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# Designing Robot Personalities for Human-Robot Symbiotic Interaction in an Educational Context

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**Abstract.** The Expressive Agents for Symbiotic Education and Learning project explores human-robot symbiotic interaction with the aim to understand the development of symbiosis over long-term tutoring interactions. The final EASEL system will be built upon the neurobiologically grounded architecture - Distributed Adaptive Control. In this paper, we present the design of an interaction scenario to support development of the DAC, in the context of a synthetic tutoring assistant. Our humanoid robot, capable of life-like simulated facial expressions, will interact with children in a public setting to teach them about exercise and energy. We discuss the range of measurements used to explore children's responses during, and experiences of, interaction with a social, expressive robot.

**Keywords:** human-robot interaction, humanoid, psychology, symbiosis, facial expression

## 1 Background

A key challenge in Human-Robot symbiotic interaction (HRSI) is to develop robots that can adapt to users during interactions. The Expressive Agents for Symbiotic Education and Learning (EASEL) project seeks to develop a biologically-grounded robot [9] that is responsive to users and capable of adaptation to user needs within, and across, interactions. One particular challenge for long-term or repeat human-robot interactions is maintaining successful social engagement with the user. A means to address this issue is ensuring the synthetic personality for a social robot is engaging and responsive to users [1]. A cornerstone of the EASEL project is the development of a synthetic personality for a social robot, which promotes *sustained* user engagement.

Robots that can effectively achieve the process of sustained social engagement and further act to positively shape user behavior (such as communicating to inform further user interactions) could be considered to behave symbiotically. HRSI extends beyond standard human-robot interaction by considering the: '[D]ynamic process of working towards a common goal by responding and adapting to a partners actions, while affording a partner to do the same. This term suggests a mutually beneficial relationship between various parties' [5]. The EASEL project explores HRSI in the context of one-to-one tutoring interactions between a socially-adaptive humanoid robot and children.

A tutoring scenario (described in section 2) gives context for the robot to adapt in *response* to a child's behaviour, updating its communication based on the developing interaction. The scenario also serves to direct children's interactions with the robot and gives goals for children to work in concert with the Synthetic Tutoring Assistant (STA). Effectiveness of the STA as an engaging personality, educational device, and model for an HRSI theoretical framework can be assessed through development of field interaction scenarios.

## 2 Field interaction scenario

### 2.1 The STA

The STA is to be developed upon the neurobiologically grounded architecture *Distributed Adaptive Control* (DAC) [9]. The DAC is a tiered, self-regulation system, structured to manage low- and high-level behaviours for synthetic agents, comprising: allostatic control, adaptation to sensory information, and the acquisition and expression of contextual plans. Behavioural outputs of the DAC are guided through synthetic motivation and emotion states. Behavioural interaction is scheduled using the AsapRealiser (e.g., [8]) interaction manager, which determines processing of sensory inputs to the robot and how content and feedback are delivered to the user.

This complete system is embodied in the Hanson Robokind Zeno R25 [7] (Figure 1). A distinctive feature of the Zeno model robot is the platform's realistic face, capable of displaying a range of life-like simulated facial expressions. This model enables the conveying of synthetic emotions from the DAC in immediately recognizable ways that are minimally obtrusive to ongoing interactions [6].

**Fig. 1.** The Robokind Zeno R25 platform (humanoid figure approximately 60cm tall)

### 2.2 Tutoring

HRSI between the user and STA will be explored in the context of a healthy-living tutoring scenario. Children will be invited to interact with the STA at a two-week special exhibit on robotics at a natural history museum.

The interaction comprises of four key stages. First, the robot briefly introduces itself and the activities for the interaction; in this period, the robot also calibrates its automatic speech recognition (ASR) to brief prompted responses from the child. Second, children engage in robot-led physical activities of different intensities and duration. After each activity, the robot provides responsive feedback about the energy used by the child to perform each action. Third, children complete a quiz based on their activity (i.e., which exercise used the most/least energy) and a similar quiz based on exercise and energy in general (i.e., identifying low- and high-energy activities). Finally, children can give Zeno voice commands to perform facial expressions or other physical actions. The interaction lasts approximately ten minutes in total.

The scenario will be delivered autonomously by the STA[1]. Development of the robot's personality is drawn from prior HRSI research to best ensure user engagement throughout the interaction. This includes regular confirmation from the robot that it is responsive to the *individual user* [4] and showing context-appropriate simulated facial expressions when delivering feedback [2]. Within the context of a tutoring scenario, supportive interactions, such as these, are anticipated to not just encourage interaction with the robot but also promote user engagement with the learning activity.

## 3 Exploring user engagement, learning, and HRSI

**User Engagement** with the scenario and the robot will be measured across multiple means, including: video recording, motion tracking, self-report and parental-report of child. User engagement will be examined using a between-subjects design. The standard scenario (section 2.2) will be contrasted against an 'enhanced' scenario, which includes a brief rapport-building introduction by the robot (experimental condition) or researcher (active-control condition). We anticipate that the rapport-building introduction by the robot will promote user engagement, particularly at the start of the interaction.

The interaction scenario will be filmed throughout and children's facial expressions coded, as done in a prior study [2]. Video data will be further used to determine children's gaze throughout interaction; our prior work indicates that children turn towards a socially-responsive robot, in anticipation of its speaking, more often than towards a less-responsive robot [4]. Children turning their attention towards parents or the researcher will be coded as measures of comfort seeking and clarity seeking respectively. Children looking towards the STA,

[1] Wizard of Oz style control is available should the ASR fail to adapt to an individual child's voice

particularly with positive facial expressions, rather than towards other figures, will be regarded as an indication of engagement with the STA.

Physical activity (in terms of joules) can be calculated automatically by the STA. This provides an additional measure of engagement; children more engaged in a prior scenario performed more physical activity at the robot's direction [4]. Interpersonal distance between the user and the robot during the physical activity will further be used as an index of social engagement with the robot: a smaller distance between user and robot indicating greater comfort in the interaction.

After the interaction, children will complete a brief survey on their affect felt when working with Zeno and their enjoyment of the scenario. Parents will also complete a brief survey on their views of their child's engagement and enjoyment of the scenario.

**User learning** will be examined using between-subjects design experiment. The standard scenario schedules general questions on the relationship between energy usage and both exercise intensity and duration *after* children have completed 1) physical activity of varying intensities and duration and 2) questions on their activity consolidating this relationship. Baseline measures of children's understanding of this relationship can be determined by scheduling the critical questions before the physical activity and consolidation questions. The number of questions answered correctly by children in each condition will be compared as a measure of learning.

The learning activity is more appropriate for seven-year-old children because it addresses topics covered in the UK National Curriculum for Lower Key Stage Two (ages seven to nine). We anticipate that the supportive social interaction and learning activity provided will provide scaffold for children to understand the relationship between exercise and energy. Given that the interaction is part of a public exhibit and open to all ages, a wide age range is anticipated in our data collection. Children's age will be co-varied in analysis to make account for children's prior education on the subject of exercise and energy.

**HRSI** development will be informed by the above factors. It will further be explored both in terms of children's perceptions of the robot and the individual differences in personality that may facilitate interaction. After interaction, children will complete a brief survey of their perceptions of Zeno's 'status' as being like a machine or person [3] and familiarity (i.e., like a stranger, acquaintance, friend, best friend). They further rate Zeno's 'knowledge' about exercise and skill at teaching. The above measures are anticipated to correlate with user engagement and user learning and further inform our understand of the *social context* that children use to understand HRSI (e.g., working with a teacher versus co-operation with a fellow friendly learner).

This study offers a potentially large-scale sample so that we may examine individual differences in personality and the impact this can have on children's perceptions of, and interaction with, a socially-responsive humanoid robot. Parents will complete a brief five-factor personality questionnaire about their child. We anticipate that openness and agreeableness will positively correlate with user engagement with the robot, conscientiousness with scenario engagement and learning, and extroversion with positive expression towards the robot.

This interaction scenario enables the further development of an engaging STA and extension of HRSI research, so that robot personalities can better adapt to user requirements throughout interaction and be tailored to meet individual needs.

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