# Communicating Failure Recovery with Robotic Body Movement

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***Abstract*— Communication of failure is important for robots to reduce negative impact on people and to maintain collaboration. To accomplish this, we used body movements to facilitate failure recovery in robotic arm. We re-frame the failure recovery process as the combination of attitude and behavior. We first design the robotic arm's motion using bodystorming and then evaluate candidate designs in study one. Study Two supports investigating the best combination of attitude and behavior that communicates positive social influence, improving people's overall perception of the robot and willingness to further collaboration. Our work could contribute to the area of interactive robot learning area by improving robot's motion trajectory planning for social failure recovery.**

## I. INTRODUCTION

Non-humanoid and non-facial robots, such as robotic arms, are being increasingly used in various human social scenarios by the Human-Robot Interaction (HRI) community [1]. However, Robots may behave unexpectedly during task-based interaction, leading to failures [2]. Recovery strategies, including setting expectation, politeness (e.g., apology and regret), asking for help, and humor, need to be applied in communication to prevent the negative influence of failure [3]. Robotic arms cannot use facial displays or verbal speech to enable communication. Instead, non-verbal information like body movement has been the most common mechanism [4]. To construct an intelligent social robot that encourages further interaction after a failure, the robot is expected to learn human's mental model of its recovery strategies [5]. In this study, we focus on body movement as a failure recovery communication channel in a robotic arm. The following guiding questions motivate this ongoing research in two studies: (1) What failure recovery strategies can we use for the motion design? How to design the motion? Which design is effective? (2) What motion representation and recovery strategy can encourage further interaction?

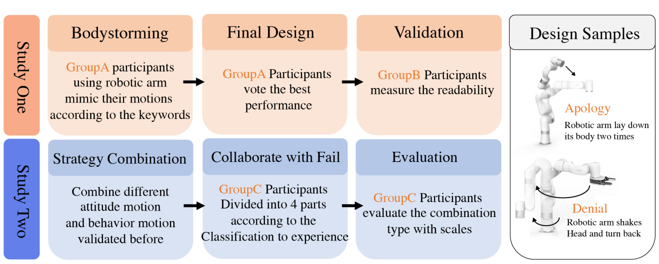


Fig. 1. Procedure of study one and two and motion Design samples representing apology and denial.

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## II. METHODOLOGY

According to the theory of reasoned action (TRA), attitude display should precede the performed behavior of failure recovery to indicate one's intent [7]. Existing research has not included attitude as part of the recovery communication strategies. Therefore, we propose a new classification (Table. I) based on previous research and TRA for our design. In Study One, We will use the bodystorming technique to design motions representing each strategy [8] with Group A participants. They will be asked to mimic the action using the robotic arm that can be freely moved. The best performances voted by the participants will be recorded in the robot's system. To evaluate the effectiveness of the design, we will invite Group B participants to measure the readability robot's motions. In Study two, we will combine different attitudes and behaviors using previously validated motion designs. We will then ask Group C participants to collaborate with robot to accomplish a block building task, in which the robot may fail and recover with the combined motion strategies, to explore our second research question. We hypothesize that the combination choice of attitude and behavior will have a significant interaction that affects people's perceptions of the robot's failure recovery communication. Scales like Trust Perception Scale-HRI [9] and RoSAS [10] will be used to measure people's collaboration willingness and social features of the robot motions.

TABLE I

THE DESIGN METRICS OF ROBOT'S BODY MOVEMENT.

| Attitude \ Behavior | | Proactive | Reative |
|---|---|---|---|
| Positive | Towards oneself | Explanation + Self recovery | Explanation + Ask for help |
| | Towards others | Humor + Self recovery | Humor + Ask for help |
| Negative | Towards oneself | Self-blame + Self recovery | Self-blame + Ask for help |
| | Towards others | Denial + Self recovery | Denial + Ask for help |

## III. CONCLUSION

We reclassify the robot's failure recovery strategies into attitudes and behaviors and to design and validate the effectiveness of the body movement. The design will provide reference data to automatically generate suitable recovery motion when encountering failure. The insight into people's perception of the interaction of different strategies can be applied to design for the robot to enhance and adjust its recovery performance by recognizing human preferences.

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