses motivator)

After viewing the sensor preparation information, a page displaying the instructions for the interviewee was displayed. This page explained the job-interview process to participants and also the compensation they would receive (which was dependent upon their motivator).

Interview Experimental Design

Your Task

- You are about to act as a recruiter for a job using an Internet application.
- Your goal is to hire candidates who used to work for Good Company and not hire candidates who used to work for Bad Company, a disreputable company.
- The interviewee is a former employee of either Good Company or Bad Company. In either case, however, the interviewee has been told to try to convince you s/he is from Good Company in order to get the job.
- If you choose to hire someone who used to work for Good Company, you will be paid a total of \$10, including \$5 for your participation.
- If you choose not to hire someone who used to work for Bad Company, you will also be paid a total of \$10, including \$5 for your participation.
- Otherwise, you will receive \$5 for your participation.
- The table below summarizes how you will be paid based on the results of this experiment:

Interviewee is from:	Good Company	Bad Company
Hire	\$10	\$5
Don't Hire	\$5	\$10

Figure 5.4. Your task (interviewer)

The interviewer, on the other hand, after viewing an initial page next saw the instructions for their task. As with the interviewee, this page related the process of the job interview to participants along with the reward structure of the experiment.

Interview Experimental Design

- You will see a program that gives you information about the candidate.
- A video stream of the candidate's face is displayed along with mouse grip force, heart rate (EKG), and skin conductivity (EDR) information.
- A calm candidate, for instance might appear as follows:

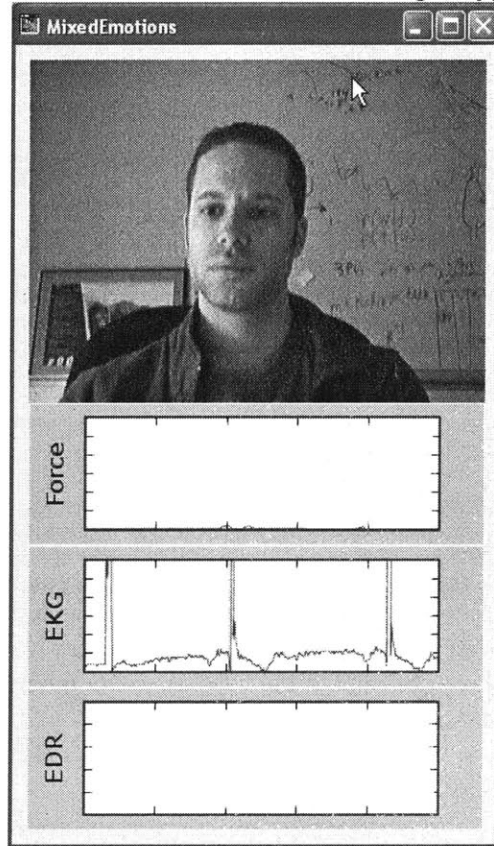


Figure 5.5. Your task - sensors (interviewer)

In the case that the interviewer was paired with a interviewee in the sensor condition, they received additional information about how to interpret the data coming from MixedEmotions. This took the form of instructions comparing a "calm" state with a "stressed" state.

Interview Experimental Design

- A candidate who is stressed may show increased grip force, irregular heart rate, and a rise in skin conductivity, as well as changes in facial expressions, as in the following image:

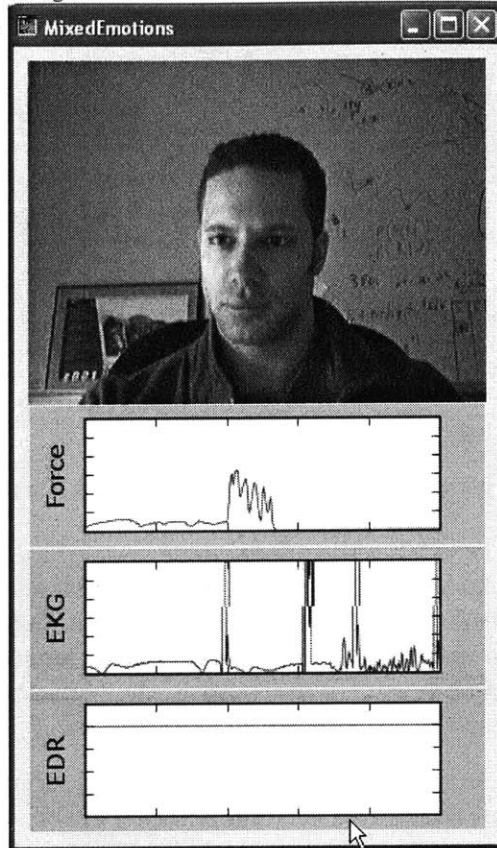


Figure 5.6. Your task - sensors (interviewer)

The goal of these instructions was to help the interviewer spot participants who might appear to be stressed. For instance, an interviewee who is being deceptive about their past employment might change facial expressions and exhibit an increase in skin conductivity. In practice, many of these signals are noisy and even thoroughly trained polygraphers may have difficulty perfectly interpreting such data.

Please note that there was an error in these instructions informing interviewers that candidates with "irregular heart rate" may be more stressed. Quite the contrary, normal resting individuals often show irregular heart rates. This should be corrected in future uses of this protocol.

Interview Experimental Design

- Please use the following list of interview questions to conduct an interview using the instant messaging software provided:
 1. What is your name?
 2. What is your address?
 3. What is one of your strengths?
 4. What is one of your weaknesses?
 5. Who was your previous employer?
 6. Why do you want to work for us?
 7. A free-form question of your choosing
- Please minimize this window and conduct the interview on the instant messenger client.
- Following the interview, please complete the following form:

Hiring Decision:

☐ Don't Hire

☐ Hire

Next Page

Figure 5.7. Your task (interviewer)

Interviewees in both sensors and No Sensors conditions were provided a script to structure the interviews along with a form to indicate their hiring decision. After the interviewer had reviewed this page, the experimenter would inquire if there were any questions about the task. Interviewers were told to notify the interviewees that the interview was over once all of these questions had been asked. Interviewers were also told to notify the experimenter that the interview and following questionnaires were complete by exiting the office and signaling by waving.

The interviewer was then expected to conduct an interview with the interviewee using the outline provided:

1. What is your name?
2. What is your address?
3. What is one of your strengths?
4. What is one of your weaknesses?
5. Who was your previous employer?

Interview Experimental Design

6. Why do you want to work for us?
7. A free-form question of your choosing

Questionnaire

Please fill out the following questionnaire before your compensation is determined.

Each of the following questions asks about the *situation* you encountered during the experiment. *Situation* refers to the methods of observation by the other individual or system with which you interacted. In the answers you give below, imagine you encountered this *situation* in everyday life.

Figure 5.8. Interview questionnaire (situation)

Once the interview was completed, both the interviewee and interviewer filled in a questionnaire designed to get at some of the ethical implications with which this thesis concerns itself. The questionnaire asked participants to consider a situation much like the one they encountered. This questionnaire is described in greater detail in Chapter 3, Figure 3.17.

Follow Up Questions

How honest were you during the interview:

Dishonest ○ ○ ○ ○ ○ ○ ○ ○ Honest
No Opinion ○

Would you say the intentions which you acted as an interviewee were:

Bad ○ ○ ○ ○ ○ ○ ○ ○ Good
No Opinion ○

Next Page

Figure 5.9. Follow up questions

Interview Results

Both interviewees and interviewers then encountered questions that served as a manipulation check. Interviewers were asked "How honest do you feel the interviewee was:" and given a 8 point Likert scale between Dishonest and Honest. Interviewees on the other hand were asked "How honest were you during the interview:" again using Dishonest and Honest as poles for the Likert scale. Additionally, interviewees were asked "Would you say the intentions which you acted as an interviewee were:" with Bad and Good as options.

Thanks

You have completed all of the information required. Please find the experimenter and let him/her know that you are finished. Thank you for participating!

I'm sorry, you were not hired and will receive \$5

Figure 5.10. Final page for all subjects who were not hired

Finally, participants encountered a page thanking them for participating. The page also prompted participants to contact the experimenter using an instant messaging client so that the experiment could be completed. Informal discussions about the purpose of the experiment were then conducted by myself.

Interview Results

This section performs data analysis comparing the questionnaire data measured between the control and sensor groups in the Interview Experiment. Wilcoxon tests were performed comparing the responses of job interviewers with their paired job interviewee who experienced sensors. Mann-Whitney tests were also performed comparing pairs who experienced sensors to those who did not. Effect sizes were calculated for significant values.

Interview Results

Table 5.2. Interviewees with sensors vs. paired interviewers p-value and r-value summary

	Control	Charity Gains	Charity Loses
Ethical	p=.002, r=1.48	p=1.0	p=1.0
Respectful	p=.01, r=1.16	p=.72	p=.57
Uncomfortable	p=.03, r=-.59	p=.08	p=.96
Hindrance	p=.50	p=.22	p=.44
Immoral	p=.08	p=.11	p=1.0
Trustful	p=.31	p=.65	p=.10
Unfair	p=.30	p=.06	p=.15
Sensors	p=.57	p=1.0	p=.06
Performance	p=1.0	p=.09	p=.06

Table 5.3. Interviewees with sensors vs. interviewees without sensors p-value summary

	Control	Charity Gains	Charity Loses
Ethical	p=.26	p=.72	p=.12
Respectful	p=.61	p=.97	p=.17
Uncomfortable	p=.30	p=.59	p=.82
Hindrance	p=.93	p=.13	p=.84
Immoral	p=.59	p=.89	p=1.0
Trustful	p=.49	p=.24	p=.39
Unfair	p=.95	p=.91	p=.48
Sensors	p=.56	p=.35	p=.07
Performance	p=.10	p=.11	p=.71

Table 5.4. Hiring rates of conditions in the Interview Experiment

	No Sensors	Sensors
Control	50%	17%
Charity Gains	58%	25%
Charity Loses	50%	58%

Interview: Control

Interview: Control

In the Control motivator, participants were rewarded for being hired. There was no mention of a charity.

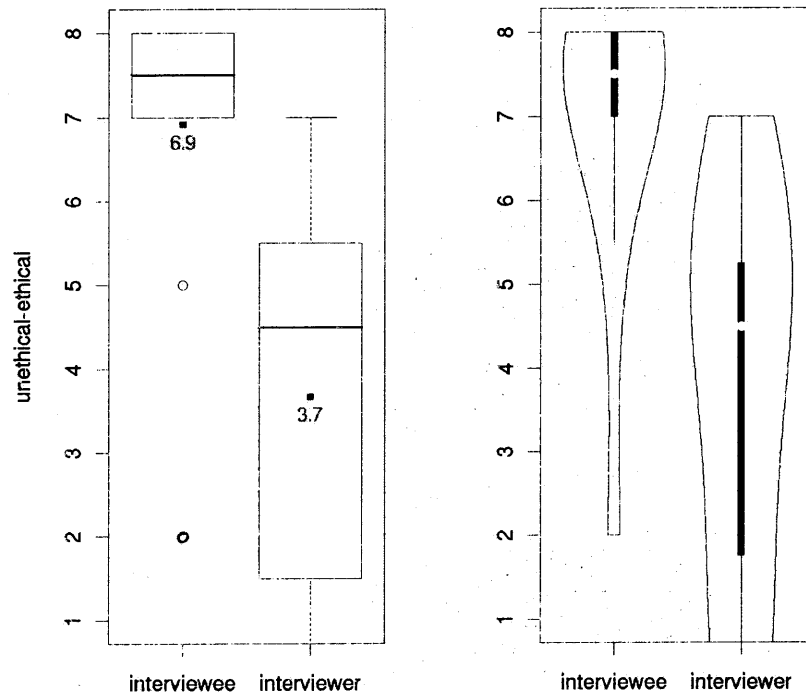


Figure 5.11. Ethical vs. interview role for Control motivator

Do you think the situation is:

Unethical ● ● ● ● ● ● ● ● Ethical
No Opinion ●

Figure 5.12. Ethical question

Interview: Control

The hypothesis in this case is false: interviewees with sensors reported the situation was significantly more ethical than the interviewers who received information from these sensors. A Wilcoxon test shows that the difference is significant ($p\text{-value} = 0.002309$). Furthermore, the effect size $r=1.48$ reflects a large positive change toward ethical from unethical for those interviewees who had sensors.

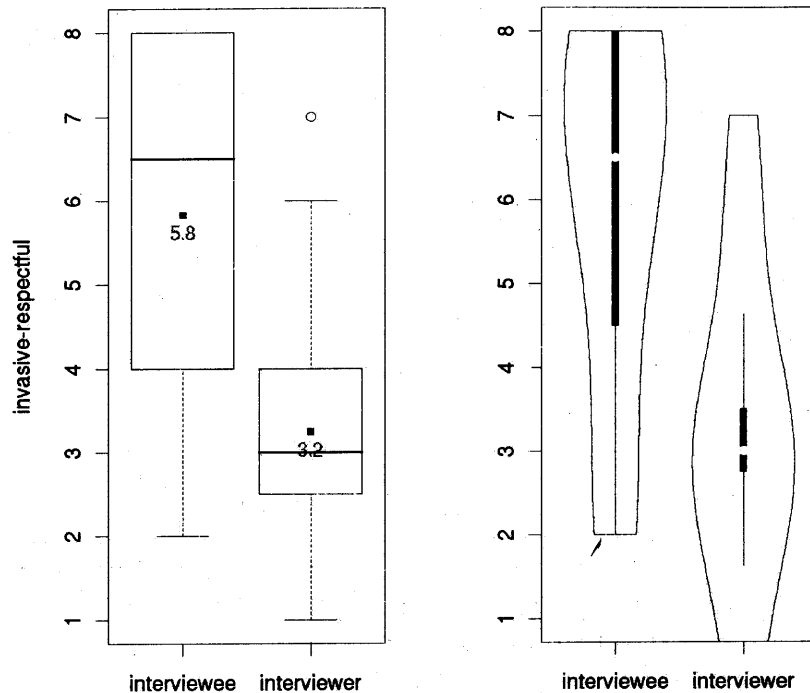


Figure 5.13. Respectful vs. interview role for Control motivator

Do you think the situation is:

Invasive ◐ ◐ ◐ ◐ ◐ ◐ ◐ ◐ Respectful
No Opinion ◐

Figure 5.14. Respectful question

Interview: Control

The hypothesis in this case is false: interviewees with sensors reported the situation as more respectful than interviewers who received sensor data. A Wilcoxon test shows that the difference is significant ($p\text{-value} = 0.01376$). Furthermore, the effect size $r=1.16$ reflects a large positive change from invasive toward respectful for those interviewees who had sensors.

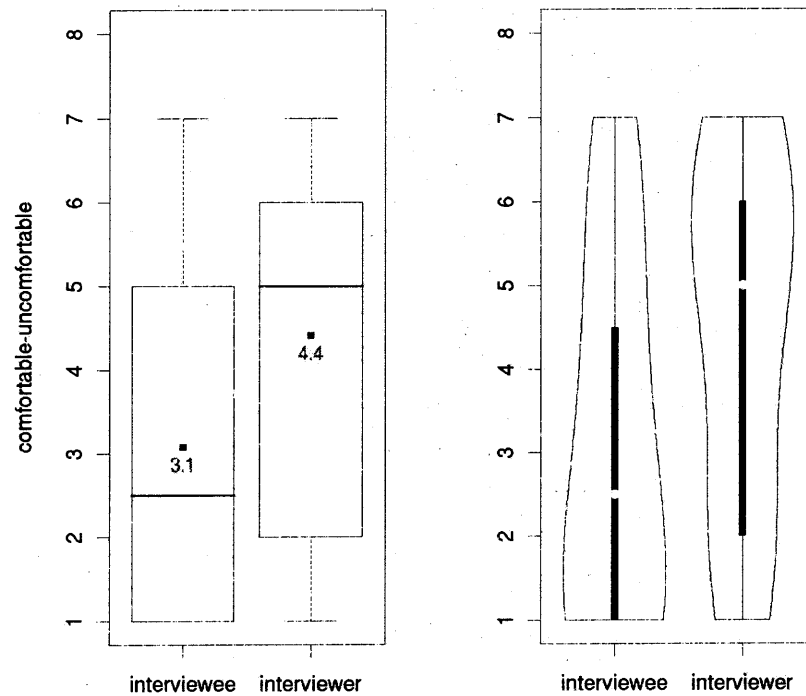


Figure 5.15. Uncomfortable vs. interview role for Control motivator

Does the situation make you feel:

Comfortable ○ ○ ○ ○ ○ ○ ○ ○ Uncomfortable
 No Opinion ○

Figure 5.16. Uncomfortable question

Interview: Control

The hypothesis in this case is false: interviewees with sensors reported they felt significantly more comfortable than interviewers who received sensor data (who felt uncomfortable). Additionally, a Wilcoxon test shows that the difference is significant ($p\text{-value} = 0.02912$). Furthermore, the effect size $r = -.59$ reflects a medium negative change from uncomfortable toward comfortable for those interviewees who had sensors.

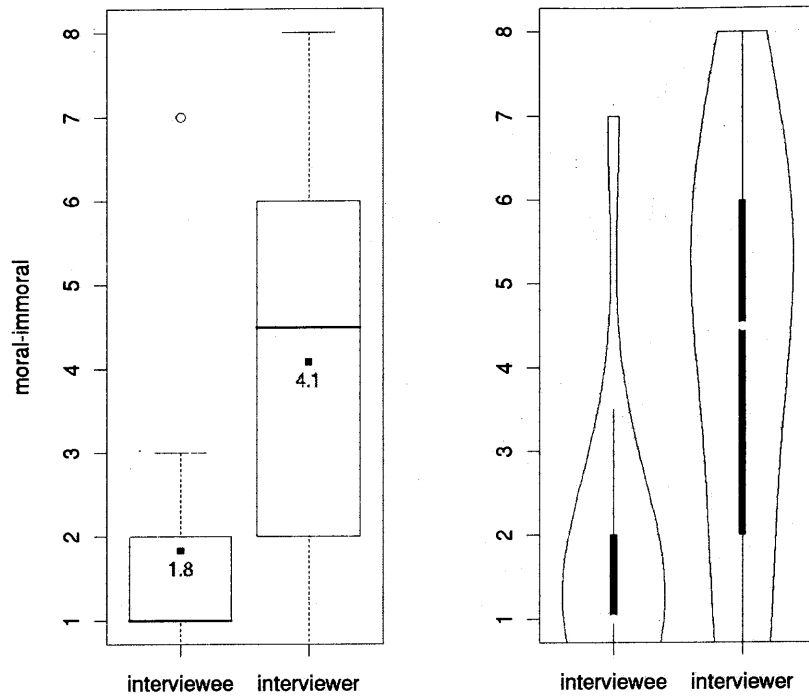


Figure 5.17. Immoral vs. interview role for Control motivator

Do you think the situation is:

Moral ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Immoral
 No Opinion ☐

Figure 5.18. Immoral question

Interview: Charity Gains

A trend occurs in this measure showing that interviewees with sensors found the situation more moral than interviewers receiving their information. A Wilcoxon test shows that the difference is not significant ($p\text{-value} = 0.08093$).

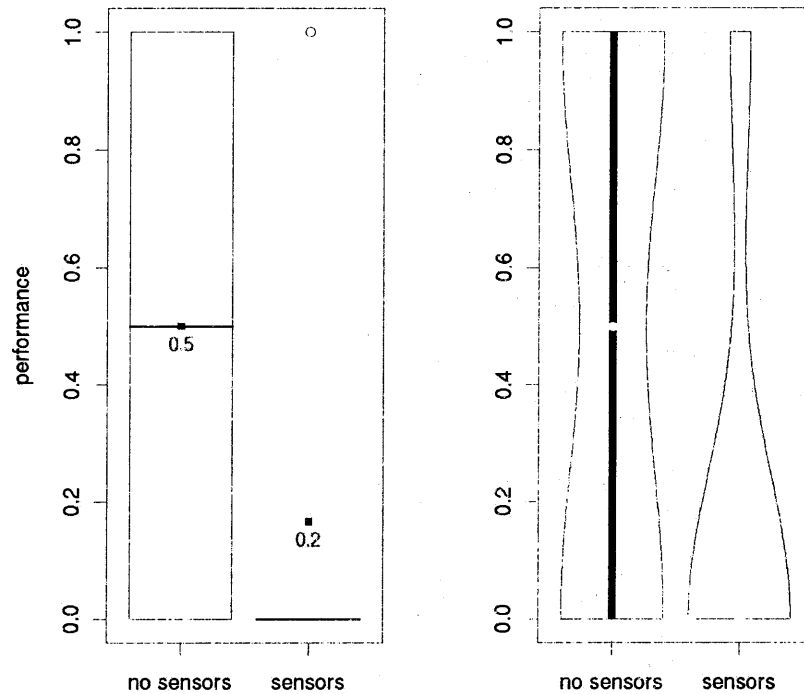


Figure 5.19. Performance vs. sensors for Control motivator

A trend occurs showing that, in the Control condition (where all the interviewees were from Good Company) hiring performance was poorer when interviews involved sensors than when they did not. Specifically, interviewees with sensors were hired 17% of the time while interviewees without sensors were hired 50% of the time. A Mann-Whitney test shows that the difference is not significant ($p\text{-value} = 0.09686$).

Interview: Charity Gains

In the Charity Gains motivator, when a participant was hired a charity of their choice also benefited.

Interview: Charity Gains

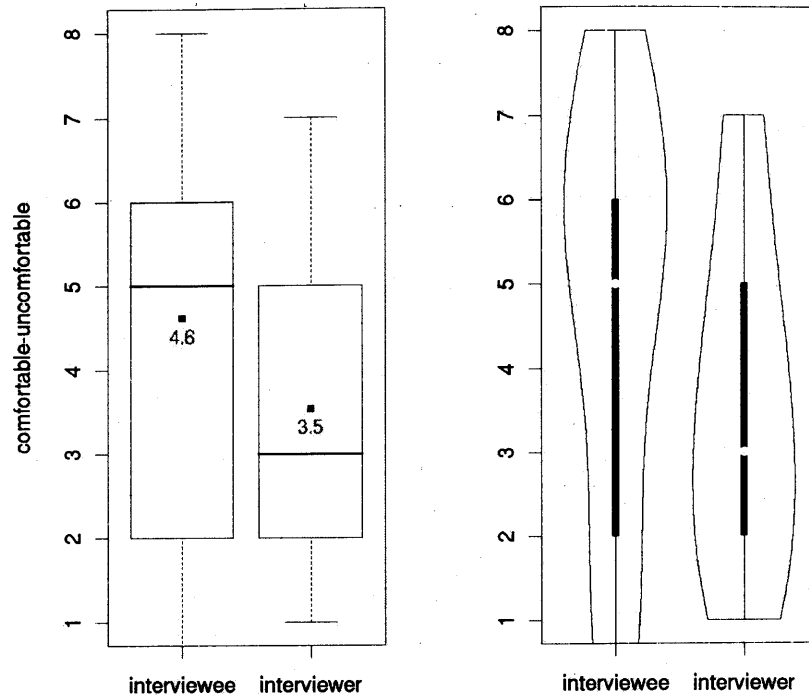


Figure 5.20. Uncomfortable vs. interview role for Charity Gains motivator

Does the situation make you feel:

Comfortable ◐ ◐ ◐ ◐ ◐ ◐ ◐ ◐ Uncomfortable
 No Opinion ◐

Figure 5.21. Uncomfortable question

A trend occurs in this measure showing a greater report of discomfort from interviewees who had sensors when compared with interviewers who received sensor information. A Mann-Whitney test shows that the difference is not significant ($p\text{-value} = 0.08073$).

Interview: Charity Gains

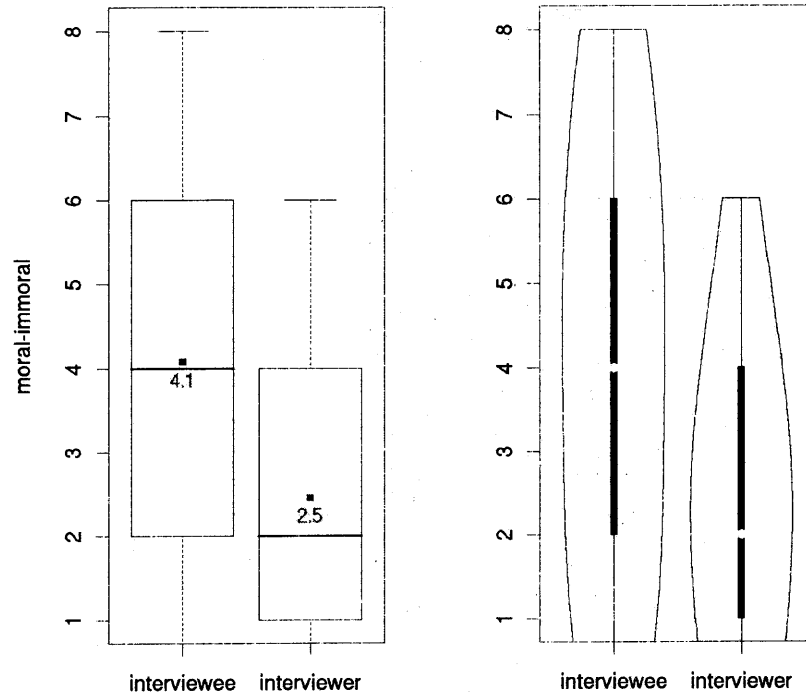


Figure 5.22. Immoral vs. interview role for Charity Gains motivator

Do you think the situation is:

Moral ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ Immoral
No Opinion ◐

Figure 5.23. Immoral question

A trend occurs here showing interviewees with sensors reported the situation was less moral and more immoral than interviewers who received sensor data. A Wilcoxon test shows that the difference is almost significant (p-value = 0.112).

Interview: Charity Gains

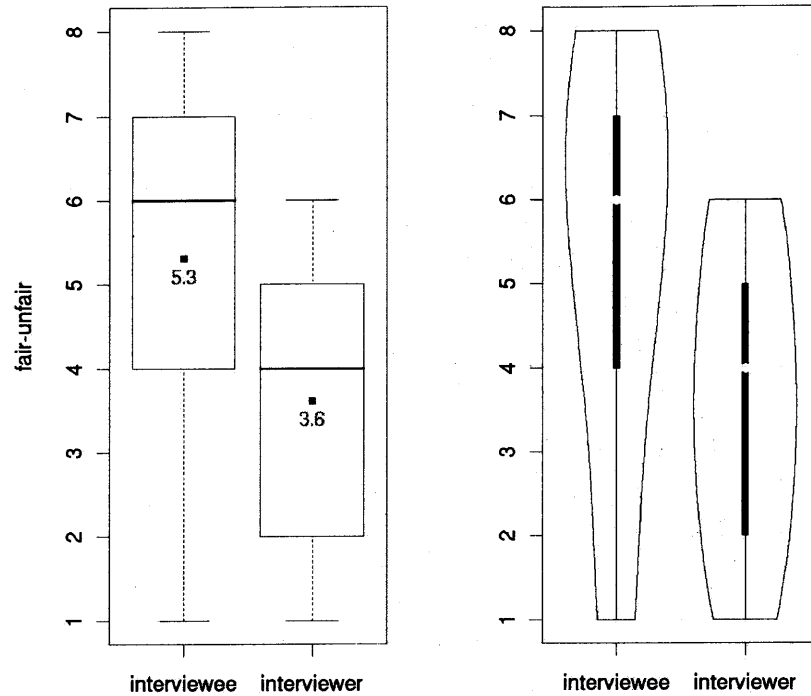


Figure 5.24. Unfair vs. interview role for Charity Gains motivator

Do you feel the situation is:

Fair ○ ○ ○ ○ ○ ○ ○ ○ Unfair
No Opinion ○

Figure 5.25. Unfair question

A trend occurs here showing interviewees with sensors reported the situation was less fair and more unfair than than interviewers who received sensor data. A Wilcoxon test shows that the difference is weakly significant (p-value = 0.0613).

Interview: Charity Loses

Interview: Charity Loses

In the Charity Loses motivator, participants benefited at the expense of a charity. This placed the interviewee in a conflicted position: the better their performance, the less money a charity of their choice received.

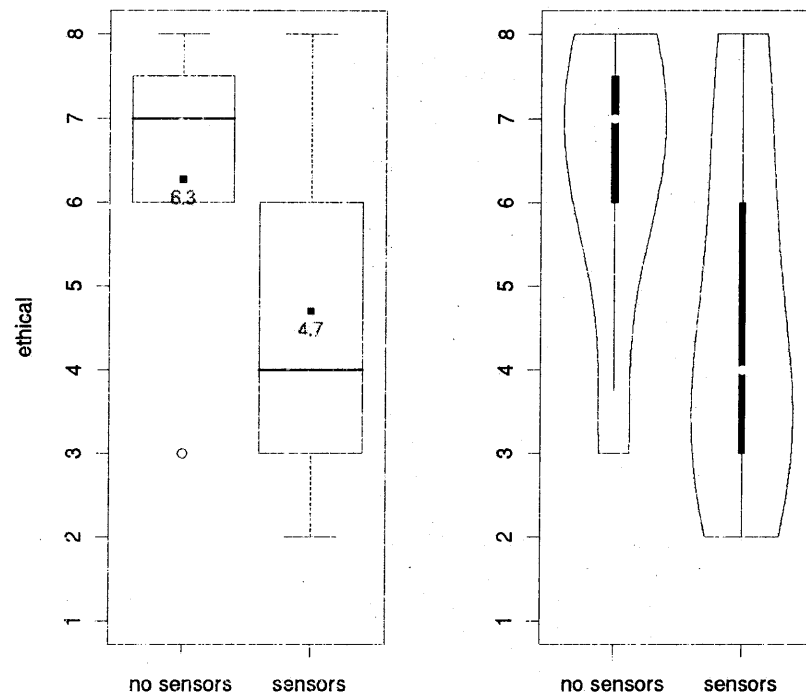


Figure 5.26. Ethical vs. sensors for Charity Loses motivator

A trend occurs showing interviewees with sensors reported the situation as less ethical than their interviewer counterparts. A Mann-Whitney test shows that the difference is not significant (p-value = 0.1219).

Interview: Charity Loses

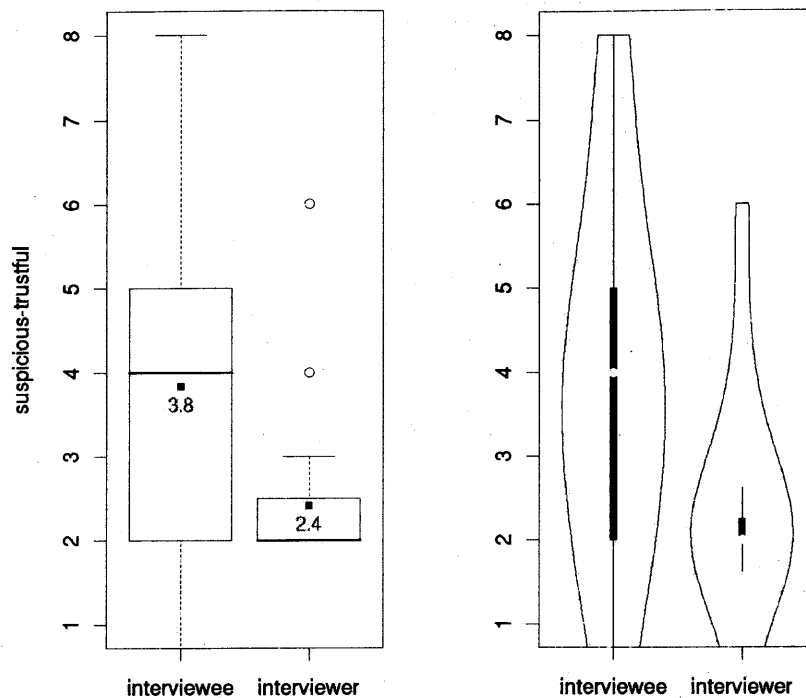


Figure 5.27. Trustful vs. interview role for Charity Loses motivator

Which of the following does the situation make you feel:

Suspicious ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Trustful
 No Opinion ☐

Figure 5.28. Trustful question

Interviewers showed a trend toward being more suspicious and less trustful than the interviewees whose information they observed. A Wilcoxon test shows that the difference is not significant (p-value = 0.1054).

Interview: Charity Loses

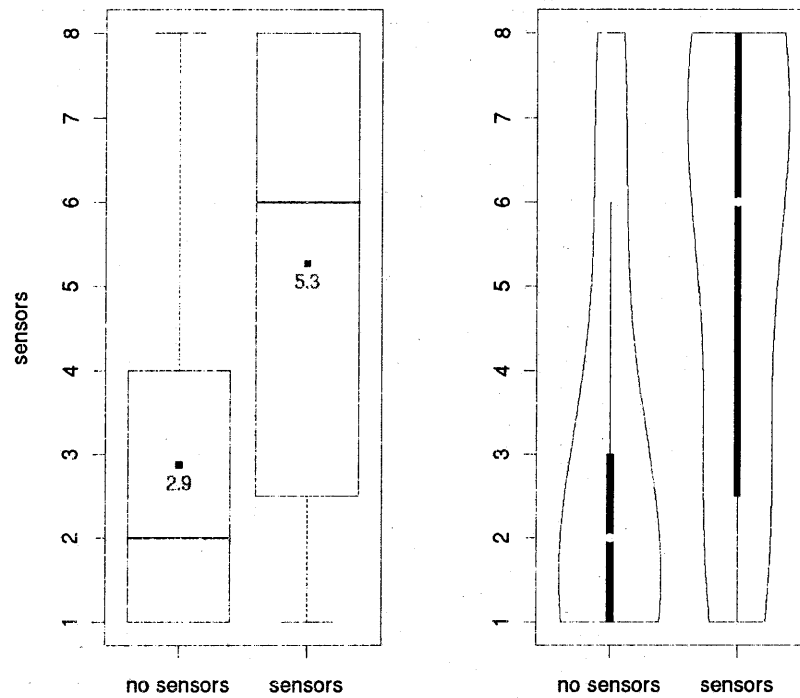
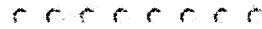


Figure 5.29. With or without sensors vs. condition for Charity Loses motivator

Given the choice between two situations you'd prefer the situation:

Without Sensors that
Collect Information
About Emotion



With Sensors that
Collect Information
About Emotion

No Opinion

Figure 5.30. With sensors question

Interviewees who used sensors expressed a trend toward preferring situations "with sensors that collect information about emotion" as compared to interviewees who did not use sensors. A Mann-Whitney test shows that the difference is almost significant (p -value = 0.06816).

Interview: Charity Loses

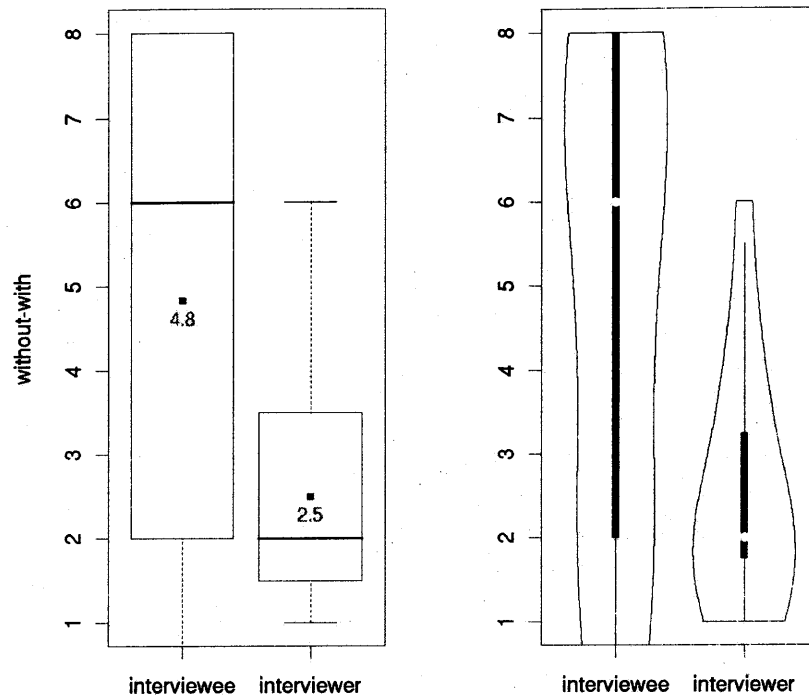


Figure 5.31. With sensors that collect information about emotion vs. interview role for Charity Loses motivator

Given the choice between two situations you'd prefer the situation:

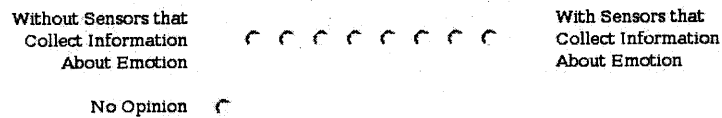


Figure 5.32. With sensors question

When comparing interviewees who used sensors with interviewers who received this information a trend also emerged. Interviewees with sensors preferred situations "with sensors the collect information about emotion" as opposed to interviewers who preferred situations "without sensors

Interview Experiment Discussion

that collect information about emotion." Wilcoxon test shows that the difference is nearly significant ($p\text{-value} = 0.05884$).

Interview Experiment Discussion

In the data analysis for this experiment some interesting phenomena are present. In the data for the Control motivator there were several significant results in which interviewers reported more negative views than interviewees. However, in the Charity Gains motivator there were instead several trends in which interviewees reported negative views instead of interviewers.

This flip in opinion can perhaps be ascribed to one group of subjects being from Good Company (and as a consequence having nothing to hide) and the other group being from Bad Company (and having something to hide). Although, the same trends are not seen in Charity Loses, where subjects were also from Bad Company. This suggests a more complex explanation: perhaps the specifics of the Charity Gains condition were responsible for this flip in opinion.

There is some evidence to support this more complex explanation. In examining reports of how "honest" the participants were, there was a significant difference ($p=.05$) dependent upon the motivator. Participants in the control were most honest while participants in the charity gains motivator were least honest.

Also, the trend toward a performance difference in hiring when sensors were present is of interest. Here it is possible that the discomfort of the interviewers was projected onto the interviewees, even though many were from Good Company and had no need to be anything other than truthful.

Chapter 6. Quiz Experiment

The purpose of the Quiz Experiment was to create an adversarial quiz-like situation in which the use of affective sensors would be studied. A secondary goal of the experiment was to explore guilt associated with cheating behavior. The adversarial relationship was created between the quiz-taker and the experimenter: the quiz-taker was given the opportunity to exaggerate their score (viz. cheat) for greater financial gain for participating in the experiment while the experimenter sought (ostensibly) to reward genuine work.

Quiz Experimental Design

In the Quiz Experiment 96 participants were asked to perform a boring and laborious task in an experimental design that allows the possibility of increasing the reward by reporting a score that is larger than what the subject actually achieved. The task asks participants to circle numbers that sum to 10 in a 3 X 4 grid [mazar2004]. The initial design of this experiment was borrowed from Nina Mazar and Dan Ariely. Following a number of changes that were made during a pilot study, the following experimental design was arrived at by myself, Phil Davis, and Rosalind Picard.

2.08	1.76	9.95
8.08	9.13	6.02
4.68	2.94	1.16
4.07	7.78	5.32

┐ Got it!

Figure 6.1. One of the 30 squares used in the quiz experiment. Participants were asked to find the pair of numbers that sum to 10

There were a total of eight conditions in the 2 x 4 experiment. The first dimension was the use of sensors versus no sensor information being collected. In addition there were four motivators: Control, No Effect on Charity, Charity Gains, and Charity Loses. In a similar experiment conducted as part of Phil Davis' thesis [davis2005], there were also 4 motivators: Control, No Charity, Charity Gains, Charity Loses. In the revised experimental design, the No Charity motivator was changed so that participants encountered a charity but their performance had no effect on the charity's reward. The rationale for this decision was that it is important to balance

Quiz Experimental Design

the presence of a charity. Thus, three of our conditions are identical to those in Davis's thesis, however new participants were recruited for all conditions.

Table 6.1. Quiz conditions

	Control	No Effect on Charity	Charity Gains	Charity Loses
No Sensors	n=12	n=12	n=12	n=12
Sensors	n=12	n=12	n=12	n=12

In the Sensors conditions, subjects were wired using ProComp+ 3-lead electrocardiogram and the HandWave skin conductance sensor. Additionally, mouse pressure and coordinates were collected. Participants in this condition also encountered an extra screen that explained how the sensors would be attached.

The No Sensor conditions performed the same task and experienced the same questionnaire instruments as the sensor condition. The difference was the absence of sensors and information related to attaching sensors.

The next few paragraphs will describe the different motivators participants experienced: Control, No Effect on Charity, Charity Gains, and Charity Loses. These motivators provided a variety of different compensation strategies to induce different behaviors. Procedures for each of these different motivators will follow.

Table 6.2. Quiz compensation

Control (w/ Observer)	No Effect on Charity (w/o Observer)	Charity Gains	Charity Loses
Dollars "equal to half of your score" and \$5 to charity regardless of performance.	Dollars "equal to half of your score" and \$5 to charity regardless of performance.	Dollars "equal to half of your score" given to both charity and participant as well as \$5 for participating.	"Total amount won between you and the charity (not including your \$5 participation payment) will be \$15." Each correct answer deducts \$0.50 from amount charity receives and gives it to participant.

The Control motivator was designed to discourage cheating through frequent presence of the experimenter in the testing room as well as the handing-in and verification of quiz work. In the Control and No Effect on Charity motivators participants were told, "Your score will determine your compensation for this experiment. The better you score, the more money you will win! Specifically, you will receive an amount of money equal to half of your score (in dollars). For

Quiz Experimental Design

example, if your score on the quiz is 20 then you will receive \$10 (half of 20). Also, no matter what, you will receive an additional \$5 for your participation. Charity Compensation: In addition, (charity) will win \$5 (independent of your score). Please try as hard as you can on this quiz to maximize your earnings!" Here and below "(charity)" was replaced by a charity of the participant's choice.

In the Control there were two points during which the experimenter was in the room and interacted with the subject that did not occur in other conditions. In the practice quiz, once 5 minutes had elapsed an alarm sounded saying "your time is up, stop your work immediately and tell the experimenter you are done through the instant messaging client." This alarm would repeat until the participant had contacted the experimenter, who would then enter the room and disable the alarm. After this, the experimenter would collect the quiz work and look it over and leave the room. During the real quiz, once 5 minutes had elapsed, the same alarm would sound and the experimenter would again enter the room, disable the alarm, and collect and look over the quiz work. These were the only points that the experimenter was present in the room during the Control and not during the other conditions.

The No Effect on Charity motivator was the same as the Control except that the experiment did not enter the room to check the work; instead the subjects reported their scores through a web form.

In the Charity Gains motivator, better performance benefited both the participant and a charity of their choice. More specifically, the charity that was chosen was given as much money as the participant won. Participants were informed "In addition, (charity) will win an amount of money. The better you score, the more money (charity) will win! Specifically, you will win an amount of money also equal to half your score. For example, if your score is 20, you and (charity) will each win \$10 (not including your \$5 participation payment)! So, by scoring well, not only do you help yourself, but you also help (charity). Please try as hard as you can on this quiz to maximize your earnings!"

In the Charity Loses motivator, participants benefited at the expense of a charity. Participants were told "In addition, (charity) will win an amount of money. Unfortunately, due to budget constraints, the better you score, the less money (charity) will win. Specifically, the total amount won between you and the charity (not including your \$5 participation payment) will be \$15. So, by scoring well, you help yourself, but you also hurt (charity). Please try as hard as you can on this quiz to maximize your earnings!"

After signing up using the experiment scheduling system described in Appendix A participants arrived at the Media Laboratory. Because of difficulties with participants not appearing for their experiment, we elected to schedule every participant initially for either the Interview or Poker experiment. When one participant arrived for these paired experiments, but the other did not appear after 15 minutes I reassigned the one who had arrived to the Quiz Experiment.

Control

I first escorted the participant to the office used to conduct the Quiz Experiments. This office was the same, regardless of whether the subject wore sensors or was in a condition without sensors. I would then launch GAIM, a freely-available instant messaging client, so that any questions participants had could be answered without them leaving the room where the experiment was conducted. At this point the participant would receive a consent form for the Quiz Experiment (see Appendix A).

Control

Participant Demographics

step: 5
test: 1
nationality: United States
education: post-graduate
email: carsonr@media.mit.edu
slot: test
sessionId: -clqhvKyjCb5BnEQ6Tw-w
age: 29
gender: Male
experiment: 1
condition: 2
task: 1

[Next Page](#)

Figure 6.2. Initial page of the Quiz Experiment (tailored for each participant)

The first web page encountered by subjects in Control motivator was used to verify their demographic information. After the consent form was signed and the identity of the participant verified, subjects were asked to move on to the next page.

Control

Initial Questions

Please indicate with which hand you use the mouse:

- ☐ Left
- ☐ Right

A charity of your choice may receive compensation in addition to your own compensation.

Please indicate a favorite charity you'd like to see a donation made toward:

- ☐ Action Against Hunger
- ☐ American Red Cross
- ☐ American Jewish World Service
- ☐ AmeriCares
- ☐ Asia Foundation
- ☐ BAPS Care International
- ☐ CARE
- ☐ Direct Relief International
- ☐ GOAL
- ☐ Habitat for Humanity International
- ☐ International Federation of Red Cross and Red Crescent
- ☐ Islamic Relief Worldwide
- ☐ Karuna Trust
- ☐ Network for Good
- ☐ Oxfam International
- ☐ Quarters From Kids: Tsunami Relief and Rebuilding
- ☐ Sarvodaya
- ☐ Save the Children
- ☐ UNICEF
- ☐ World Food Programme (UN)
- ☐ World Vision
- ☐ Other Charity

How much do you care about the charity you have chosen?

Not at all ☐ ☐ ☐ ☐ ☐ ☐ ☐ A lot

[Next Page](#)

Figure 6.3. Initial questions for the Quiz Experiment for all conditions

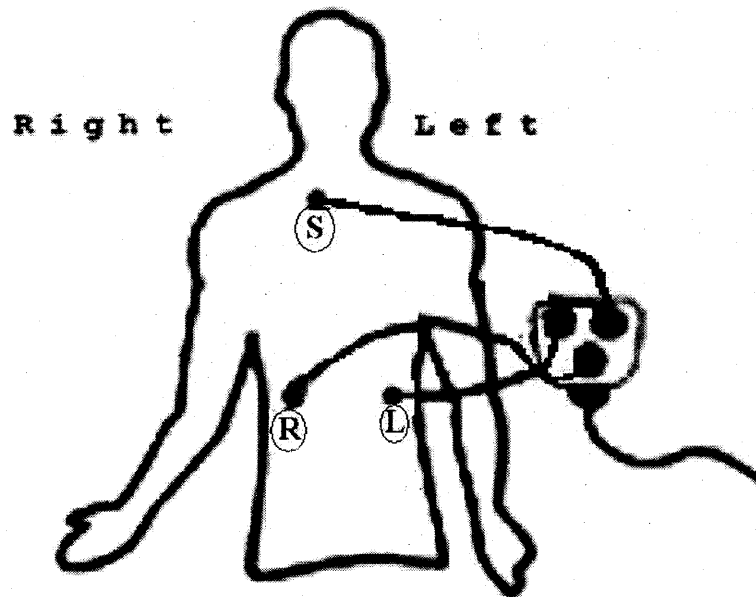
On the second page of the Control motivator, participants answered initial questions. All participants were asked if they were left or right handed. Next participants were asked to select or name a charity that "may receive compensation in addition to your own compensation." Lastly, participants were asked "How much do you care about the charity you have chosen?" These first two pages were the same across all conditions.

Control

Sensor Preparation

The experimenter will now ask you to attach sensors. You may go to the bathroom for privacy if you would like.

The sensors should be placed to match the following diagram:



The HandWave device will also be attached by the experimenter to your left hand.

Note: There will be no video, no audio, and no other sensors used in this experiment.

The experimenter should now show you how to use the paper shredder and then leave the room.

If you have any additional questions for the experimenter during the experimenter, please use the instant messaging client to contact him.

[Next Page](#)

Figure 6.4. Sensor preparation information

In the case that participants were assigned to a sensor condition, they were shown a page that informed them that sensors would be used and how to contact the experimenter once the experiment started. In the non-sensor conditions, participants received verbal instructions explaining how to contact the experimenter. Participants were shown how to use an instant messaging

Control

client to contact the experimenter. This page was accompanied by audio instructions played from a speaker attached to a computer. Note that the page states "no other sensors" will be present. We were thinking at the time about video or audio, which could make subjects feel surveilled. We forgot that the pressure mouse was used, and it is a sensor (although technically so are keyboards and regular mice). Nonetheless, this should be reworded more accurately in future versions.

Instructions: Practice Quiz

- You will soon participate in a game that will determine your compensation.
- However, before you begin this game, you will do a **practice quiz** that will not count toward your compensation.
- The quiz will be done on paper, not on the computer, so please locate a pen or pencil now.
- It will contain 30 grids of numbers that look like these 2 grids shown below:

0.23	1.86	7.34	9.96	8.26	4.79
3.40	6.60	1.71	2.81	3.38	9.58
1.07	1.97	5.23	7.72	6.55	0.04
6.01	9.13	0.55	8.84	1.50	9.33

- Each grid will contain exactly one pair of numbers that adds up to 10.
- To be sure you are clear on the instructions, the correct pairs of numbers for these two grids are shown in **bold** below:

0.23	1.86	7.34	9.96	8.26	4.79
3.40	6.60	1.71	2.81	3.38	9.58
1.07	1.97	5.23	7.72	6.55	0.04
6.01	9.13	0.55	8.84	1.50	9.33

- Your task is to find as many of these pairs as possible in 5 minutes.
- When your 5 minutes is up, you will:
 - a) tell the experimenter that you are done through the instant messaging client so he can take your work
 - b) enter the number of pairs that you found on the computer
- Note: The experimenter will verify that the number of pairs you report is accurate.
- Please make sure that you understand these instructions before going on to the next page.

Next Page

Figure 6.5. Instructions: practice quiz (Control motivator)

Following this, instructions for the practice quiz were given on screen and through recorded verbal instructions. Participants were told that "Your task is to find as many of these pairs as possible in 5 minutes. When your 5 minutes is up, you will: a) tell the experimenter that you are done through the instant messaging client so he can take your work. b) enter the number

Control

of pairs that you found on the computer. Note: The experimenter will verify that the number of pairs you report is accurate."

YOUR TIME IS UP!!

Stop writing and tell the experimenter that you are done through the instant messenger.

If you do not tell the experimenter that you are done within 30 seconds, you will be DISQUALIFIED.

Seconds Elapsed Since Alarm Went Off: 20

For Experimenter: Stop Alarm

Figure 6.6. Instructions: 5 minutes are up

Once five minutes had elapsed, in the Control motivator participants were told they must contact the experimenter over the instant messaging client and were not allowed to continue. The experimenter would gather and examine their work to discourage cheating.

Practice Quiz Score

- In the real quiz, you would enter the number of pairs that you found before going on.
- Note: The experimenter will verify that the number of pairs you report is accurate for the real quiz.

Next Page

Figure 6.7. Practice quiz score (Control motivator)

Control

The next screen informed participants what actions they will need to perform when they've completed the real quiz. In the Control motivator participants were informed again that the experimenter would verify their score.

Instructions: Real Quiz

Your Task:

- You have now finished your practice quiz and will complete the real quiz that will determine your compensation.
- This quiz will be **identical** in format to the practice quiz.
- As in the practice quiz, each grid will contain exactly one pair of numbers that add up to exactly 10.
- Your task is to find as many of these pairs as possible in 5 minutes.
- When your 5 minutes is up, you will:
 - a) tell the experimenter that you are done through the instant messaging client so he can take your work
 - b) enter the number of pairs that you found on the computer
 - c) answer some final questions about the experiment before your compensation is determined and given to you.
- Note: The experimenter will verify that the number of pairs you report is accurate.

[Next Page](#)

Figure 6.8. Instructions: real quiz

The next screen provided instructions concerning the real quiz. In the Control motivator, participants were told that the "experimenter will verify" their work. Outside of these verifications and initial instructions, participants did not interact with and were not directly surveilled by the experimenter.

Control

Compensation

Your Compensation:

- Your score will determine your compensation for this experiment.
- The better you score, the more money you will win!
- Specifically, you will receive an amount of money equal to half of your score (in dollars).
- For example, if your score on the quiz is 20 then you will receive \$10 (half of 20).
- Also, no matter what, you will receive an additional \$5 for your participation.

Charity Compensation:

- In addition, **World Food Programme (UN)** will win \$5 (independent of your score).

Please try as hard as you can on this quiz to maximize your earnings!

Additional Questions:

- If you have any questions about how you will be compensated, please ask the experimenter through the instant messaging client now.
- You should not go on to the next page until you are clear on how you will be compensated.

[Next Page](#)

Figure 6.9. Compensation

Following this was a page which described what sort of compensation participants and the charities that they had chosen would receive. In the figure above, the participant has chosen "World Food Programme (UN)" as their charity. Participants are notified that \$5 will be given to this charity "independent of their score."

Complete the Real Quiz!

- Please open the blue folder marked **Real Quiz** in the top drawer of the filing cabinet next to your left leg and take out the real quiz.
- You have exactly 5 minutes to complete this quiz.
- The average score so far on this quiz is: **21.7**.
- Good Luck!

Figure 6.10. Complete the real quiz

Next participants in all motivators of the Quiz Experiment received a prompt that instructed them to complete the quiz. In an attempt to induce cheating, all participants were told that the average score on the quiz was much higher ("21.7") than the actual observed average.

Control

YOUR TIME IS UP!!

Stop writing and tell the experimenter that you are done through the instant messenger.

If you do not tell the experimenter that you are done within 30 seconds, you will be DISQUALIFIED.

Seconds Elapsed Since Alarm Went Off:

Figure 6.11. Instructions: 5 minutes are up

After 5 minutes had elapsed, a screen appeared along with voice prompts that notified participants that they should either contact the experimenter.

Control

Your Score

- Please report the number of pairs that you found below.
- Note: The experimenter will verify that the number of pairs you report is accurate.

Number of pairs found in this quiz:

- When you are finished, please click the **Next Page** button.

[Next Page](#)

Figure 6.12. Your score

Participants then saw a screen which asked them to enter the number of correct answers they found on the quiz. In the Control motivator, to discourage cheating participants were reminded the "experimenter will verify that the number of pairs you report is accurate."

Questionnaire

Please fill out the following questionnaire before your compensation is determined.

Each of the following questions asks about the *situation* you encountered during the experiment. *Situation* refers to the methods of observation by the other individual or system with which you interacted. In the answers you give below, imagine you encountered this *situation* in everyday life.

Figure 6.13. Quiz questionnaire (situation)

After finishing the real quiz and reporting their performance, subjects moved on to a questionnaire designed to get at some of the ethical implications with which this thesis concerns itself. The questionnaire asked participants to consider a situation much like the one they encountered.

Control

Do you think the situation is:

Unethical ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Ethical

No Opinion ☐

Do you think the situation is:

Invasive ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Respectful

No Opinion ☐

Does the situation make you feel:

Comfortable ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Uncomfortable

No Opinion ☐

When performing the task was the situation a:

Help ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Hinderance

No Opinion ☐

Do you think the situation is:

Moral ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Immoral

No Opinion ☐

Which of the following does the situation make you feel:

Suspicious ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Trustful

No Opinion ☐

Do you feel the situation is:

Fair ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Unfair

No Opinion ☐

Given the choice between two situations you'd prefer the situation:

Without Sensors that
Collect Information
About Emotion ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ With Sensors that
Collect Information
About Emotion

No Opinion ☐

Were the intentions with which you did the quiz:

Bad ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Good

No Opinion ☐

Next Step

Figure 6.14. Quiz questionnaire (questions)

Control

The survey questions on this page were shown as eight-point Likert-scale questions with a "No Opinion" option. Each of the questions opposed a category related to ethically positive term like "respectful" or "moral" against ethically negative terms like "invasive" or "immoral." Specific to the Quiz experiment was a last section of the questionnaire that asked participants to rate "the intentions with which you did the quiz" between "bad" and "good."

Determining Your Compensation

Thank you for participating!

Based on your score of **10**, you have won **\$10.00** (including your participation payment)! Also, **World Food Programme (UN)** has won **\$5.00**.

Also, please ask yourself the following questions:

- How do you feel about the amount of money that you and **World Food Programme (UN)** have won?
- Were you **dishonest** in an attempt to make more money?
- Do you really deserve the money you have won?

If you have any questions about the final compensation, please ask the experimenter over the instant messaging client now.

[Next Page](#)

Figure 6.15. Determining your compensation

Having completed the questionnaire a page was displayed that explained to participants what their compensation would be as well as what their chosen charity's compensation would be. In an attempt to elicit some emotional states associated with guilt, some pointed questions about dishonesty and whether the money was deserved were displayed to participants. This was used for another piece of research [davis2005].

No Effect on Charity, Charity Gains, and Charity Loses Motivators

Thank you

Thank you for participating! The experiment is now over.

Please let the experimenter know that you are finished and he will give you your compensation.

IMPORTANT: Please do not tell anyone who may participate in this experiment later about the details of this experiment.

For Experimenter:

- Total won: **\$10.00** (including your participation payment)!
- **World Food Programme (UN)** has won **\$5.00**.

Figure 6.16. Final page

Finally, participants encountered a page thanking them for participating. The page also prompted participants to contact the experimenter using an instant messaging client so that the experiment could be completed. Informal discussions about the purpose of the experiment were then conducted by myself.

No Effect on Charity, Charity Gains, and Charity Loses Motivators

Participants assigned to the non-Control motivators experienced a very similar procedure. This section will detail the differences between the Control motivator and these motivators.

The first difference occurred on the sensor preparation information screen. Participants were told "The experimenter should now show you how to use the paper shredder and then leave the room." This was to show participants how to destroy their work so that no verification could be performed. The idea was that with a lack of verification, subjects would be more likely to inflate their score (cheat).

On the "instructions: practice quiz" screen participants were told: "When your 5 minutes is up, you will: a) shred your paper in the paper shredder b) enter the number of pairs that you found on the computer." instead of being told the experimenter would verify their work.

Please Shred Your Quiz

IMPORTANT: Please shred your quiz in the paper shredder located to your left before going on to the next page.

- To use the paper shredder, simply slip your quiz through the slit at the top.
- If you have any trouble with this, please notify the experimenter over the instant messaging client.
- **Note: Please remember the number of pairs that you found. You will be asked this number on the next page.**

Next Page: I have shredded my quiz

Figure 6.17. Please shred your quiz

After participants' 5 minutes were up for the practice quiz, subjects in the non-Control motivators saw a screen which asked them to shred the quiz and to remember the number of correct answers they'd found.

On the following page, Practice Quiz Score (figure 6.7), participants were additionally told "REMINDER: Please be sure that your quiz has been shredded before going on to the next page." instead of being told that the experimenter would verify their work.

On the "Instructions: Real Quiz" (figure 6.8) page participants again saw a page that was similar to the Control motivator except they received different instructions: "When your 5 minutes is up, you will: a) shred your paper as you did before b) enter the number of pairs that you found on the computer c) answer some final questions about the experiment before your compensation is determined and given to you."

No Effect on Charity, Charity Gains, and Charity Loses Motivators

Compensation

Your Compensation:

- Your score will determine your compensation for this experiment.
- The better you score, the more money you will win!
- Specifically, you will receive an amount of money equal to half of your score (in dollars).
- For example, if your score on the quiz is 20 then you will receive \$10 (half of 20).
- Also, no matter what, you will receive an additional \$5 for your participation.

Charity Compensation:

- In addition, **CARE** will win an amount of money.
- The better you score, the more money **CARE** will win!
- Specifically, **CARE** will win an amount of money also equal to half your score.
- For example, if your score is 20, **you** and **CARE** will each win \$10 (not including your \$5 participation payment)!
- So, by scoring well, not only do you help yourself, but you also help **CARE**.

Please try as hard as you can on this quiz to maximize your earnings!

Additional Questions:

- If you have any questions about how you will be compensated, please ask the experimenter through the instant messaging client now.
- Some subjects have asked if we will really give money to the charity. The answer is: **YES!** We will give real money to the charity you have chosen depending on your performance!
- You should not go on to the next page until you are clear on how you will be compensated.

Next Page

Figure 6.18. Compensation (No Effect on Charity, Charity Gains, and Charity Loses Motivators)

On the compensation page, participants saw text which reflected their motivator. The specifics of these different motivators were described above when the motivators were introduced. Participants experiencing the Charity Gains and Charity Loses motivators also were informed: "Some subjects have asked if we will really give money to the charity. The answer is: YES! We will give real money to the charity you have chosen depending on your performance!"

The next difference between the Control motivator and the remainder was the existence of a second shred quiz page after their five minutes were up for the real quiz. This page was identical to the figure entitled "Please Shred Your Quiz" above.

On the "your score" page the followed participants in the non-Control motivator were informed: "REMINDER: Please shred the quiz so that later subjects will not see your answers."

The remainder of the quiz was identical in all conditions. The next section turns its attention to the results from this experiment.

Quiz Results

Quiz Results

This section reports significant and trend-evidencing results comparing the questionnaire data measured between the control and sensor groups in the Quiz Experiment. Statistical comparisons were performed using the Mann-Whitney test comparing variables between sensor and no sensor conditions. The significance of this test is reported below as a p-value, where p less than or equal to .05 is considered to be significant. Effect sizes or r-values are also reported below for significant values.

Table 6.3. Sensors vs. no sensors p-value and r-value summary

	Control	No Effect on Charity	Charity Gains	Charity Loses
Ethical-Unethical	p=.15	p=.86	p=.52	p=.22
Respectful-Invasive	p=.03, r=-1.08	p=.95	p=.05, r=-.96	p=.70
Uncomfortable-Comfortable	p=.53	p=.21	p=.43	p=.39
Hindrance-Help	p=.97	p=.68	p=.02, r=1.21	p=.32
Immoral-Moral	p=.05, r=1.06	p=.36	p=.12	p=.40
Trustful-Suspicious	p=.07	p=.74	p=.07	p=.37
Unfair-Fair	p=.54	p=.56	p=1.0	p=.25
Sensors-No Sensors	p=.45	p=.53	p=.78	p=.41
Performance	p=.35	p=.41	p=.93	p=.22

In the following sections I will detail the trends and significant results that had p-values less than 0.15. These are grouped by the motivator the participant experienced.

Quiz: Control Motivator

The Control motivator was designed to try to discourage cheating by frequent presence of the experimenter in the testing room as well as handing-in and verification of the quiz results by the experimenter.

Quiz: Control Motivator

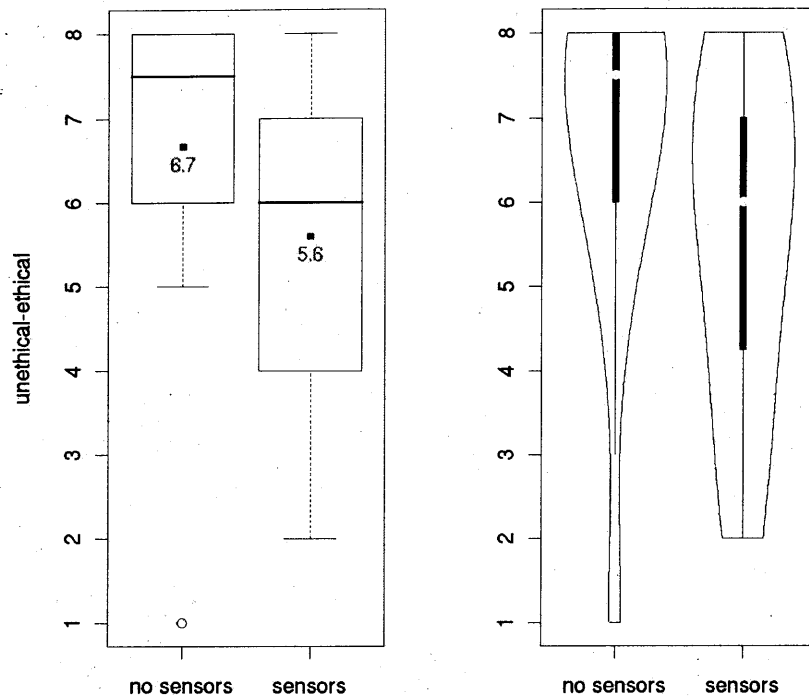


Figure 6.19. Ethical vs. sensors for quiz Control motivator

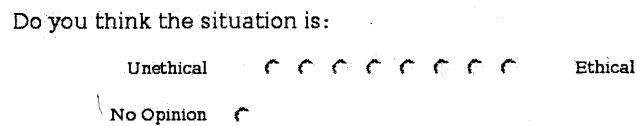


Figure 6.20. Ethical question

A trend occurs in this measure showing that participants with sensors found the situation less ethical than those in the no Sensors condition. A Mann-Whitney test shows that the difference is not significant ($p\text{-value} = 0.1534$).

Quiz: Control Motivator

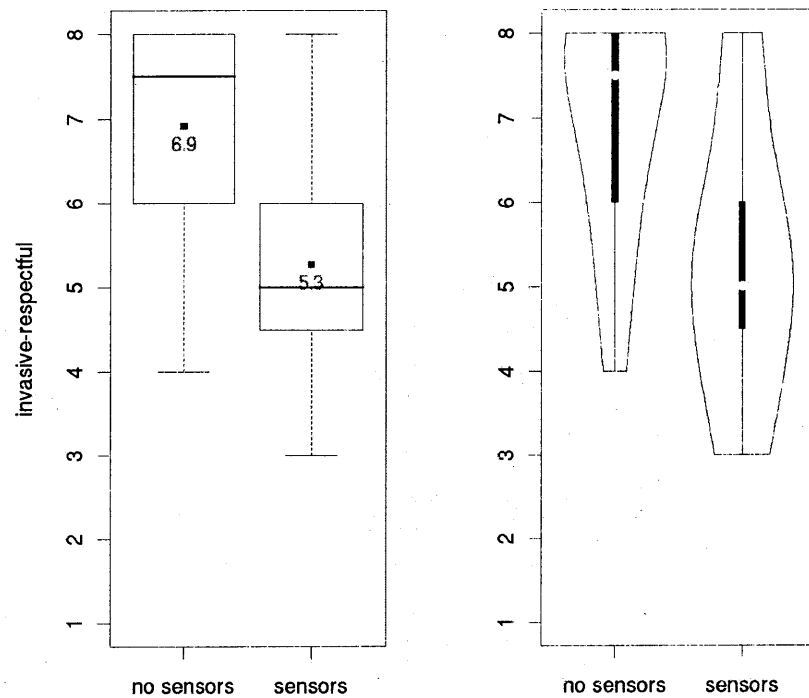


Figure 6.21. Respectful vs. sensors for quiz Control motivator

Do you think the situation is:

Invasive ◐ ◐ ◐ ◐ ◐ ◐ ◐ ◐ Respectful
 No Opinion ◐

Figure 6.22. Respectful question

The hypothesis in this case is true: participants with sensors reported the situation as less respectful than those with no sensors. A Mann-Whitney test shows that the difference is significant ($p\text{-value} = 0.0265$). Furthermore, the effect size $r = -1.08$ reflects a large negative change from respectful toward invasive for those who had sensors.

Quiz: Control Motivator

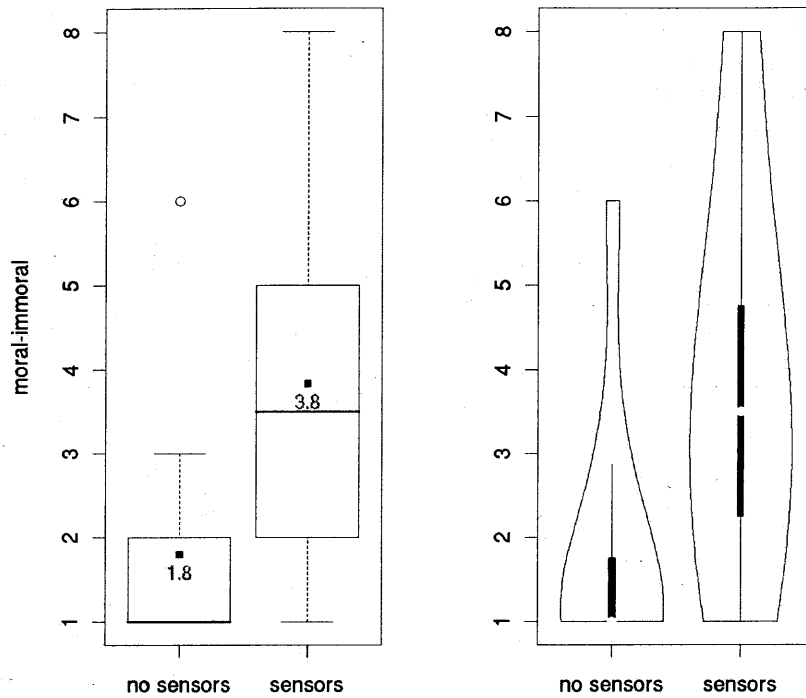


Figure 6.23. Immoral vs. sensors for quiz Control motivator

Do you think the situation is:

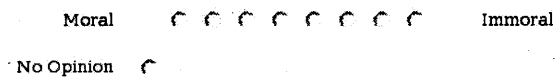


Figure 6.24. Immoral question

The hypothesis in this case is true: participants with sensors found the situation to be significantly less moral than those without sensors. A Mann-Whitney test shows that the difference is significant ($p\text{-value} = 0.0485$). Furthermore, the effect size $r=1.06$ reflects a large increase from moral towards immoral for those who had sensors.

Quiz: Control Motivator

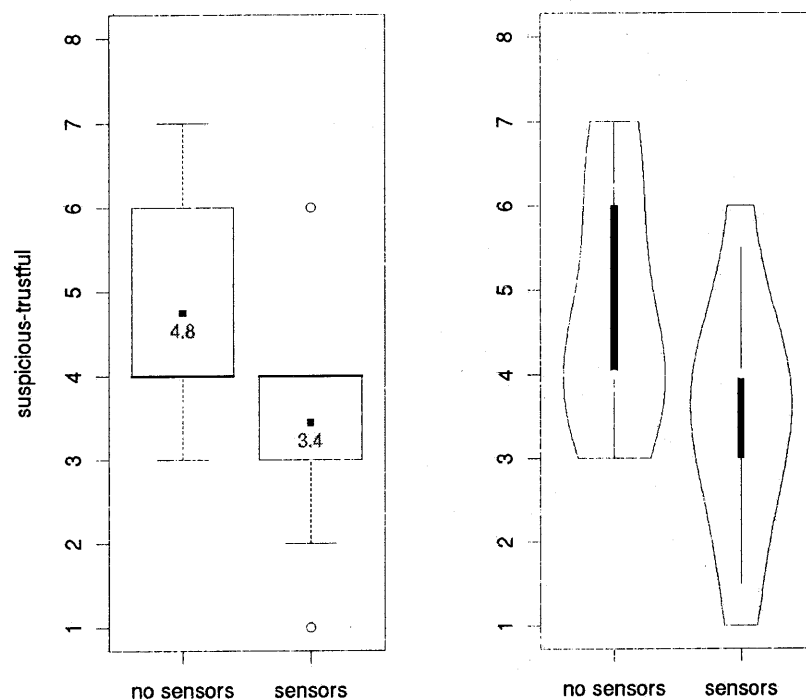


Figure 6.25. Trustful vs. sensors for quiz Control motivator

Which of the following does the situation make you feel:

Suspicious ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Trustful
 No Opinion ☐

Figure 6.26. Trustful question

A trend occurs in this measure showing that participants with sensors found the situation more suspicious and less trustful than those in the No Sensors condition. A Mann-Whitney test shows that the difference is almost significant (p-value = 0.06288).

Quiz: No Effect on Charity

Quiz: No Effect on Charity

In the No Effect on Charity motivator, participants were working to benefit themselves. Regardless of their performance \$5 would be given to a charity of their choice.

No significant differences in the variables measured were observed between conditions with sensors and without sensors. As such, no box-plot violin-plot pairs will be presented.

Quiz: Charity Gains

In the Charity Gains motivator, better performance benefited both the participant and a charity of their choice. More specifically, the charity that was chosen was given as much money as the participant won.

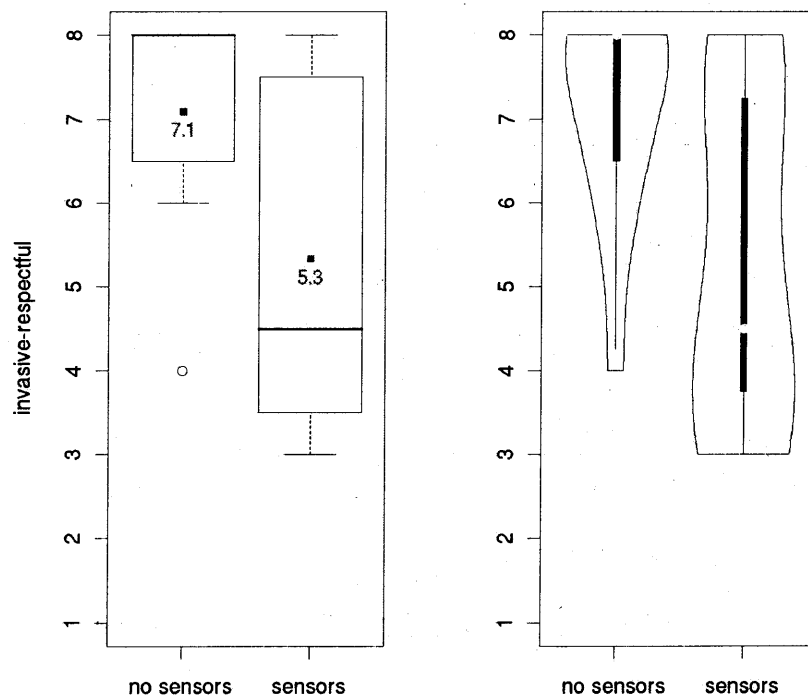


Figure 6.27. Respectful vs. sensors for Charity Gains motivator

Quiz: Charity Gains

Do you think the situation is:

Invasive ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Respectful
 No Opinion ☐

Figure 6.28. Respectful question

The hypothesis in this case is true: participants with sensors reported the situation as less respectful than those with no sensors. A Mann-Whitney test shows that the difference is significant ($p\text{-value} = 0.0477$). Furthermore, the effect size $r = -.96$ reflects a large negative change from respectful toward invasive for those who had sensors.

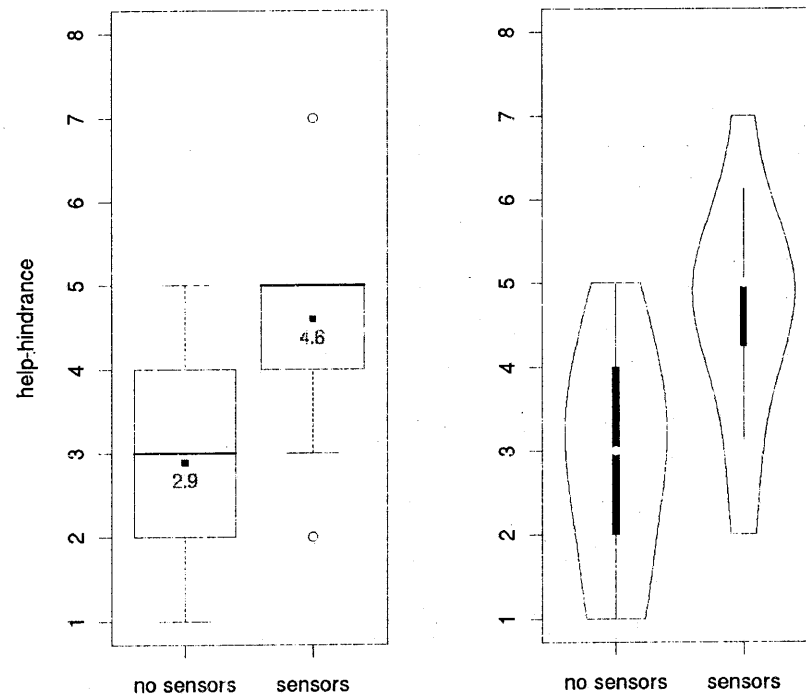


Figure 6.29. Hindrance vs. sensors for Charity Gains motivator

When performing the task was the situation a:

Help ○ ○ ○ ○ ○ ○ ○ ○ Hindrance

No Opinion ○

Figure 6.30. Hindrance question

The hypothesis in this case is true: participants with sensors reported the situation as more of a hindrance and less helpful than those without sensors. Additionally, a Mann-Whitney test shows that the difference is significant ($p\text{-value} = 0.0162$). Furthermore, the effect size $r=1.21$ reflects a large increase toward hindrance from help for those who had sensors.

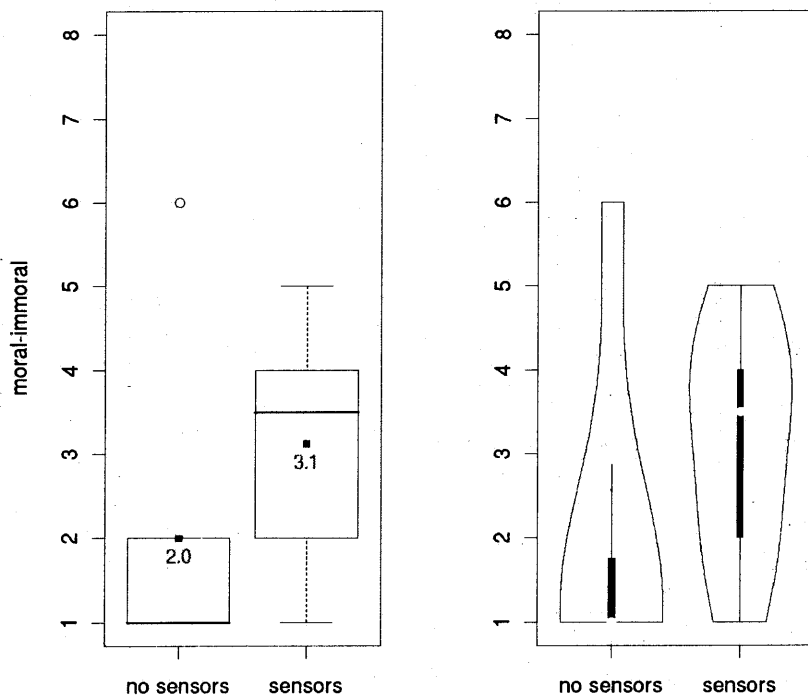


Figure 6.31. Immoral vs. sensors for Charity Gains motivator

Quiz: Charity Gains

Do you think the situation is:

Moral ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Immoral
No Opinion ☐

Figure 6.32. Immoral question

A trend occurs in this measure showing that participants with sensors found the situation less moral than those in the No Sensors condition. A Mann-Whitney test shows that the difference is not significant (p-value = 0.1254).

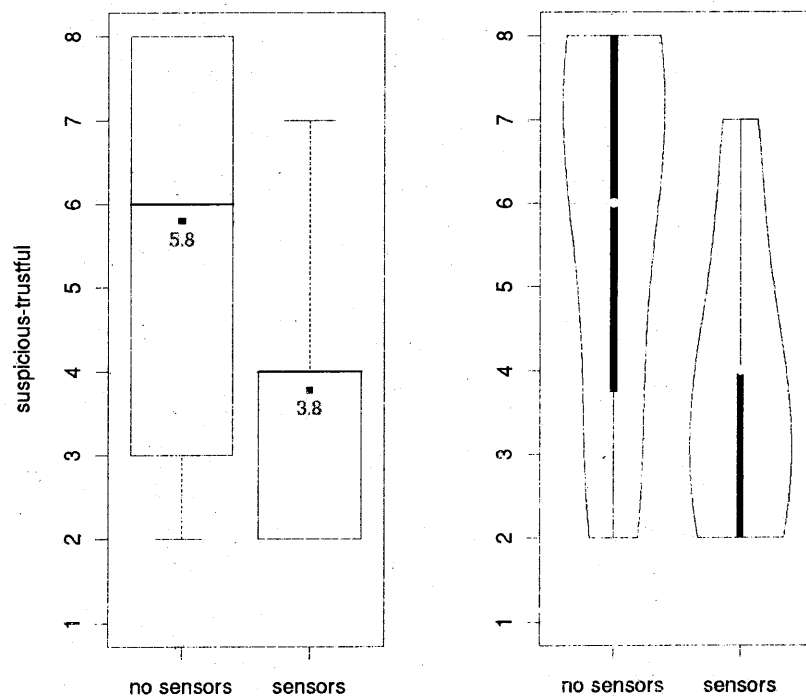


Figure 6.33. Trustful vs. sensors for Charity Gains motivator

Quiz: Charity Loses

Which of the following does the situation make you feel:

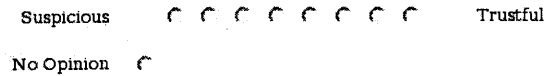


Figure 6.34. Trustful question

A trend occurs in this measure showing that participants with sensors found the situation less trustful and more suspicious than those in the No Sensors condition. A Mann-Whitney test shows that the difference is not significant ($p\text{-value} = 0.0742$).

Quiz: Charity Loses

In the Charity Loses motivator, participants benefited at the expense of a charity. Participants were told "In addition, (charity) will win an amount of money. Unfortunately, due to budget constraints, the better you score, the less money (charity) will win. Specifically, the total amount won between you and the charity (not including your \$5 participation payment) will be \$15. So, by scoring well, you help yourself, but you also hurt (charity). Please try as hard as you can on this quiz to maximize your earnings!"

No significant differences in the variables measured were observed between conditions with sensors and without sensors. As such, no box plot or violin plot pairs will be presented.

Quiz Experiment Discussion

In summary, the results of the quiz experiment were closest to what had originally been hypothesized. Participants who used sensors in the Control and Charity Gains conditions found the situation to be significantly less respectful. Participants in the Control condition also reported the situation to be significantly less moral. Furthermore, subjects who used sensors in the Charity Gains condition reported their situation to be more of a hindrance. However, no significant differences in the sensors groups related to performance were discovered.

Chapter 7. Discussion

In this chapter phenomena that occurred across the experiments or involving comparisons between experiments will be discussed. In addition, this chapter will conjecture explanations for some of the differences that appear between experiments using dimensional metaethics as a framework. This will be followed by an explanation of what sort of conclusions can be drawn from these experiments.

Ecological Validity and the Expression of Opinion

One striking meta-experiment trend was observed in the ratio of "no opinion" between the No Sensors and Sensors conditions. A larger proportion of "no opinion" appeared in conditions without sensors and is analyzed in this section.

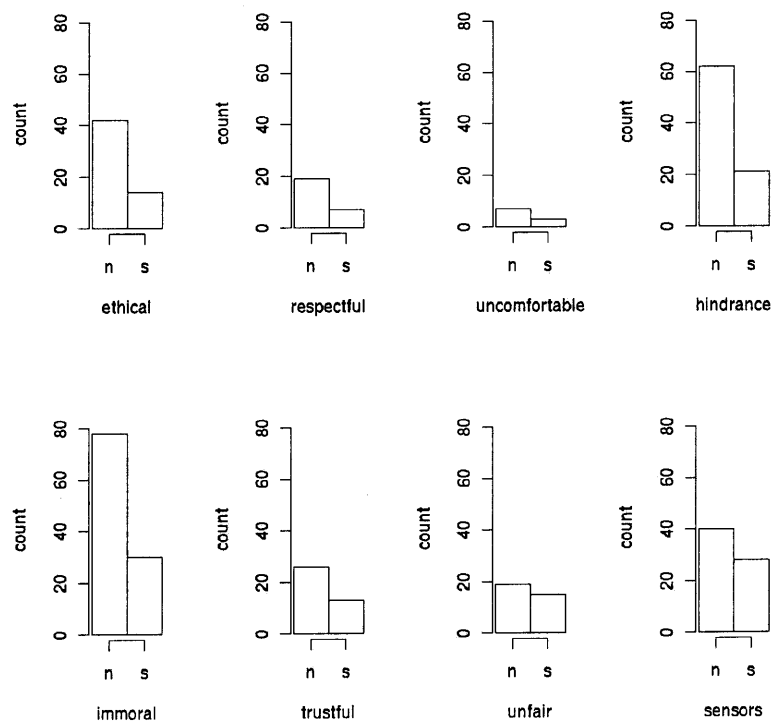


Figure 7.1. Histograms of no opinion vs. sensors, grouped by variable

Pooled Results

Across experiments and tasks, those who encountered sensors less frequently reported no opinion. Using a binomial test of a null-hypothesis that an equal number of no opinions would occur between Sensors and No Sensors conditions several variables are significant. Specifically, Ethical, Respectful, Hindrance, Immoral, and Trustful all were significant on binomial tests. Furthermore, the probability of having a greater proportion of no opinion in 8 of 8 cases is $p=.008$.

This result suggests that introducing affective sensor systems was related to the formation of opinions regarding the variables in the questionnaire. With at least some questions this may be related to ecological validity. Namely participants are perhaps better able to decide whether they prefer situations "with sensors that collect information about emotion" when they have experienced them first hand. However, this may also be related to the comparative novelty of the situations with sensors. Encountering these more unusual and arousing situations may have motivated participants to express their opinion significantly more frequently.

Pooled Results

A variation of the hypotheses tested in the individual experiments is that the changes in questionnaire reports will occur when data is pooled from all subjects. As such, analysis was performed by taking the set of all subjects who used sensors and comparing them to the set of all subjects who did not.

Wilcoxon tests comparing these two groups reveal that significant differences occur in several of the variables. Pooled participants with sensors reported that the situation was more of a hindrance ($p=.02$) than those without sensors. However, pooled participants with sensors also reported the situation to be less suspicious ($p=.05$), more fair ($p=.05$), and expressed a preference for using sensors ($p=.02$). A trend also occurred with pooled participants with sensors reporting the situation as more ethical than pooled participants without sensors ($p=.06$).

This pooling however groups interviewers, disadvantaged Visible Card participants, and poker opponents along with others who did not experience sensors. Perhaps what is needed is something which is finer-grained pooling like the set of quiz takers, interviewees, and poker players who used sensors vs. quiz takers, interviewees, and poker players who did not use sensors.

Wilcoxon tests performed with these new groups show only a significant difference in preference to use sensors ($p=.002$), with those who had been assigned to sensor conditions preferring situations "with sensors that collect information about emotion." Additionally, trends occurred in these groups with those who used sensors reporting the situation to be less respectful ($p=.09$) but more comfortable ($p=.07$).

Another interesting pooling is to ignore the Poker subjects since it can be argued that they were playing a game and may have not felt as strongly about the experiment (which might explain the lack of significant results for that experiment). If instead only participants from the Quiz and Interview experiments are included in the analysis such that we have the set of Quiz and

Same System But Different Evaluation

Interview participants who used sensors vs. Quiz and Interview participants who did not use sensors then the following results occur. Wilcoxon tests find that those who used sensors found the situation less suspicious ($p=.05$) and more fair ($p=.05$). Performance varied significantly as well, with sensor participants performing better ($p=.007$), although the Quiz and Interview experiments are not scored the same way. Trends also occur showing that those with sensors reported the situation to be more ethical ($p=.07$), more of a hindrance ($p=.14$), and preferred situations "with sensors that collect information about emotion" ($p=.09$).

A final pooling groups quiz takers and interviewees who used sensors vs. quiz takers and interviewees who did not use (and whose partners did not use) sensors.

Wilcoxon tests between these groups reveal that those who used sensors found the situation to be less respectful ($p=.04$) but also expressed a preference for situations "with sensors that collect information about emotion" ($p=.01$). A trend also occurred showing that participants who used sensors found the situation to be more comfortable ($p=.06$).

Same System But Different Evaluation

The strongest evidence of the ethical implications of the particular experiments does not come from the individual variables measured but how all of the variables change collectively from experiment to experiment.

Consider that in the Interview and Poker experiments the sensor system used by participants was identical. Yet, there is an enormous difference in participants evaluations of the respective situations: the interview situation exhibits many significant differences while the Poker Experiment only exhibits one trend.

So with the same sensing technology we observe very different responses. What might account for these differences in ethical opinions?

Social Dimensions and Dimensional Metaethics

Previously, Reynolds and Picard have described a dimensional metaethical position and procedure to anticipate and improve consideration of affective computing systems [reynolds2005AUG-COG]. This section briefly describes this procedure and applies it to situations described by the Poker and Interview experiments.

Dimensional metaethics is a procedure that sees "what is good" about a system as related to the value of a number of different social dimensions. As such, it first advocates that designers of systems describe different social dimensions that they think are relevant to their system's design and use. The next step is then for the designers to list their assumptions about values along these dimensions. Lastly designers are asked to vary these assumptions and to speculate or (even better) to observe the resulting changes in ethical acceptability.

Social Dimensions and Dimensional Metaethics

Table 7.1. Social dimensions relevant to evaluation of systems that mediate the communication of affect (a non-exhaustive list)

Dimension	Examples	Description
Whom	Supervisor, Friends, Nicholas	The individual or individuals who receive the communicated affective message.
What	Telephone, Emotemail, Learning Companion	Artifact that acts as a transmitter or receiver for the communicated affective message.
Goal Relationship	Adversarial, Cooperative	The degree of conflict between the goals of the sender and receiver, which can be (but does not have to be) modeled from a game-theoretic perspective.
Power Relationship	Dominant, Submissive, Peer	Role that reflects the ability of either source or destination to alter the political, economic, or social situation of the other.
At Stake	Nothing, Ego, Money	What things are risked in using a system.
Genre of Emotion	Valence-Arousal Space, Categories, Emotional Orientation	Model used by the system to describe and encode emotion.
Valence	Positive, Neutral, Negative	Classification of transmitted emotion using an axis with positive or negative poles to describe feeling state.
Demeanor of Recipient	Angry, Sad, Excited	Emotional state of the message destination.
Gender	Female, Male, Intersex	Classification of either message source or destination based on reproductive role.
Ethnicity	Latino, Multi-Ethnic, Asian, Caucasian	Classification of either message source or destination based on racial or cultural identity.
Age	18, Middle-Aged, Mature, Minor	Classification of either message source or destination based on duration of life.
Culture	Rural, Icelandic, Traditional	Cultural context of communication and of either message source or destination.
Risk	Dangerous, Safe, Hazardous, LD50 (lethal dose for 50% of population), LC50 (lethal concentration for 50% of the population)	Potential impact of communication on goals of message source or destination.

Social Dimensions and Dimensional Metaethics

Dimension	Examples	Description
Symmetry	Balanced, Skewed	Information or power balance between users of communication system.
Trust	Trustworthy, Deceitful	The degree to which the message source trusts either the destination or the channel.
Designer	Affective Computing Group, Microsoft, GNU, Jussi Angesleva, Employer	Person or organization who created the system that mediates the communication of affect.
Experimenter	Stanley Milgram, Carson Reynolds	The person who conducts an experiment that evaluates the ethical acceptability of communication system.
Time	Now, Ten Years Ago, Tomorrow	When the system that mediates the communication of affect is used.
Informed Consent	None, Compliant with CFR Title 45 Section 46.116	Does message source voluntarily consent to transmission of affective signals?
Security	None, C2, RC5-64, Hardened, Encrypted	Classification of security level of communication system or encoded signal.
Control	None, Partial, Complete	Degree to which message source can control the transmission of affective signals.
Feedback	None, Partial, Complete	Can the message source access the transmitted affective signal?
Transparency	Opaque, Open	Are the workings of the system that mediates the communication of affect visible for inspection, and by whom?
Proximity	Near, Far	Distance between message source and message destination.

The above table presents a non-exhaustive list of many factors that could influence an ethical evaluations of systems that mediate the communication of affect. Let us consider a subset of these that change between the Poker and Interview Experiments.

Table 7.2. Assumptions in the Poker Experiment

Dimension	Value
Whom	Friends
What	MixedEmotions
Goal Relationship	Adversarial
Power Relationship	Peer
At Stake	Small Sum of Money
Demeanor of Recipient	Neutral

Participants in the Poker Experiment, it could be conjectured, were involved in a relatively friendly game among peers. In keeping with the tradition of poker they might have tried to assume neutral poker faces. In terms of what was at stake in using the system, there was a small amount of money to be won or lost. This may or may not affect one's ego depending on how seriously the player views poker play. Other mitigating factors include that participants played only one real hand, and it was with a stranger, so what might be blamed on skill in a higher-stakes situation was easily blamed on chance and other less personal factors in this situation. Also in a game like poker, bluffing (deception) is expected and not unethical.

Table 7.3. Assumptions in the Interview Experiment

Dimension	Value
Whom	Potential Co-Workers
What	MixedEmotions
Goal Relationship	Adversarial
Power Relationship	Dominant-Submissive
At Stake	Ego, Small Sum of Money
Demeanor of Recipient	Nervous

In contrast, participants in the Interview Experiments were placed into a relatively tense situation in which one had the power to hire or not hire the other. Over and above this the stakes of the situation were quite different: not being hired reflected not upon one's luck but potentially also on one's self-esteem or ego. Many subjects commented on how real this was as many were looking for jobs; one remarked "I am interviewing for jobs this week, so this seemed pretty real to me." Additionally, for many subjects being put into a condition where they had to lie (in a non-game situation) was stressful.

Social Dimensions and Dimensional Metaethics

In seeing how these values differ between the two situations we may be able make some sense of why the questionnaire reports were so different. However, it doesn't appear that any single variable is directly related to these changes.

Dimensional metaethics is neither the only nor the first approach at providing a metaethical position for the evaluations of systems. In the paragraphs below we will briefly describe other metaethical positions that have been applied to computer ethics and compare them to dimensional metaethics.

Discussed previously in chapter 2, Value-Sensitive Design [friedman2002] considers Human Welfare, Ownership and Property, Privacy, Freedom From Bias, Universal Usability, Trust, Autonomy, Informed Consent, Accountability, Identity, Calmness, and Environmental Sustainability as values that may be of ethical consequence.

In many ways, a dimensional metaethics is an extension of value-sensitive design. Both provide a list of criteria which can be used to help structure evaluations and critiques of computing system. The chief difference between Value-Sensitive Design and a dimensional metaethics is what Kagan refers to as "evaluative focal points" [kagan2000]. Value-Sensitive Design is essentially a virtue ethics that focuses on different values that are of import to the design of computer systems. A dimensional metaethics instead focuses on dimensions along which the context of use of affective computing systems may vary.

Disclosive Computer Ethics [brey2000] "is concerned with the moral deciphering of embedded values and norms in computer systems, applications and practices." In contrast to value sensitive design, disclosive computer ethics focuses on justice, autonomy, democracy and privacy. Brey contrasts "mainstream" approaches to computer ethics (which he views as limited) with disclosive computer ethics. Brey sees the disclosive metaethical position as more of a process which is concerned with "disclosing and evaluating the embedded normativity in computer systems."

Dimensional metaethics position differs from this approach by not focusing on the embedded norms and instead considering the context in which the technology is used and factors, perhaps even very subtle, that might influence ethical judgments. Put another way, dimensional metaethics is not just artifact-centric, but also is fixated on the environment in which ethical judgments are formed.

Let us make these comparisons more concrete by providing an example ethical analysis of the interview experiment. Value-Sensitive Design would ask to consider the virtues of Human Welfare, Ownership and Property, Privacy, Freedom From Bias, Universal Usability, Trust, Autonomy, Informed Consent, Accountability, Identity, Calmness, and Environmental Sustainability as they pertain to the MixedEmotions affect sensing and communication system as it is used in the Interview Experiment. Disclosive computer ethics, on the other hand asks us to examine how a technology embeds various normative judgments. In the case of the interview experiment, we would examine how justice, autonomy, democracy, and privacy are embedded and supported by the MixedEmotions systems design. Dimensional metaethics position, in

Effects of Motivators

contrast would ask us to consider the use of MixedEmotions while the value of the different dimension vary. Thus we might consider MixedEmotion's usage when there is and is not a power relationship present between users.

Effects of Motivators

In each of the experiments, a variety of motivators were introduced in the hopes of influencing participant behavior. This section analyzes what effect the motivators (and not the sensors) had on the questionnaire variables.

In the Poker experiment, there were no significant differences between the motivators.

In the Interview experiment, Kruskal-Wallis tests comparing the various motivators also revealed some significant differences. Reports on whether the situation was ethical varied between motivators ($p=.008$) where the ordering from most to least ethical was: Control, Charity Loses, Charity Gains. Reports as to whether the situation was immoral varied significantly between motivators ($p=.004$) where the ordering from most to least immoral was: Charity gains, Charity Loses, and Control. A trend also occurs in reports between motivators as to whether the situation was unfair ($p=.10$), where the ordering from most to least unfair was: Charity Gains, Charity Loses, Control.

In the Quiz experiment, using Kruskal-Wallis tests to compare the Control, No Effect on Charity, Charity Gains and Charity Loses groups the following was observed. The reports on whether the situation was ethical varied significantly between different motivators ($p=.03$). The ordering of the means of the groups from most ethical to most unethical was: No Effect on Charity, Charity Gains, Control, Charity Loses. A trend occurred in reports as to whether the situation was immoral ($p=.06$) where the ordering from most to least was immoral was: Charity Loses, Charity Gains, Control, No Effect on Charity. A trend also occurred in reports of whether the situation was unfair ($p=.09$) where the ordering from most to least unfair was: Charity Loses, Control, No Effect on Charity, Charity Gains.

These results are interesting in that they suggest that different motivators can alter perceptions of what is ethical or moral. Some recent research regarding the relationship between emotions and moral judgment has argued that different levels of engagement of emotional processing alter perspectives on what is moral [greene2001]. It is possible, then these motivators are inducing different levels of engagement of emotional processing.

Revisiting Hypotheses

At the outset of the thesis and before the experiments were conducted predictions were made regarding the variables. Specifically:

The primary hypothesis is that in a variety of situations participants who are using systems that sense and transmit information related to emotion will view

Performance and Ethical Reports

the situation they are placed in as more unethical, invasive, uncomfortable, hindering, immoral, suspicious, and unfair when compared to a control.

What we found was that only in the Quiz Experiment were these hypotheses partially true. In the control and charity gains motivators, significant differences were observed in reports on the respectful-invasive variable. In only the Control motivator a significant difference was observed in reports on the immoral-moral variable. In the Charity Gains condition a significant difference was reported on the hindrance-help variable. In these limited cases some of the original hypotheses were true: subjects reported their situation as less respectful ($p=.03$), less moral ($p=.05$), and more of a hindrance ($p=.02$).

Elsewhere, the hypotheses were not observed to be true and in some cases the opposite of what was expected was shown to be true. Specifically, in the Control motivator in the Interview Experiment, interviewees when paired with their interviewer reported the situation as significantly more ethical, more respectful, and comfortable when they were using sensors than when they were not.

These results seemingly contradict earlier findings in which affective computing systems presented without an ethical contract were reported as tending toward invasion of privacy [reynolds2004CHI]. To what might we attribute this disagreement?

It is quite possibly the case that the experience of live systems may be responsible for this difference in opinion. As evidence for this consider the following: if participants for all experiments are pooled and a Wilcoxon test is performed on the variable "with sensors that collect information about emotion" to "without sensors that collect information about emotion" we see a significant difference between the sensor and no sensor groups ($p=.02$). Those who did not experience sensors express a preference for using systems "without sensors that collect information about emotion," which is consistent with the contract findings. However, those experiencing systems "with sensors that collect information about emotion" have a more positive opinion. This suggests that the ecological validity of the questionnaire surveys was indeed lacking. In this more realistic approximation of using affective systems, participants express different opinions.

It may also be the case that the control participants (who were all from Good Company) had nothing to hide, so perhaps their ability to act ethically was projected onto their views of the technology. This may be related to the demeanor of the participants, one of the social dimensions discussed above.

Performance and Ethical Reports

One question that may interest readers was how subject behavior and performance interacted with reports of ethical opinions. Specifically, subjects' performance would be improved by deceptive behavior such as inflating scores in the Quiz Experiment or dishonesty about previous employment experience in the Interview Experiment. Subjects who performed "better" were thus more likely to have engaged in ethically questionable behavior. Would such subjects have

Performance and Ethical Reports

different opinions about the ethical implications of their situation than those who were likely to have been honest?

Consider participants in the Interview Experiment who were in the Control motivator (viz. from "Good Company" so they had no need to lie) and also who were successful in getting hired. How did the successful "Good Company" candidate reports differ from those in the other motivators (viz. from "Bad Company") who also were hired?

Using a Wilcoxon test, significant differences were observed on the variables measured: the immoral-moral and unfair-fair variables. Participants from Bad Company reported the situation as more Immoral ($p=.05$). In addition, participants from Bad Company reported their situation as more unfair ($p=.04$). A trend also occurred along the uncomfortable-comfortable axis with those from Bad Company reporting their situation as more uncomfortable ($p=.14$).

One possible explanation for these differences is that the participants from Bad Company were placed in a difficult situation where they needed to be dishonest in order to maximize their reward. One plausible conjecture is that these sorts of situations influence view of the ethical acceptability of the systems tested. In support of this conjecture, consider that there was a significant difference ($p=.05$) in statements of how honest interviewees were. Those in the control condition and from "Good Company" reported being most honest followed by those from "Bad Company" in the Charity Loses and Charity Gains conditions.

Participants in the Quiz Experiment in some cases were give opportunities to cheat and inflate their score by misrepresenting the number they had gotten right. How do the results of those who were in the control condition (which was constructed to reduce opportunities to cheat) compare with those who reported the highest scores from the other conditions?

If we take the top quartile in terms of performance from the three non-control motivators (where people had an opportunity to cheat) and compare it with all those in the control condition (who had a decreased opportunity to cheat) then many significant differences emerge. Differences were seen on the following variables: ethical-unethical ($p=.02$), uncomfortable-comfortable ($p=.01$), hindrance-help ($p=.02$), trustful-suspicious ($p=.02$), and unfair-fair ($p=.009$). The control condition was reported to be significantly less ethical, more uncomfortable, more of a hindrance, less trustful, and less fair. A trend also occurred in reports along the respectful-invasive variable ($p=.08$) where the control was less respectful.

Surprisingly, here it seems that those with highest scores, who were not visibly surveilled by the experimenter, reported more positive opinions than did the group who were visibly surveilled. One possible explanation for this might be that the frequent presence of the experimenter (who entered the room two times during the control to examine their work vs. zero in the non-control conditions) was actually more uncomfortable than the sensors. It is also possible that subjects (lacking feedback) did not stop to consider what the attached sensors were doing, or how that information could be used in an adversarial way.

Ability to Interpret Affective Information

One element of both the Poker and Interview Experiments was that they involved one participant receiving sensor information and interpreting it. Some may question the ability of untrained participants to assess sensor data, especially given that it was at time noisy and that the instructions they had to interpret the data were flawed. Is this an explanation for the findings we have observed?

One would expect a persistent inability to understand sensor information to uniformly manifest itself in the performance of the participants tasked with interpreting. However, there is some evidence to the contrary. For instance in the Interview experiment a trend occurred in hiring performance in response to different motivators. This suggests that interviewers did respond in different ways to different groups of interviewers based solely on sensor information (since the interviewers themselves never knew of the interviewee's motivator). Also MixedEmotions displayed video of the face, which even untrained participants should have been able to interpret.

Gender Differences

Readers may also be interested in whether there were gender differences in the variables measured in the various experiments. This would relate to an ongoing discussion within ethics about the role of gender in the formation of ethical opinion.

Lawrence Kohlberg's work on the moral development of children early on argued "that girls on average reached a lower level of moral development than boys did" [wikipediaGilligan2005]. Subsequent work by Gilligan argues that Kohlberg's view of moral development was biased towards Justice and values that appealed to boys. Gilligan offered "ethics of care" as a voice which contrasted with the more male-centric "ethics of justice" voice [gilligan1993].

In an effort to at least begin the discussion of how gender might relate to ethical evaluation of affective systems, I performed an analysis comparing the opinions of the participants pooled by gender. As gender differences were not among my original hypotheses, it is important to emphasize that this analysis was performed following the analyses outlined in the results chapter.

When pooling subjects based on gender and comparing the female groups with and without sensors as well as the male groups with and without sensors many trends and significant differences were observed. The following table lists the p-values from Wilcoxon tests comparing females with sensors to those without (denoted as f=) and males with sensors to those without (denoted as m=).

Gender Differences

Table 7.4. Gender pooled sensors vs. no sensors p-value summary

	Poker-Charity Gains	Poker-Charity Loses	Inter-view-Control	Inter-view-Charity Gains	Inter-view-Charity Loses	Quiz-Control	Quiz-No Effect on Charity	Quiz-Charity Gains	Quiz-Charity Loses
Ethical-Unethical	f=.76, m=1.0	f=.79, m=.10	f=.43, m=.51	f=.08, m=.19	f=.46, m=.49	f=.51, m=.22	f=1.0, m=.38	f=.11, m=.65	f=.45, m=.12
Respectful-Invasive	f=1.0, m=.79	f=1.0, m=.08	f=.63, m=.83	f=.19, m=.39	f=.60, m=.19	f=1.0, m=.08	f=.69, m=.86	f=.15, m=.18	f=.64, m=1.0
Uncomfortable-Comfortable	f=.31, m=.35	f=.46, m=.75	f=.88, m=.36	f=.14, m=.85	f=.88, m=1.0	f=.31, m=.83	f=.38, m=.46	f=.29, m=.06	f=.47, m=.91
Hindrance-Help	f=.05, m=.21	f=.15, m=.26	f=.10, m=.49	f=.04, m=1.0	f=.80, m=.48	f=.82, m=.91	f=1.0, m=.68	f=.20, m=.10	f=.71, m=.26
Immoral-Moral	f=.10, m=.71	f=.52, m=.47	f=.82, m=.84	f=.02, m=.10	f=.84, m=1.0	f=.24, m=.14	f=1.0, m=.64	f=.48, m=.50	f=.32, m=.84
Trustful-Suspicious	f=.66, m=.02	f=.26, m=1.0	f=.54, m=.43	f=.04, m=1.0	f=1.0, m=.34	f=.65, m=.09	f=.49, m=.94	f=.05, m=.51	f=.37, m=1.0
Unfair-Fair	f=.78, m=.89	f=.51, m=.66	f=.64, m=.55	f=.08, m=.06	f=.68, m=.16	f=1.0, m=.29	f=.74, m=.44	f=.27, m=.53	f=.05, m=.73
Sensors-No Sensors	f=.22, m=.89	f=.22, m=.27	f=.11, m=.54	f=.06, m=1.0	f=.36, m=.32	f=1.0, m=.31	f=.65, m=.29	f=.81, m=.51	f=.28, m=.37
Performance	f=.49, m=.51	f=.73, m=.57	f=.84, m=.11	f=.28, m=.47	f=.94, m=1.0	f=.35, m=.03	f=.34, m=1.0	f=.42, m=.91	f=.44, m=.48

In the Poker Experiment a significant difference was observed with women in the Charity Gains motivator who had sensors reporting the situation to be more of a hindrance. Men in the Charity Gains motivator on the other hand reported that the situation was less suspicious when they had sensors.

In the Interview Experiment all of the significant differences occurred in the Charity Gains motivator. Women in that situation with sensors found them significantly less of a hindrance, more moral, and more trustful.

In the Quiz Experiment there were significant differences for men in the Control motivator: those with sensors performed significantly worse. For women, those with sensors viewed the situation as less trustful in the Charity Gains motivator. Women viewed the situation as more unfair in the Charity Loses motivator.

The Employee Polygraph Protection Act

This early analysis of gender effects suggests that there are some interesting differences. However, more work ought to be undertaken to address the role that gender plays directly.

The Employee Polygraph Protection Act

Some legal codes may be applicable to affective computing systems. Title 29 Chapter 22 of the United State's legal code describes the "Employee Polygraph Protection Act" [eppa1998]. This act makes it extremely difficult for an employer to use polygraph (or lie-detector) techniques on an employee (or job applicant) except under very special circumstances. These regulations do not affect government agencies but are applicable to almost every employer.

These regulations are certainly applicable to situations like the "mole experiment" described above. In the act, a "lie detector" is defined to be "a polygraph, deceptograph, voice stress analyzer, psychological stress evaluator, or any other similar device (whether mechanical or electrical) that is used, or the results of which are used, for the purpose of rendering a diagnostic opinion regarding the honesty or dishonesty of an individual" [eppa1998].

If it were argued that most affective computing systems are used "for the purpose of rendering a diagnostic opinion regarding" honesty by observing "psychological stress" then this law implies that the use of affective computing systems cannot be required by employers.

What Can We Conclude?

It is tempting to move from the observations of the results sections of the various experiments toward normative judgments about what is in fact good or bad about the use of affective computing systems.

However, to do so would be to confuse observing the results of a series of psychology experiments with the formation of notions of what is good concerning affective systems. To simply base guidelines or recommendations upon the results of such empirical investigations would be somewhat like deciding what is good by vote. This is problematic because of the tyranny of the majority; namely that which the largest number says is good is often not the good.

Instead it would be more prudent to make some observations here about the worth of actual observation as compared to professional intuition. As someone who has not only observed but pioneered the development of affective computing systems for many years, it seems that I ought to be able to predict how people respond to them. We have seen that this is certainly not the case and that what has been observed in many cases runs counter to prediction and expectation. This may have implications for methods that ultimately rely exclusively on determinations by the designer, such as Value-Sensitive Design.

Thus, what I can advocate is that professional intuition ought not be relied upon in developing assessments of the ethical implications of affective systems. Instead, situated observation can provide stronger indications of where affective systems are seen as ethical or unethical. Moreover,

Future Work

it is important for these observations to vary social dimensions such as what is at stake and what sort of power relationships exist between individuals.

Future Work

As we have seen, the results of this thesis raise several interesting questions which ought to be addressed in future work. There are a number of variations on the experimental designs that could yield other useful results related to the ethical implications of affective computing systems.

One extremely important aspect that this thesis neglected was the exploration of the physiology data collected. Pattern recognition on the skin conductance, mouse pressure, EKG, and video data collected has the potential to provide insights into not just subjects' reports but subjects' physiological reactions.

In the Quiz experiment it would be interesting to explore how subject results varied if they are not told that the average score was "21.7" and instead are made to feel positively about their performance. This might serve to make the control condition more of a neutral situation as opposed to one which manipulates subjects in negative ways.

Closer examination of the relationship between emotional involvement and unethical behavior as well as strong negative opinions would also be enlightening. Future work should not treat affective responses and ethical opinions as closed systems which do not interact with one another.

One problem that occurred frequently with the MixedEmotions program was the presence of noise in the sensor data due to motion artifacts and errors in the device drivers for the EKG system. It would be interesting to explore variations of the experiment which both reduce and increase the amount of noise in this data and subsequently examine how performance varies.

In the Interview experiment it would be interesting if the interviewer had "something else" (such as annoying sounds in the experimental space) to attribute discomfort to besides the unusual situation. It would also be intriguing to see how subjects change their impressions if they are induced into other affective states prior to starting the experiment, perhaps by watching videos with compelling content.

Lastly, it would be worthwhile to repeat the experiments whilst varying how much information subjects have about the capabilities of affective systems used. In the experiments documented here, participants were deliberately not told about the capacities of the sensors they used. If instead, subjects had feedback or detailed information about the sort of emotional information transmitted and how it might be used, then the results are likely to be quite different. How might individuals feel if they are given everything in truth and in detail?

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Experiment Registration System

Need Cash?

Visit <http://arsenal.media.mit.edu/study/> for further details.

[illegible]

The text used to solicit participants in the experiments in email and on boston.craigslist.com (an area community website) was quite similar to this poster:

Experiment Registration System

Earn up to \$20 and participate in an exciting experiment

Need Cash?

Participate in an exciting 30-45 minute MIT Media Lab experiment and earn up to \$20!!

Visit <http://arsenal.media.mit.edu/study> for further details.

The first page of the registration system sought to inform potential participants about the purpose of the experiment as well as what sort of participants were being solicited. An effort was made to be deliberately vague so as not to influence questionnaire data collected later in the experiment.

Welcome to Experiment Registration

The purpose of this experiment is to collect data to evaluate the acceptability of applications that recognize and communicate emotions.

- We are seeking subjects ages 18 and over.
- You will be asked to perform a simple task at the MIT Media Laboratory.
- Additionally, you will be asked to fill out questionnaires about your experience.
- Participants will receive at least \$5 and up to \$20 depending on the experiment you are chosen for and your performance during that experiment.

The experiment provides subjects with an opportunity to interact with cutting edge technologies and applications. The results of this research will help us better understand how to design systems that sense and communicate emotions.

[Start Registration](#)

Figure 3. Initial page of experiment registration system.

The second page of the experiment registration system collected simple demographic information. This data is presented in the thesis to show a breakdown of the participants who were involved in the experiment.

Experiment Registration System

Demographics: Step 1 of 3

Please enter the following demographic information.

<input type="text"/>	<input type="text"/>
AGE	GENDER
<input type="text"/>	<input type="text"/>
NATIONALITY	EDUCATION

Next Page

Figure 4. Demographics page of experiment registration system.

The third page of the experiment registration system asked participants to choose a time slot from a calendar. When choosing a time slot they were either randomly assigned to one of experiments involving two participants or (in the case that someone else had chosen that slot) they were assigned to a complementary condition and task. This was because a large number of participants did not appear for their experiments during the pilots. For the sake of efficiency, we chose to use subjects whose partner did not appear for the Quiz experiment, which only required one subject.

Time, Date, and Email: Step 2 of 3

Your session will take approximately 30 minutes.
You will receive between \$5 and \$20 for participating.
A modest amount of computer experience is required.

Note: If none of the following times work for you, please try back again later.

TIME SLOT	<input type="text"/>
EMAIL	<input type="text"/>

Next Page

Figure 5. Calendar page of experiment registration system.

Experiment Registration System

The last page of the experiment registration system was designed to provide subjects with information on how to locate the facilities as well as a reminder of what date and time they had selected. A small map from public transportation and a picture of the Media Lab were given to aid participants.

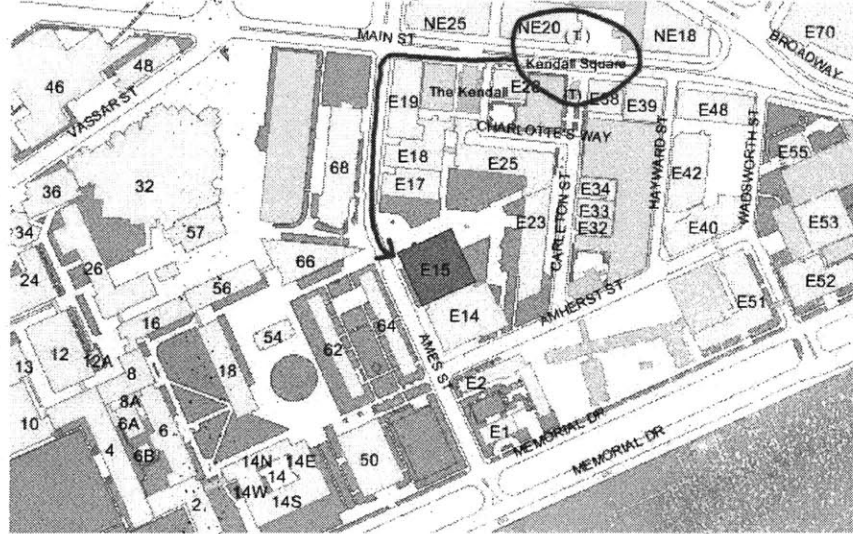
Experiment Registration System

Take note: Step 3 of 3

Thank you for registering for our experiment. Your appointment is at the following time:

You will receive a confirmation email shortly. Take an opportunity to write this in your calendar.

Here are directions to the building and to the room:



The Media Lab is in Building E15 (a.k.a. The Weisner Building), at 20 Ames Street on the east side of campus. It's the building with the big white tiles, rounded corners and the big modern concrete arch connected to the side of it. Room 001 is located on the lower level (LL) of the lab directly across from the elevators.



If you have any problems, please email experiment@media.mit.edu.

Figure 6. Reminder page of experiment registration system.

Experiment Registration System

Additionally, three reminder emails were sent out to participants. Once immediately after registering, a second a day before their experiment, and a third one hour before the experiment.

To:
From: experiment@media.mit.edu
Subject: Experiment Appointment

Greetings,

You have signed up for an experiment at the MIT Media Lab at:

[subject's time and date here]

Here are directions to the building and to the room:

The Media Lab is in Building E15 (a.k.a. The Weisner Building), at 20 Ames Street on the east side of campus. It's the building with the big white tiles, rounded corners and the big modern concrete arch connected to the side of it. You can find a map of the area at this URL:

<http://arsenal.media.mit.edu/study/walk-e15.jpeg>

The Lab is easily accessible by T (see the Kendall Square T stop on the above mentioned map).

When you arrive at the Lab, please come to Room 001 on the lower level, directly across from the elevators. Have a seat on the couches; we will be with you shortly.

If you will be unable to make it to your appointment or know that you will be late, please contact experiment@media.mit.edu at least 24 hours in advance so that the experimenters can make alternative arrangements.

It is very important that you arrive on time to your appointment since the experiment may involve multiple participants. The whole group will be delayed if you are late so please be considerate of the other subjects and show up on time.

Thanks for your interest and participation.

Regards,
The Experimenters

Appendix B

Means and Standard Deviations of Experimental Data

This appendix reports mean and standard deviation data for the sensor and no-sensor groups from each motivator of each experiment. This data is incomplete and needs to be replaced.

Table 5. Poker experiment: mean (μ) and standard deviation (σ) summary for disadvantaged participants using sensors vs. disadvantaged participants with No Sensors or Visible Card

	Poker-Charity Gains-No Sensors	Poker-Charity Gains-Sensors	Poker-Charity Loses-No Sensors	Poker-Charity Loses-Sensors
Ethical-Unethical	$\mu=5.78, \sigma=1.99$	$\mu=5.50, \sigma=2.31$	$\mu=5.40, \sigma=1.90$	$\mu=5.63, \sigma=2.34$
Respectful-Invasive	$\mu=5.54, \sigma=2.25$	$\mu=5.52, \sigma=2.04$	$\mu=4.75, \sigma=2.30$	$\mu=5.41, \sigma=1.87$
Uncomfortable-Comfortable	$\mu=3.75, \sigma=2.01$	$\mu=4.04, \sigma=2.20$	$\mu=4.17, \sigma=1.85$	$\mu=4.48, \sigma=2.31$
Hindrance-Help	$\mu=4.87, \sigma=1.64$	$\mu=3.73, \sigma=1.62$	$\mu=4.30, \sigma=1.83$	$\mu=4.58, \sigma=2.31$
Immoral-Moral	$\mu=2.57, \sigma=1.72$	$\mu=4.17, \sigma=2.48$	$\mu=3.80, \sigma=0.92$	$\mu=3.44, \sigma=2.22$
Trustful-Suspicious	$\mu=3.30, \sigma=1.42$	$\mu=2.85, \sigma=1.35$	$\mu=2.90, \sigma=0.94$	$\mu=3.19, \sigma=1.40$
Unfair-Fair	$\mu=4.00, \sigma=2.11$	$\mu=4.32, \sigma=2.59$	$\mu=4.00, \sigma=1.69$	$\mu=4.60, \sigma=1.96$
Sensors-No Sensors	$\mu=4.44, \sigma=2.30$	$\mu=3.35, \sigma=2.35$	$\mu=5.25, \sigma=2.37$	$\mu=3.59, \sigma=2.83$
Performance	$\mu=5.58, \sigma=3.29$	$\mu=5.24, \sigma=3.00$	$\mu=4.67, \sigma=2.64$	$\mu=5.71, \sigma=3.15$

Means and Standard Deviations of Experimental Data

Table 6. Poker experiment: mean (μ) and standard deviation (σ) summary for participants with sensors vs. paired opponents

	Poker-Charity Gains-No Sensors	Poker-Charity Gains-Sensors	Poker-Charity Loses-No Sensors	Poker-Charity Loses-Sensors
Ethical-Unethical	$\mu=4.33, \sigma=3.11$	$\mu=4.25, \sigma=2.42$	$\mu=4.50, \sigma=2.71$	$\mu=5.50, \sigma=2.15$
Respectful-Invasive	$\mu=5.08, \sigma=2.68$	$\mu=4.50, \sigma=1.98$	$\mu=4.75, \sigma=2.30$	$\mu=4.83, \sigma=2.52$
Uncomfortable-Comfortable	$\mu=3.75, \sigma=2.01$	$\mu=4.50, \sigma=1.62$	$\mu=4.17, \sigma=1.85$	$\mu=3.42, \sigma=2.75$
Hindrance-Help	$\mu=3.25, \sigma=2.73$	$\mu=1.92, \sigma=2.02$	$\mu=3.58, \sigma=2.35$	$\mu=2.42, \sigma=2.47$
Immoral-Moral	$\mu=1.50, \sigma=1.83$	$\mu=2.50, \sigma=2.47$	$\mu=3.17, \sigma=1.70$	$\mu=2.75, \sigma=2.90$
Trustful-Suspicious	$\mu=2.75, \sigma=1.82$	$\mu=2.58, \sigma=1.38$	$\mu=2.67, \sigma=1.23$	$\mu=2.50, \sigma=2.32$
Unfair-Fair	$\mu=3.33, \sigma=2.46$	$\mu=4.50, \sigma=2.81$	$\mu=2.67, \sigma=2.39$	$\mu=4.25, \sigma=3.22$
Sensors-No Sensors	$\mu=3.33, \sigma=2.81$	$\mu=3.50, \sigma=2.68$	$\mu=3.50, \sigma=3.21$	$\mu=2.67, \sigma=2.74$
Performance	$\mu=5.58, \sigma=3.29$	$\mu=6.42, \sigma=3.29$	$\mu=4.67, \sigma=2.64$	$\mu=7.25, \sigma=2.63$

Means and Standard Deviations of Experimental Data

Table 7. Interview experiment: mean (μ) and standard deviation (σ) summary for interviewees with sensors vs. interviewees without sensors

	Interview- Control-No Sensors	Interview- Control- Sensors	Interview- Charity Gains-No Sensors	Interview- Charity Gains- Sensors	Interview- Charity Loses-No Sensors	Interview- Charity Loses- Sensors
Ethical-Un- ethical	$\mu=6.00$, $\sigma=2.19$	$\mu=6.92$, $\sigma=1.78$	$\mu=3.92$, $\sigma=2.54$	$\mu=4.42$, $\sigma=2.71$	$\mu=6.27$, $\sigma=1.79$	$\mu=4.70$, $\sigma=2.16$
Respectful- Invasive	$\mu=6.50$, $\sigma=1.62$	$\mu=5.83$, $\sigma=2.33$	$\mu=5.50$, $\sigma=1.43$	$\mu=5.20$, $\sigma=2.53$	$\mu=6.36$, $\sigma=1.36$	$\mu=5.27$, $\sigma=1.90$
Uncomfort- able-Com- fortable	$\mu=4.08$, $\sigma=2.35$	$\mu=3.08$, $\sigma=2.27$	$\mu=5.50$, $\sigma=2.11$	$\mu=4.91$, $\sigma=2.30$	$\mu=4.36$, $\sigma=1.91$	$\mu=4.58$, $\sigma=2.27$
Hindrance- Help	$\mu=4.70$, $\sigma=2.41$	$\mu=5.00$, $\sigma=2.65$	$\mu=5.64$, $\sigma=1.86$	$\mu=4.60$, $\sigma=1.71$	$\mu=4.50$, $\sigma=2.17$	$\mu=4.58$, $\sigma=1.78$
Immoral- Moral	$\mu=2.40$, $\sigma=1.65$	$\mu=2.00$, $\sigma=1.79$	$\mu=4.45$, $\sigma=2.16$	$\mu=4.45$, $\sigma=2.66$	$\mu=3.30$, $\sigma=2.00$	$\mu=3.33$, $\sigma=2.06$
Trustful- Suspicious	$\mu=3.58$, $\sigma=1.93$	$\mu=4.00$, $\sigma=1.95$	$\mu=2.75$, $\sigma=1.82$	$\mu=3.36$, $\sigma=1.96$	$\mu=3.33$, $\sigma=1.00$	$\mu=4.18$, $\sigma=1.99$
Unfair-Fair	$\mu=3.92$, $\sigma=2.19$	$\mu=3.92$, $\sigma=2.31$	$\mu=5.42$, $\sigma=2.27$	$\mu=5.17$, $\sigma=2.52$	$\mu=4.90$, $\sigma=2.08$	$\mu=4.10$, $\sigma=2.18$
Sensors-No Sensors	$\mu=2.80$, $\sigma=2.90$	$\mu=3.71$, $\sigma=2.93$	$\mu=3.11$, $\sigma=2.89$	$\mu=4.36$, $\sigma=2.84$	$\mu=2.88$, $\sigma=2.64$	$\mu=5.27$, $\sigma=2.76$
Perform- ance	$\mu=0.50$, $\sigma=0.522$	$\mu=0.167$, $\sigma=0.389$	$\mu=0.583$, $\sigma=0.515$	$\mu=0.25$, $\sigma=0.452$	$\mu=0.50$, $\sigma=0.522$	$\mu=0.583$, $\sigma=0.515$

Means and Standard Deviations of Experimental Data

Table 8. Interview experiment: mean (μ) and standard deviation (σ) summary for interviewees with sensors vs. paired interviewers

	Interview- Control-No Sensors	Interview- Control- Sensors	Interview- Charity Gains-No Sensors	Interview- Charity Gains- Sensors	Interview- Charity Loses-No Sensors	Interview- Charity Loses- Sensors
Ethical-Un- ethical	$\mu=6.92$, $\sigma=1.78$	$\mu=3.67$, $\sigma=2.42$	$\mu=4.42$, $\sigma=2.71$	$\mu=4.33$, $\sigma=1.61$	$\mu=3.92$, $\sigma=2.68$	$\mu=3.92$, $\sigma=2.07$
Respectful- Invasive	$\mu=5.83$, $\sigma=2.33$	$\mu=3.25$, $\sigma=1.96$	$\mu=4.33$, $\sigma=3.06$	$\mu=3.83$, $\sigma=2.17$	$\mu=4.83$, $\sigma=2.37$	$\mu=4.42$, $\sigma=1.88$
Uncomfort- able-Com- fortable	$\mu=3.08$, $\sigma=2.27$	$\mu=4.42$, $\sigma=2.15$	$\mu=4.50$, $\sigma=2.61$	$\mu=3.25$, $\sigma=1.82$	$\mu=4.58$, $\sigma=2.27$	$\mu=4.50$, $\sigma=1.57$
Hindrance- Help	$\mu=3.75$, $\sigma=3.19$	$\mu=2.92$, $\sigma=2.02$	$\mu=3.83$, $\sigma=2.37$	$\mu=2.75$, $\sigma=1.54$	$\mu=4.58$, $\sigma=1.78$	$\mu=3.58$, $\sigma=2.54$
Immoral- Moral	$\mu=1.83$, $\sigma=1.80$	$\mu=4.08$, $\sigma=2.57$	$\mu=4.08$, $\sigma=2.84$	$\mu=2.42$, $\sigma=2.02$	$\mu=2.50$, $\sigma=2.32$	$\mu=2.42$, $\sigma=2.15$
Trustful- Suspicious	$\mu=3.67$, $\sigma=2.19$	$\mu=2.92$, $\sigma=1.73$	$\mu=3.08$, $\sigma=2.11$	$\mu=2.83$, $\sigma=1.75$	$\mu=3.83$, $\sigma=2.25$	$\mu=2.42$, $\sigma=1.44$
Unfair-Fair	$\mu=3.92$, $\sigma=2.31$	$\mu=4.67$, $\sigma=1.92$	$\mu=5.17$, $\sigma=2.52$	$\mu=3.58$, $\sigma=1.88$	$\mu=3.42$, $\sigma=2.54$	$\mu=5.25$, $\sigma=2.18$
Sensors-No Sensors	$\mu=2.17$, $\sigma=2.89$	$\mu=2.92$, $\sigma=2.47$	$\mu=4.00$, $\sigma=2.98$	$\mu=3.92$, $\sigma=2.54$	$\mu=4.83$, $\sigma=3.04$	$\mu=2.50$, $\sigma=1.51$
Perform- ance	$\mu=0.167$, $\sigma=0.389$	$\mu=0.167$, $\sigma=0.389$	$\mu=0.25$, $\sigma=0.452$	$\mu=0.75$, $\sigma=0.452$	$\mu=0.583$, $\sigma=0.515$	$\mu=0.417$, $\sigma=0.515$

Means and Standard Deviations of Experimental Data

Table 9. Quiz experiment: mean (μ) and standard deviation (σ) summary for sensors vs. no sensors

	Quiz-Control-No Sensors	Quiz-Control-Sensors	Quiz-No Effect on Charity-No Sensors	Quiz-No Effect on Charity-Sensors	Quiz-Charity Gains-No Sensors	Quiz-Charity Gains-Sensors	Quiz-Charity Loses-No Sensors	Quiz-Charity Loses-Sensors
Ethical-Unethical	$\mu=6.67$, $\sigma=2.06$	$\mu=5.60$, $\sigma=2.07$	$\mu=7.33$, $\sigma=0.816$	$\mu=7.20$, $\sigma=0.919$	$\mu=7.12$, $\sigma=2.10$	$\mu=6.50$, $\sigma=2.27$	$\mu=5.42$, $\sigma=1.44$	$\mu=6.18$, $\sigma=2.04$
Respectful-Invasive	$\mu=6.92$, $\sigma=1.38$	$\mu=5.27$, $\sigma=1.68$	$\mu=6.92$, $\sigma=1.24$	$\mu=7.09$, $\sigma=0.831$	$\mu=7.09$, $\sigma=1.30$	$\mu=5.33$, $\sigma=2.10$	$\mu=5.67$, $\sigma=1.72$	$\mu=5.82$, $\sigma=2.36$
Uncomfortable-Comfortable	$\mu=4.92$, $\sigma=2.11$	$\mu=4.45$, $\sigma=2.21$	$\mu=4.75$, $\sigma=2.45$	$\mu=3.50$, $\sigma=1.73$	$\mu=4.08$, $\sigma=2.11$	$\mu=3.36$, $\sigma=1.63$	$\mu=4.17$, $\sigma=1.85$	$\mu=3.50$, $\sigma=1.68$
Hindrance-Help	$\mu=4.90$, $\sigma=1.45$	$\mu=4.90$, $\sigma=1.29$	$\mu=4.11$, $\sigma=2.26$	$\mu=4.70$, $\sigma=1.49$	$\mu=2.89$, $\sigma=1.36$	$\mu=4.60$, $\sigma=1.35$	$\mu=4.40$, $\sigma=1.78$	$\mu=3.38$, $\sigma=2.33$
Immoral-Moral	$\mu=1.80$, $\sigma=1.62$	$\mu=3.83$, $\sigma=2.48$	$\mu=1.88$, $\sigma=1.13$	$\mu=2.43$, $\sigma=1.13$	$\mu=2.00$, $\sigma=2.00$	$\mu=3.12$, $\sigma=1.36$	$\mu=4.00$, $\sigma=1.63$	$\mu=3.44$, $\sigma=1.74$
Trustful-Suspicious	$\mu=4.75$, $\sigma=1.42$	$\mu=3.44$, $\sigma=1.42$	$\mu=4.58$, $\sigma=1.93$	$\mu=4.33$, $\sigma=1.56$	$\mu=5.80$, $\sigma=2.35$	$\mu=3.78$, $\sigma=1.79$	$\mu=3.36$, $\sigma=1.96$	$\mu=4.18$, $\sigma=2.27$
Unfair-Fair	$\mu=3.00$, $\sigma=1.90$	$\mu=3.70$, $\sigma=2.21$	$\mu=3.18$, $\sigma=1.83$	$\mu=2.73$, $\sigma=1.62$	$\mu=2.42$, $\sigma=1.78$	$\mu=2.27$, $\sigma=1.49$	$\mu=4.17$, $\sigma=1.99$	$\mu=3.11$, $\sigma=1.69$
Sensors-No Sensors	$\mu=3.09$, $\sigma=2.74$	$\mu=3.57$, $\sigma=1.51$	$\mu=2.90$, $\sigma=1.91$	$\mu=3.60$, $\sigma=2.55$	$\mu=3.73$, $\sigma=3.32$	$\mu=3.44$, $\sigma=2.51$	$\mu=3.60$, $\sigma=2.46$	$\mu=4.62$, $\sigma=3.16$
Performance	$\mu=11.17$, $\sigma=5.24$	$\mu=8.92$, $\sigma=4.54$	$\mu=9.42$, $\sigma=6.04$	$\mu=11.67$, $\sigma=5.52$	$\mu=11.67$, $\sigma=5.14$	$\mu=12.50$, $\sigma=5.99$	$\mu=12.67$, $\sigma=5.53$	$\mu=10.17$, $\sigma=5.02$

