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## **Revised Project Proposal: Emotional Referencing for the robot Leonardo**

I believe that one of the keys for designing systems that are deeply engaging for humans is to create systems that are themselves deeply engaged with humans. Many current robots and other interactive systems fail to be interesting because it's obvious that we don't matter to them - they see us as just another source of input instead of as thinking, acting, social partners. We can make robots more engaging by making humans important to them and to their understanding of the world. An important first step in this process is to design robots that attend to us and learn from us in some of the same ways that we attend to and learn from each other.

To this end, I propose to build support for emotional referencing into Leonardo, our interactive robot. Emotional referencing is the process by which humans, especially infants, learn an affective response to a novel object or situation by essentially borrowing the affective response of another person. Babies, for example, often learn how to react emotionally to a new object by looking at how their caregiver reacts to that object. Giving Leonardo this ability will create an important channel for emotional communication between the human and the robot. This project fits into a larger, ongoing effort to increase Leonardo's social understanding of objects: where people think they are, what people think they're useful for, how people feel about them, etc.

Adding emotional referencing to Leonardo will require the creation and integration of a number of new technologies that will be incorporated into the robot's existing behavior and motor control system. First, Leonardo will need to be able to perceive which object in the scene the person is attending to. Second, Leonardo will need to be able to measure the person's emotional reaction to the object - for this project, by recognizing their facial expression as one of a small set of emotional poses. Third, Leonardo will need to be able to attach this emotional information to his long-term, persistent model of the object. Finally, Leonardo will need to be able to use this emotional information to bias his interactions with the object. To be truly engaging, the emotional referencing must affect Leonardo's behavior in an important, easily readable way.

These new abilities will build on a large body of existing research by the Robotic Life group, especially research into new vision algorithms for the robot. My efforts for this project will revolve around refining and integrating existing work to build support for emotional referencing, and creating a compelling interaction with the robot involving emotional referencing.

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I'd like to update the proposal above with some additional specifics about the work that I'm currently engaged in, and where I see it ending up by the due date.

I am currently working on:

- developing a number of new input systems for Leonardo that will increase his ability to measure the human's attentional and emotional state. these include:
  - a system to identify which object in the scene the person is attending to. this will be based on an existing head pose tracker that we have tested, but have yet to integrate into the robot's perceptual pipeline.
  - a system for recognizing the human's emotional state from their facial expression. this will be based on an existing vision-based facial feature tracker.
  - a system for recognizing the human's emotional state from their vocal intonation. this will be based on an existing vocal pitch tracker.
- increasing Leonardo's ability to convey his emotional state through gestures and facial expressions. this will likely involve testing and calibrating some of Leonardo's facial motors, as well as testing out existing animated facial expressions on the real physical robot and modifying them as needed.

- developing a core emotional model for Leonardo. for the purposes of this project, the model will need to enable three important functions:
  - allowing Leo to map the human's perceived affective state into his own emotional space.
  - allowing Leo to attach the human's perceived appraisal of the various objects in the scene to his own long-term, persistent memories about the objects.
  - allowing Leo to use these remembered appraisals to bias his emotional signaling and overall behavior towards the objects in the scene.

integrating all of the above into a simple but interesting behavior-shaping interaction with the robot. i am envisioning a simple game in which there are a number of brightly colored toys in the space between the participant and Leonardo. Leonardo shifts his attention between the different toys, reacting to them in a way that reflects his appraisal of each object. the person's goal is to cause Leo to like some of the toys, and dislike others of them. the person can accomplish this by reacting to the various objects through their facial expressions and vocal intonation. in a successful interaction, Leo's assessments of the toys adjust to match the human's assessments. if there is time, i would love to bring in a number of participants and videotape them trying out this game in order to gauge the effectiveness of the emotional communication as well as the performance of the various new components of the system.