Group Vs. Individual Comfort When a Robot Approaches

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Abstract. This paper quantifies how the comfort of a person approached by a robot changes when that person is alone or in a group of two. A total of 140 participants in lone and paired configurations were approached by a robot from eight different directions and asked to rate their level of comfort. Results show that while the comfort of an individual was influenced by the presence and relative position of a second person, there were some common features in the comfort responses of all participants regardless of their group configuration.

Keywords: Human-robot interaction · Comfort · Group

1 Introduction

In human-robot interaction, the initiation phase leading to a subsequent interaction is important to the success of the interaction [1]. A major part of the initiation phase is the way a robot approaches potential interactants, including the path taken by the robot in approaching the person or group of people. In this work we define the “best” approach direction as the most comfortable one, and define comfort in terms of a natural language understanding of mental comfort as tranquility and contentedness; being free from a state of unease, constraint, fear or anxiety. Comfort is assessed simply by asking a person “how comfortable” they are. We define the comfort profile of a person as the mapping of their comfort levels to a set of robot approach directions.

It has been shown [2] that people tend to interact with robots in their personal space, as defined by Hall’s theory of proxemics [3]. When people are alone, they are most comfortable when a robot approaches them from the front—where the robot can easily be seen—and are least comfortable when they are approached from behind [4–6]. In our previous work [7] we showed that the comfort of people in groups of two was qualitatively similar to that of individuals in single-person, single-robot (SPSR) scenarios, although a person’s comfort level was influenced both by the group formation shape and the position of participants within the group.
The cited works on SPSR scenarios show that people are more comfortable when approached from a ‘frontal’ direction rather than from a ‘rearward’ direction. Extension to groups of more than one person introduces complexities. When people interact in a group, they tend to orient themselves towards other group members. In the most extreme case, when a group of two people face each other, a robot that approaches one person from a ‘frontal’ direction must approach the other person from a ‘rearward’ direction. Our work in two-person, single-robot (TPSR) scenarios investigates how the comfort profile of an individual is influenced by the location of the second person. The comfort profile of a person is defined here as the mapping of their comfort levels to the set of robot approach directions. Knowledge of how comfort profiles differ between individuals who are alone or in a group can be integrated with existing robot path planning algorithms, allowing for a robot to maximise the comfort of individuals it might interact with.

Although previous SPSR studies have been conducted [4–6], the diverse experimental conditions and relatively small sample numbers don’t allow for a qualitative comparison with our TPSR results. We therefore chose to repeat single-person experiments under the same conditions as our prior two-person experiments [7], and with significantly more participants than previously reported. Performing group and individual experiments under the same conditions allows for a direct quantitative comparison of the two data sets. As a result, this paper presents experimental work that quantifies differences in comfort levels between people seated alone and those seated in pairs, in various sitting configurations. The comfort profiles of individuals in pairs and alone are compared across eight robot approach directions through intra- and inter-position statistical analyses.

2 Design and Conduct of Experiments

Two sets of experiments were performed to investigate the hypothesis that people in pairs have a similar comfort to lone individuals when they are approached by a robot from different directions. The two experiments followed a similar procedure: with two participants for the TPSR scenario, and with a single participant for the SPSR scenario. All participants were naive to the experiment and were recruited at a campus of the University of New South Wales, Australia. For the group-experiment trial, a pair of participants was seated in low armchairs at a low table in the centre of a room and asked to work on a cooperative task for the duration of the experiment. The task was included in the experiment design to provide a cognitive load on the participants, intended to minimise their attention to the robot’s location and movement. The selected task was to complete a three-dimensional jigsaw puzzle. This task was chosen as it has a clear objective, is temporally demanding and does not require any turn-taking activity.

During the experiment, participants were seated in one of three maximally-different seating configurations, selected using Kendon’s [8] F-formation framework for analysing interactions between two or more people. An F-formation—or