Stoop to Conquer: Posture and affect interact to influence computer users' persistence

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Abstract. RoCo, a novel robotic computer, has the capability to move its monitor in subtly expressive ways that respond to and promote its user's postural movement. Motivated by Riskind's "Stoop to conquer" research where it was found that postures congruous to the type of outcome a person received (e.g. slumping following a failure or sitting up proudly following a success) led to significantly better performance in a subsequent cognitive task than incongruous postures (e.g. sitting up proudly following a failure or slumping following success), we performed two experiments where RoCo was used to manipulate its user's posture. Our results show that people tend to be more persistent on a subsequent task when RoCo's posture is congruous to their affective state than when it is incongruous. Our study is the first to show that a computer's "pose" congruous or incongruous to a user's affective state can influence factors such as persistence in problem solving tasks.

Keywords: User Studies, Robotic Computer (RoCo), Affective Interaction, Posture and Emotion, Human-Robot Interaction

1 Introduction

Everyone knows that how you feel can influence what you think and do. However, many people do not know that there is a growing body of findings from psychology, cognitive science, and neuroscience where more subtle affective states have been shown to systematically influence cognition [10,12,13,19]. In particular, a number of studies have explored the effect of body posture on affect and cognition [16,17,5,21]. An example is the theory in Riskind's "stoop to conquer" research [16,17], where it was found that incongruous postures, such as slumping after a success, negatively affected subsequent performance, while congruous postures, such as slumping after a failure, helped to mitigate the effects of failing.

Motivated by Riskind's "stoop to conquer" research, we performed two experiments examining the interaction of posture and affect on persistence, creativity, and comfort. While Riskind's experiments were conducted over 22 years ago with pencil and paper and with human-manipulated postures, we modified the experiment, adapting it to be applicable to today's computer users, and importantly, to users of future new technologies that we believe will have articulated smooth movements (like RoCo).

This paper is organized as follows. First we present a brief description of the new RoCo robotic computer platform to motivate this new desktop technology that moves and can get people to shift their posture naturally while working. Next we offer a summary of relevant psychological literature with respect to body, affect, and cognition interaction effects that informs and guides our work. We then present two novel user studies adapting Riskind's experiment to the RoCo platform. Finally we discuss the findings and conclusions, and suggest future directions.

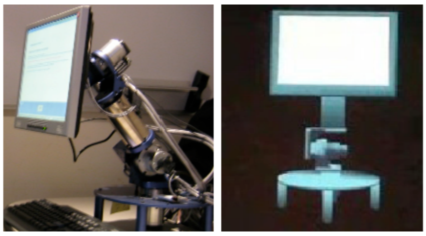

Figure 1. RoCo: a robotic computer (left) and its graphical simulator for designing new behaviors (right)

2 RoCo: A New Robotic Computer Platform

RoCo is designed to lie within a continuum that might be loosely described as having ordinary fixed desktop computers at one end, and humanoid robots at the other end. In between is a huge unexplored space, where one can begin to animate the things in the office environment that usually do not move on their own: computers, chairs, and more. With increasing interest in promoting healthy activity, we are starting with the desktop computer, considering how it might move in ways that get the person using it to move more. RoCo was carefully designed to look like an ordinary computer, but to move in ways that are completely paradigm changing. RoCo has no face or body that attempts to evoke humanoid or animal characteristics: it has a regular monitor, keyboard, and box, which are sessile. However, it also has motors that give it smooth, expressive, articulated movement.

The physical RoCo robot has five degrees of freedom (DoFs) that manipulate its mechanical "neck" with a LCD screen as its "face" and "head." See Figure 1. Two DoFs move the mechanical neck (base yaw and base pitch) and three DoFs (head yaw, head pitch, and head roll) move the LCD display. These five degrees allow RoCo to perform a wide variety of simple motions, including nodding, shaking its head, and leaning forward. These life-like motions are sufficient to implement a wide variety of immediacy behaviors and postural changes. For example, if you lean toward RoCo, perhaps to read something tiny on the screen, it could meet you halfway. At the same time, we are designing RoCo with sensors to monitor your facial and postural movements so that it does not move in ways that distract you. Inspired by examining how and when humans move naturally, we are currently aiming to have RoCo hold very still while you are attentive to the screen, but to look for natural breaks to maximize your movement without distracting or annoying you. For example, if you have been slumping for a while, and then turn away your gaze, then when you return your gaze, you might find RoCo has “stretched” upward, subtly encouraging you to adjust your posture upward. However, as we show in this paper, there is more to consider than your attention and your posture.

In this paper we wish to isolate how its posture interacts with and influences the person using it. In fact, for this paper, we will pre-set RoCo’s postures so that the novelty of a computer moving does not enter into our results. We do this as the first set of experiments with this new technology, to carefully control the variables influencing the outcomes.

3 Body, Affect and Cognition Interaction

3.1 Affect and Cognition Interactions

Studies from psychology, cognitive science, and neuroscience indicate that affect and emotional experience interact with cognition in significant and useful ways. Current understanding is that emotion plays a useful role in regulating learning, creative problem solving, and decision making. For example, Isen shows that a positive mood promotes a tendency toward greater creativity and flexibility in negotiation and in problem solving, as well as more efficiency and thoroughness in decision making [10]. These effects have been found across many different groups, ages, and positive affect manipulations. Other specific influences of affect on cognition have also been found for negative affective states, e.g., Schwartz argues that being in a sad mood enables better performance on certain kinds of analytic tests [19].

Emotion not only influences cognition, but it also interacts with information in the environment in ways that can enhance or hinder your ability to perform. Cliff Nass and colleagues, while trying to decide if a voice in the automobile driver’s environment should sound subdued and calm or energetic and upbeat, ran an experiment trying both kinds of voices [13]. Importantly, they also looked at the two conditions where drivers were either upset or happy (having just viewed disturbing or funny films.) In a total of four conditions, the happy or upset drivers drove in a simulator with either an energetic voice or a subdued voice talking to them and asking them questions. On multiple measures of driving performance and cognitive performance, happy drivers did better overall than upset drivers. But there was also an important and interesting interaction, highly relevant to the work in this paper. When the voice was congruous with the driver’s state (energetic/upbeat for happy drivers, subdued/calm for upset drivers) then performance was significantly better than in the two incongruous conditions. The worst performance of all four conditions occurred when the upset drivers were paired with the energetic and upbeat voice. It is this kind of effect – where performance is improved by mood congruent interaction – that we explore in this paper. However in this paper, we induce the congruence condition in an entirely new way.

3.2 Body and Affect Interactions

According to Riskind's [16] "appropriateness hypothesis", slumped or upright physical postures are not just passive indicators of mental states but can reciprocally affect the mental states and behavior. The results suggest that "inappropriate" postures, such as slumping after a positive success, can undermine subsequent motivation and feelings of control, while "appropriate" postures, such as slumping after a failure, help to mitigate the effects of failing. His findings suggest that it is therefore not beneficial after a failure to sit with chin up as if proud, despite that people often tell children to do that.

In Riskind's original experiment, all the subjects were first asked to perform a cognitive task (e.g. a tracing puzzle task). The affective manipulation (positive/negative affect) was handled by the experimenter who informed the subject of his or her "score" on the task. A high score (success) was designed to elicit a positive affect in the subject, while a poor score (failure) to elicit a negative affect. After this first task, the subjects were escorted to a different room and assisted to take one of three postures reflecting appropriateness (neutral/slumped/upright) under the false pretense of a biofeedback experiment. The subjects were required to hold this posture for 8 minutes before relaxing it and performing a subsequent cognitive task (e.g. additional puzzle tracing tasks). Riskind found that subjects in incongruous postures (stooped/slumped following success, upright following failure), felt like they had less control, showed less motivation in persistence tasks, and reported higher depression than subjects in congruous postures. His study suggested that a slumped versus upright posture orientation can guide and moderate information processing and responses to positive and negative mood-relevant stimuli.

4 Our Purpose, Hypothesis and Predictions

In this paper, we explore whether a computer's "posture" can influence its user's subsequent posture, and if the congruence of the user's body state with their affective state during a task leads to improved task measures, such as persistence in problem solving. This research serves as a baseline study to investigate RoCo's ability to manipulate both the user's posture and the user's cognitive and affective state, illuminating the capabilities of this new technology. The key question, therefore, is how we design new technologies to beneficially influence the interactions between a human user's body, affective, and cognitive states. We wish not only to provide an ergonomic experience, but also to foster healthful computer usage and improved task outcomes.

Our study expands on the appropriateness hypothesis [17], predicting that congruous posture guides an individual towards self-regulating behaviors while incongruous posture leads to self-defeating behavior. Taking advantage of the unique RoCo research platform, our experiment introduces a different posture manipulation method that allows the subject to perform dependent measure tasks on a computer while in the manipulated posture. Thus, while Riskind measured the effect of a prior posture on a subsequent cognitive task, we can now measure the effect of the posture concurrent with the task. Our prediction is that RoCo will be an effective agent for manipulating posture and inducing the "stoop to conquer" effect.

In Riskind's original experiment, subjects were asked to either slump or sit upright under the false pretense of a biofeedback experiment. In his study, a human experimenter was responsible for posture manipulation. While this kind of manipulation is useful for detecting the "stoop to conquer" effect, it is not practical in real applications that aim to utilize this effect in a more natural way. However, when a user works on the RoCo platform, by changing RoCo's posture, we have been able to get RoCo to subtly lure the user into a target posture without seriously interrupting his or her workflow. Also, in our experiment using the RoCo platform, since RoCo is responsible for posture manipulation instead of a human experimenter, this change makes the manipulation significantly more subtle and unobtrusive than in the Riskind experiment.

5 Experiments and Results

5.1 EXPERIMENT 1

This experiment measures persistence on a helplessness task, creativity on a word association task, and general spatial cognition on a puzzle task as a function of congruous and incongruous postures following affect manipulation [3, 20].

Subjects. Seventy-one naive subjects were recruited from our school and the surrounding area. Subjects were given a $10 gift certificate to Amazon.com as compensation for their participation. In this study there were six control conditions each of which involved a mood manipulation (success / failure) and one of RoCo's posture states (slumped / neutral / upright). Subjects were assigned to one of the six conditions based on the order that they signed up to participate in the study.

Preliminaries. When subjects arrived they were first greeted by the experimenter then led to a standard PC. The experimenter read the following standard set of instructions aloud to the subject: "Please be seated. In front of you is a standard computer setup with mouse, keyboard, monitor and a pen tablet for use in the tracing puzzles. You may arrange these components on the desk any way you like. Please read the instructions carefully as you go. The height of the chair is adjustable with a lever underneath the seat. I will be outside the curtains, if you have any questions or get confused, but in general, please try do as much on your own as possible." The experimenter then left the area while the subject was shown a two minute video clip previously shown to induce neutral affect [18].

Success-Failure Manipulation. Half of the six conditions involved inducing a feeling of success, while the other half involved inducing a feeling of failure. This was accomplished as follows. Subjects were given a series of four tracing puzzles to solve. They had two minutes to solve each puzzle. To solve a puzzle, the subject must trace over the design without lifting a pen from the puzzle or retracing any lines. In this case, the puzzles were presented on a standard LCD screen and pen tracing is done with a computer pen and tablet input device. The puzzles used are the same set used by Riskind [16] in his studies as well as by Glass and Singer [7]. To create a success condition, all four puzzles were solvable. Generally each subject was able to solve at least three out of the four. Unsolved puzzles were usually the result of not carefully reading the instructions beforehand or difficulty using the pen and tablet interface. Regardless of how the subject actually performed, a results chart was displayed and subjects were told they scored an 8 out of 10. For the failure condition, the first and last puzzles were insolvable. The sense of failure was further reinforced by displaying the same results chart as in the success condition, except in this case they were told that they scored a 3 out of 10.

Posture Manipulation. Following the success-failure manipulation, the subject's chair was rolled over a few feet to RoCo, the position of which had already been preset to slumped, upright, or neutral, relative to the first PC. These positions are shown in Figure 2. Notice that they are not quite the same as can be obtained with the typical degrees of freedom on a desktop monitor, although people certainly are capable of slumping or sitting up straight in front of an ordinary desktop monitor. The poses of RoCo are somewhat exaggerated to more strongly encourage sitting up or slumping relative to the neutral position used during the interaction with the regular PC. The subject, while seated in the same calibrated-height chair, was then asked to perform another series of puzzles, this time on RoCo. The subject was video taped as a manipulation check.

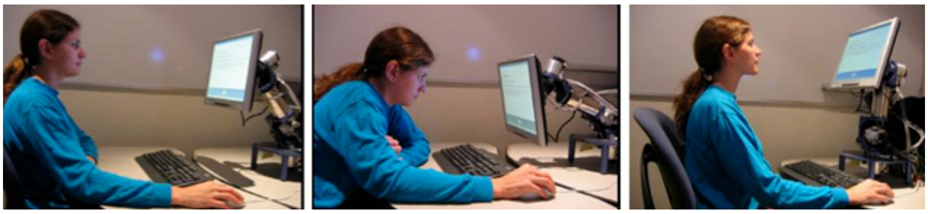

Figure 2. RoCo's postures: neutral (left), slumped (center), upright (right)

Dependent Measures. The experiment examined three dependent measures: persistence, spatial cognition, and creativity. However, in this paper we only discuss the results about persistence, because we do not have enough space to discuss all the dependent measures.

Insolvable Tracing Task to Test Persistence: The subject was given four mathematically insolvable tracing puzzles with a time limit of two minutes for each. This task assumes that the fewer the number of tries in the allotted time, the lower the subject's tolerance for a frustrating task. Some of the puzzles are the same as those used in Riskind's original study. Additional puzzles were created by transforming some solvable into insolvable. Debriefings showed that only people who knew the mathematical rule for solvability ahead of time were able to distinguish solvable from insolvable puzzles; their data was dropped.

Debriefing. Following the dependent measure tests, each subject was given a full debriefing. As a check on the success-failure manipulation, subjects were asked how well they thought they performed on the first part. All subjects in the failure manipulation responded with answers like "not well", "below average", and "ok", suggesting that the manipulation was successful. Similarly, most subjects in the success case responded with answers such as “well” and “above average”. Four subjects in the success condition who had trouble with the tracing puzzles in part one reported that they did not do well. Their data were omitted since the manipulation was not successful. Following the manipulation check, the details of the study were disclosed including the impossibility of some of the tracing puzzles and the fabricated test results in part one. Four subjects also reported at this time that they knew the tracing puzzles were mathematically impossible. Their data were also omitted.

Main Results. 1. *RoCo posture’s influence on the user posture:* An outside hypothesis-blind person coded the changing user posture for the video data collected from 64 subjects. Based on the states of the chin, shoulder and back of the user, the coder classified the user posture into three basic states (Slumped / Neutral / Upright) every 30 seconds. We could not code three subjects’ video data because they sat down too close to RoCo so the camera didn’t capture their posture properly. The video analysis shows that RoCo’s posture strongly influenced the user’s posture in both success and failure conditions (See Tables 1 and 2). The most frequently occurring posture state during the subsequent tasks was used for counting the user posture in these tables. Most subjects (about 70% of all subjects) tended to keep the dominant posture for over 80% of the task time. Also, about 15% of all subjects changed the posture state every 5~7 minutes. 2. *Persistence on Task:* As predicted, the analysis on the persistence on the insolvable puzzles data (summarized in Table 3 and shown in Figure 3) did reveal a statistically significant interaction effect, $F(2, 57) = 4.1$, $p < 0.05$. Further simple effects analysis by success-failure outcome revealed that success subjects exhibited more persistence when they used RoCo in its upright position ($M = 11.97$) after their success than when they used RoCo in its neutral position ($M = 8.32$), or in its slumped position ($M = 8.15$), $F(2, 57) = 7$, $p < 0.01$. However, unlike in Riskind’s study, failure subjects showed no statistical difference across postures, $F(2, 57) = 0.1$. We address this in the discussion and in Experiment 2. Also, there were no main effects for either the success-failure or the posture manipulations, $F(2, 57) < 2$, $p < 0.2$ and $F(2, 57) < 3$, $p < 0.07$ respectively.

User \ RoCo	Slumped	Neutral	Upright
Slumped	9	4	3
Neutral	2	5	0
Upright	0	0	9

Table 1. RoCo posture’s influence on the user posture in the success condition (the number of subjects is shown)

User \ RoCo	Slumped	Neutral	Upright
Slumped	7	2	0
Neutral	4	5	0
Upright	0	0	11

Table 2. RoCo posture’s influence on the user posture in the failure condition (the number of subjects is shown)

Outcome	Slumped	Neutral	Upright
N	10	11	9
Success	8.15	8.32	11.97
N	12	10	11
Failure	8.33	8.75	8.41

Table 3. Average number of tracing attempts

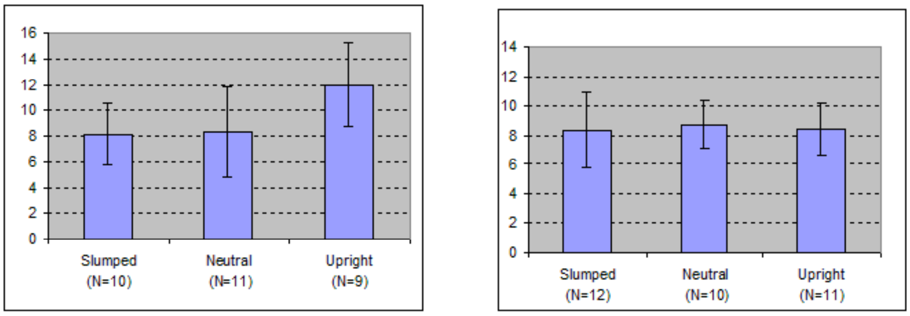

Figure 3. Average number of tracing attempts: success (left) and failure (right) conditions

Discussion. We adapted a number of factors from Riskind's original study to work with RoCo, which may explain why our results differ for the failure condition. In Riskind's study, subjects were taken to a separate room and told to hold the assigned posture for approximately eight minutes under the pretense of a biofeedback experiment. They then performed the second set of tasks without controlling for posture. However, in our study, the user is free to adopt any posture as long as he or she can still read the screen. The video footage shows that users seemed to adjust their posture, particularly while sitting back and thinking about possible solutions. They tended to move more in the slumped conditions where they reported lower comfort (especially the failure-slumped condition, which can also foster a sense of malaise). While thinking, the primary posture manipulation was relaxed. Thus, our subjects who encountered the slumped condition of RoCo did not slump as consistently as Riskind's subjects did, as his were forced to hold the slumped position for 8 minutes, without moving. In sum, one possible explanation for why we are seeing the positive-upright effect but not the "negative-stooped" effect in our study may be that subjects did not sustain the stooped posture for a sufficiently long period of time. We designed Experiment 2 to address this problem.

5.2 EXPERIMENT 2

Experiment 2 was designed to see if having the subject hold the slumped position (giving a person a more involved task to do on RoCo during the posture manipulation) after failure would produce the "stoop to conquer" effect. Here we observed the dependent measures in each of the three conditions (failure-upright, failure-neutral and failure-slumped). Moreover, differently from Experiment 1, we included a new decision-making (gambling) task that had reading instructions and content written in a small font on the LCD monitor in order to encourage the subject to stay in a position focused on the monitor. This task did appear (from videos) to keep subjects in the desired posture for a longer time than Experiment 1 because they had to scrutinize details on a screen for 8 minutes.

Subjects. Thirty-seven subjects were recruited from our school and surrounding area, each between 18 and 40 years old. Subjects were randomly assigned to one of the three conditions (failure-upright/failure-neutral/failure-slumped).

Procedure. The same procedure as in Experiment 1 was performed, except that they performed the decision-making task before other dependent measure tasks. Since our primary interest in Experiment 2 was the "stoop to conquer" effect on the persistence measure in the failure conditions, all subjects were assigned to the failure manipulation. Subjects used RoCo for the 8 minute decision-making task, then performed dependent measure tasks.

Debriefing. Following the dependent measure tests, the 37 subjects were given a full debriefing as in Experiment 1. We found 7 of the subjects did not feel bad after the failure manipulation: four subjects did not feel bad in spite of the low score, and three subjects believed that the low score given for the manipulation was not true (failed mood manipulation). Thus, their results were excluded from all our analysis, and we see 30 subjects in Tables 4 and 5. In Table 6, we found we had to omit additional 12 subjects: after the video analysis, we found that two subjects' posture did not match with RoCo's conditioned posture (failed posture manipulation). Also, one subject reported that she had much trouble in using the pen tablet for the tracing puzzles, and nine subjects knew the rule for whether a tracing puzzle was solvable or not. While these problems did not interfere in the mood manipulation (as verified in the debriefing), they would make comparisons of persistence unfair, because they skipped puzzles, so they are omitted from Table 6. Since the sample size is small, we risk false acceptance or rejection of the null hypothesis. Thus, below, we report all the averages and standard deviations as well as results of statistical tests.

Main Results. 1. *RoCo posture's influence on the user posture:* RoCo's posture strongly influenced the user's posture. Also, compared with the failure condition of Experiment 1 (Table 2), the 8 minute cognitive task helped the user keep a constant posture longer (See Tables 4 and 5). 2. *Persistence on Task:* One-way ANOVA analysis was applied to the persistence measure from the insolvable puzzles data (summarized in Table 6 and shown in Figure 4). The result shows a statistically significant posture effect on the persistent measure, $F(2, 15) = 3.70$, $p < 0.05$. Subjects showed higher persistence when they used RoCo in its slumped position ($M = 9.75$, $SD = 2.50$) after their failure than when they used RoCo in its neutral position ($M = 7.36$, $SD = 1.58$), or in its upright position ($M = 6.85$, $SD = 1.60$). Thus, the better persistence of the matched combinations supports the appropriateness hypothesis.

Discussion. Experiment 1 showed that people tended to be more persistent on a subsequent task when they used RoCo in its upright position after success than when they used RoCo in its neutral or slumped position. However, Experiment 1 did not show a significant "stoop to conquer" effect on the same persistence measure in the negative mood conditions. We hypothesized that these results were mainly caused by the fact that subjects did not keep the target posture for a significant period of time while doing the subsequent task on RoCo. Thus, Experiment 2 was designed to encourage subjects to hold the target posture longer before doing subsequent tasks. This new experiment allowed us to observe that people in the negative mood were more persistent using RoCo's slumped posture than using its neutral or upright postures, thus achieving the "Stoop to Conquer" effect. Therefore, Experiment 1 and 2 show that a computer's "pose" congruous or incongruous to a user's affective state can influence performance factors such as task persistence. Also, we find that holding the target posture before doing other dependent measure tasks may be critical in utilizing the "stoop to conquer" effect. This makes sense if the slumping helps a person to process their negative state, and thus go on to better performance.

RoCo / User	Slumped	Neutral	Upright
Slumped	11	0	0
Neutral	2	8	0
Upright	0	0	9

Table 4. RoCo posture's influence on the user posture for the initial 8 minutes (the number of subjects is shown)

RoCo / User	Slumped	Neutral	Upright
Slumped	10	3	0
Neutral	3	5	0
Upright	0	0	9

Table 5. RoCo posture's influence on the user posture for the total task time (the number of subjects is shown)

Groups	Slumped	Neutral	Upright
N	6	7	5
Average	9.75	7.36	6.85
SD	2.50	1.58	1.60

Table 6. Average number of tracing attempts

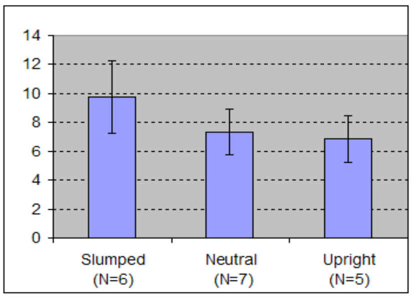

Figure 4. (Failure condition) Average number of tracing attempts

Since we first wanted to observe the "stoop to conquer" effect on the RoCo platform without involving any other effects between RoCo and the human subject, the experiments in this paper did not engage RoCo's dynamic movements of responding appropriately to the user's affective state. When RoCo uses these dynamic behaviors, there might be additional emotion contagion effects between RoCo and the user. Thus, we sampled these behavioral positions by exposing users to three different fixed points: slumped, neutral, upright. There was probably still a novelty effect of using a monitor with wires running up it, but this effect was constant across all conditions.

RoCo is an entirely new kind of system, which can greet its user socially and move during natural interaction much like people move. Suppose the user greets RoCo cheerily, then sits and slumps. Our findings confirm the theory that an upright posture (congruent with cheery mood) could help this user be more productive. RoCo can begin to move upward, subtly, without being distracting. More likely, RoCo will observe that you are already slumped, and then choose movements to respond best to your wishes, which may include increased productivity. The three positions tested so far (and the 8min timing) provide the first proof of concept that posture-mood interaction matters in HCI. This now opens the door to investigating what timings and positions are most effective.

6 Conclusion

We use RoCo in a novel user study to explore whether a computer's "posture" can influence its user's subsequent posture, and if the interaction of the user's body state with their affective state during a task leads to improved task measures, such as persistence in problem solving. These findings lend support to the theory of embodied cognition where invoking a cognitive concept invokes an associated bodily (and/or affective) state, and vice-versa. When the states are congruent, there is less conflict, and more resources to devote to task performance. This paper is the first to show that mood-posture interactions influence performance for a person sitting in a chair using a computer monitor.

Research in computer-human interaction has long ignored human feelings, conducting experiments that (effectively) assume users are in a neutral mood. Our findings suggest that it might be important to bias users into multiple moods, and then measure outcomes. The field of economics has found that this makes a big difference in matching theory to real behavior (e.g., [12], where the endowment effect is reversed dependent on mood.) We suggest that the field of human-computer interaction may similarly find that measuring affective state is important, and can lead to measurably different outcomes. Persistence and perhaps many other cognitive variables are likely to be influenced by body and affective states.

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