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On the Pertinence of Social Practices for Social Robotics

Aurélie CLODIC[a,1], Javier VAZQUEZ-SALCEDA[b], Frank DIGNUM[c], Samuel MASCARENHAS[d], Virginia DIGNUM[e], Agnese AUGELLO[f], Manuel GENTILE[g], Rachid ALAMI[a]

[a] *LAAS-CNRS, Université de Toulouse, CNRS, Toulouse, France*
[b] *Center for Intelligent Data Science and Artificial Intelligence (IDEAI), Universitat Politècnica de Catalunya-Barcelona TECH, Barcelona, Spain*
[c] *Utrecht University, Utrecht, The Netherlands*
[d] *INESC-ID, IST University of Lisbon, Lisbon, Portugal*
[e] *Delft University of Technology, Delft, The Netherlands*
[f] *Institute for high performance computing and networking (ICAR), CNR, Italy*
[g] *Institute for Educational Technology (ITD), CNR, Italy*

Abstract. In the area of consumer robots that need to have rich social interactions with humans, one of the challenges is the complexity of computing the appropriate interactions in a cognitive, social and physical context. We propose a novel approach for social robots based on the concept of Social Practices. By using social practices robots are able to be aware of their own social identities (given by the role in the social practice) and the identities of others and also be able to identify the different social contexts and the appropriate social interactions that go along with those contexts and identities.

Keywords. Social practices, social interaction, social robotics, human-robot interaction

1. Introduction

Understanding the impact of long term interactions between consumer robots and their users is currently a main barrier to the deployment of consumer robots. In particular, more knowledge is needed about the combined effect of cognitive, social and physical functionalities on long-term interactions in realistic social contexts. When designing social robots at this moment this problem is not very apparent because they are usually designed for a particular task for which the social context is clear and can be taken into account in the way the robot behaves. E.g. social robots that serve drinks at receptions. This situation does not necessitate the robot to remember persons beyond the present meeting and also its behavior towards each person is equal.

For situations where robots do have longer term interactions with users, they are usually restricted to a very particular domain and either are being completely controlled by the human or have fixed triggers from the environment on which they react. E.g. robots that are used in health care are mainly used to chat with and give comfort while they might have some sensing capacity to check the health of a patient. These robots do not change their relationship with a patient (also not over time).

[1] Aurélie Clodic, LAAS-CNRS, 7 avenue du Colonel Roche 31400 Toulouse, France. E-mail: aurelie.clodic@laas.fr

The main problem for more "open" contexts is the complexity and uncertainty of the interactions and the fact that social context is no longer fixed, but can change. It is almost impossible to pre-program all possible reactions of a robot for all possible situations (especially when trying to take into account the slowly changing social relation between the robot and the humans interacting with it regularly). People have managed this complexity for ages already. One of the ways to simplify social interactions is by standardizing them based on particular contexts. E.g. even though greetings have many variations, the patterns they follow are quite standard and used in some form all over the world. At the same time the variations within the physical actions that can be chosen have their own social effect. E.g. boxing a hand instead of shaking it signifies that we are in an informal setting and are peers in this context.

We chose the human use of social practices and its associated theory as a basis for modeling the interactions for social robots. Social practices describe physical and social patterns of joint action as routinely performed in society and provide expectations about the course of events and the roles that are played in the practice. At first instance, social practices can look very much like the frames introduced by M. Minsky in AI in [1]. However, these frames concentrate on a particular protocol that should be performed in a certain situation. If a party deviates from this protocol the frame fails and it is unclear what to do next. A social practice serves more as a combination of aspects like roles, plans, norms, resources, etc. that can be used to construct the interaction. It thus gives more freedom and possibilities to recover from failed expectations.

In the next section, we will explain a bit more about the background theory of social practices and its differences with other social constructs such as conventions, norms, etc. In the rest of this paper, we will show how social practices can structure human-robot interactions in a way that feels natural to people, would be able to ensure that robots are aware of their own social identities and the identities of others and also be able to identify the different social contexts and the appropriate social practices in those contexts.

2. Social Practices

Social practices are accepted ways of doing things, contextually and materially mediated, that are shared between actors and routinized over time [2]. They can be seen as patterns which can be filled in by a multitude of single and often unique actions. Through (joint) performance, the patterns provided by the practice are filled out and reproduced.

In Social Sciences, *social practices* (SP) are defined on the basis of materials, meanings and competences [3].

- **Material**: covers all physical aspects of the performance of a practice, including the human body (relates to physical aspects of a situation)
- **Meaning**: refers to the issues which are considered to be relevant with respect to that material, i.e. understandings, beliefs and emotions (relates to social aspects of a situation)
- **Competence**: refers to skills and knowledge which are required to perform the practice (relates to the notion of deliberation about a situation)

These components are combined by individuals when carrying out a practice. Each individual embeds and evolves (through conditioning) meaning and competence, and adopts material according to its motives, identities, capabilities, emotions, and so forth,

such that it implements a practice. Individuals and societies typically evolve a collection of practices over time that can be applied in different situations. Moreover, depending on the situation, the personality and the skills of an individual, carrying out a practice will be a more automatic or a more deliberated process. E.g. a greeting might be an automatic quick handshake in a familiar environment, while the greeting has to be more deliberate at the start of an international negotiation meeting.

Each time it is used, elements of the practice, including know-how, meanings and purposes, are reconfigured and adapted [4]. Therefore the use of social practices includes a constant learning of the individuals in ever changing contexts. In this way, social practices guide the learning process of agents in a natural way. In [4] the social aspect of social practices is emphasized by giving the social practice center stage in interactions and letting individuals be supporters of the social practice. It shows that social practices are shared (social) concepts. The mere fact that they are shared and jointly created and maintained means that individuals playing a role in a social practice will expect certain behavior and reactions of the other participants in the social practice. Thus it is this aspect that makes the social practices so suitable for use in individual planning in social situations.

Practices structure situations, incorporating both the physical and social aspects and the connected knowledge and expectations. Practices are more flexible than the classical frames in that they can be extended and changed by learning and the "slots" only need to be filled in as far as they are needed to determine a course of action. Using these structures changes planning in many common situations to pattern recognition and filling in parameters. Of course in practice it is more than just this, but it gives some handles to reduce the search space.

2.1. Social practice in operation

Although social practices provide a handle for modeling the deliberation of social robots because they seem to combine the elements that we require for socially intelligent behavior, they are a relatively novel and vaguely defined concept from sociology that cannot be just applied in robot systems. Thus based on these ideas, a model was developed to represent social practices that can be used in social deliberation by intelligent agents and robots [5, 6]. Obviously, as it is the case with e.g. the representation and use of norms, other representations of social practices are possible given the many dimensions of the use of social practices. Our proposal is especially suitable for use in social robotics. It is illustrated in Table 1, using a scenario for a social robot assisting in a class room.

Let us consider a small shop keeping scenario that we envision to take place in the context of a classroom where children learn how to do some shopping. In this scenario a child plays the role of the customer and the robot plays the role of the shopkeeper (but we should be able to handle the other way around). The setting is a shop with some tangible products. For each product there is a price tag. The customer has a bag, cart, or other clear container to store products that he wants to buy (or has bought). Table 1 describes this practice in an informal way. More about the social practice specification and its formalization can be found in [5, 6]. This social practice is nested in the overall classroom social practice.

The ***Context*** part describes elements that can be recognized in the environment and often trigger the use of the social practice. Elements like *resources* and *actors* determine the availability of people and objects to perform certain actions within this practice. The ***Activities*** part of the table describes the actions that are available and which

actor can perform each action. Thus this part limits the expected events during the practice.

Table 1. Informal shop keeping scenario, social practice description .

Context	
Actors	The child and the robot
Roles	Customer and shopkeeper
Resources	Products in the shop, counter, cash register, money
Positions	Shopkeeper behind the counter, customer in front of it
Activities	
Basic actions	Pick-up-product, put-product, … (joint plans are built using these actions)
Capabilities	The customer can pay, pick-up products, etc. The shopkeeper can answer questions
General preconditions	The customer wants to buy a product and the shopkeeper sells it
Meanings	
Purpose	E.g. the customer gives money to pay for a product it wants
Promote	Indicates that in the context of this social practice, an action α promotes value v. E.g. paying promotes fairness.
Counts-as	Indicates that within this social practice executing action α is seen as performing β. E.g. handing money counts-as paying (but handing a credit card can also count as paying)
Expectations	
Plan pattern	The customer enters, finds products, puts them together in a basket, pays and leaves the shop
Norms	There are obligations and prohibitions. E.g. the customer has to pay before leaving
Triggers	E.g. a question to explain something is followed by an explanation
Start Condition	E.g. the customer has money to pay
Duration	Expected durations of actions and plans (some actions may have no expected duration)

The ***Meanings*** part is limited in our model to some elements that can be practically used by the robot to reason about the current situation and how well the practice contributes to the goals and relations of the robot. Thus the *counts-as* element indicates the social meaning of actions performed in this context and the *promote* element indicates which values are promoted by (parts of) the practice. This facilitates the development of value base robots that also have social awareness over the long term.

Finally, the ***Expectations*** part is a very prominent part of the social practice model as it describes what kind of actions and events are expected at each time during the performance of the social practice. Expectations come in different forms. The *plan patterns* are the kernel of the social practice, indicating the possible action sequences of which the social practice is build. Besides this concrete expectation of actions there are also expectations about norms that are followed such as the payment in the example. In general *norms* are used when actions have to be performed or are forbidden whenever a condition becomes true. Thus these actions can occur at many possible times. At the same time describing them as norms also gives the possibility to specify what should be done when the norm is violated. *Triggers* are similar to norms, but do not have the moral connotation. These patterns just happen to occur whenever a *start condition* becomes true during the practice and thus deserve a special status.

In the next section we will briefly sketch how a novel architecture for social robots could make optimal use of social practices to support several vital elements of the human-robot interaction (using the above scenario).

3. Social Practice aware Accountable Responsible and Transparent Robot Architecture (SPART-RA)

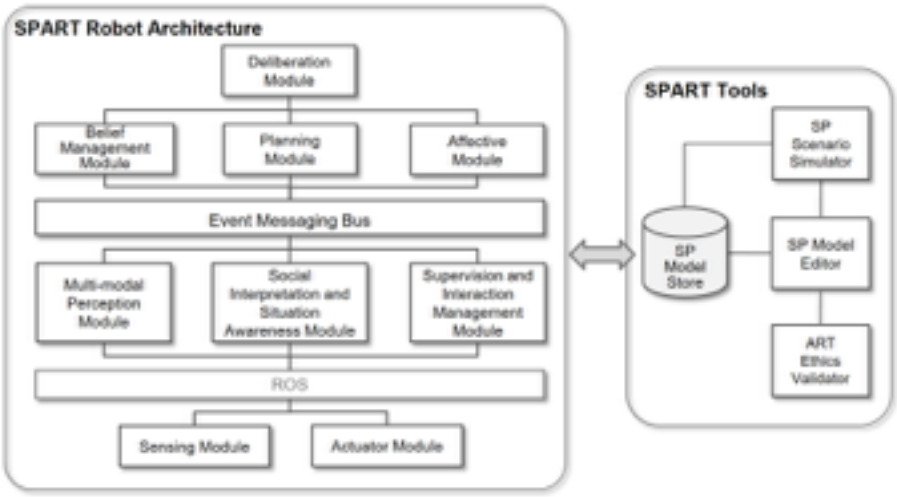

Figure 1. SPART-RA Architecture and SPART Tools.

Our aim is to incorporate Social Practices into social robotic architectures to make robots fully socially-aware (aware of the social context) of the social role(s) the robot and humans are playing, recognize the social protocols and use them appropriately. We propose to create an operational model of social practices and to specify a **Social Practice aware Accountable Responsible and Transparent Robot Architecture (SPART-RA)** that utilizes the model to frame the social interactions that the robot participates. This is for now a **conceptual** architecture that has not yet been implemented as such but we will see in each module description that some elements are already existing and how we propose to build upon them.

This architecture is designed to achieve the following objectives (fulfilled by the elements in italic):

- Provide the capacity for the robot to have different beliefs in accordance to the social roles it is enacting (*Belief Management Module)*
- Implement social practice based deliberation that also includes meta-cognition to guide perception, planning and execution of actions (*Deliberation, Planning and Supervision and Interaction Management Modules*)
- Implement an affective module that uses social practice based expectations to monitor, interpret and cope with affective interactions (*Affective Module*)
- Create a complete formal specification for social practices to create unambiguous and precise specifications and possibilities for re-use (*SP models* created and maintained through the *SPART tools*)
- To enhance existing modules of robots by relying on social practices, to make them context sensitive and also more efficient, flexible and robust in those contexts (*Social Interpretation and Situation Awareness Module and Multi-Modal Perception Module*)

The proposed architecture is designed as a parallel architecture in which the different modules concur to the identification of a practice and then to its implementation and monitoring. In the following sections, we present the models underlying the SPART-RA and then the modules and how the formalization of the practice is used by each of them.

At this point, it has to be noticed that from a philosophical point of view, we have been taught that some philosophers such as Seibt [7] stressed that the robotics intentionalist vocabulary that we use is considered as problematic especially when robots are place in social interaction spaces. In the following, we will use this intentionalist vocabulary in order to describe the functionalities of the robot, such as 'believe', 'answers' etc. because this is the way we describe our work in robotics and AI communities. However, to accommodate the philosophical concern, we would like to note that this can be considered as shorthand for 'the robot simulates the belief', 'the robot simulates an answer' etc. Thus whenever robotic behavior is described with a verb that normally characterizes a human action, these passages can be read as a reference to the robot's simulation of the relevant action.

3.1. SP Models

Social practices will embed societal and moral values which must be understood by the robot in order to ensure that actions and plans follow the ethical standards of the society. The SPART-RA will be based on these two key aspects: Social Practices and Ethics and Moral values that should be modeled.

First, a Social Practices model (SP Model) is needed, i.e. a computational model to express expected behaviors, perceptions and interpretations in a given social (sub)context. The model, should be defined formally in order to provide precise and unambiguous information about the (social) context used by the *SPART-RA Modules* (e.g., for inferring the current active social practices from the observed behavior of other actors). To do so, it should embed declarative and procedural knowledge necessary for the agent/robot to act in a socially effective manner in a specific scenario. SP Models will be created through the *SP Model Editor* tool, and could be tested in a *SP Scenario Sim-*

ulator before being tested in robots. All *SPART-RA Modules* will be able to retrieve the relevant SP Models from the *SP Model Store*.

Then, we aim to develop a mechanism to incorporate ethics and moral values in the robot deliberation process. Following ART principles (Accountability, Responsibility and Transparency), we will need a computational representation language to specify, reason about and validate values and ethical consequences of actions and plans. This will be further explained in [8], where we discuss how the proposed model and architecture address ethical issues both from a design and implementation point of views. SP Models will be evaluated according to ART principles by an *ART Ethics Validator* tool.

3.2. SPART-RA Modules

3.2.1. Multi-Modal Perception Module

This module will be responsible for providing sensing abilities to the architecture, that is the ability to monitor its environment on the base of the expected events. The expectations provided by the social practices regarding the course of events and the roles that are played in a practice will allow the robot to filter its perceptions for those elements that are meaningful for a particular social context. From the technical point of view, let us consider that the module will have a set of basic features (e.g., object detection/recognition, face detection/recognition) as well as more interactive ones (e.g., look at/identify/recognize somebody in the scene, recognize basic orders) and that it will be possible to combine these algorithms (multimodality). To benefit from social practice(s), it will be needed to extract possible tuning (through parameters or costs). For example: at perception level, we should be able to tune the face recognition algorithm to look only to the one involved in the social practice(s) (almost at first). In addition, if we consider nested social practices as the shopping example nested in the behaving in the classroom one, we should be able to determine on one side who is who in the shopping setup and on the other side who is who in the classroom setup. This idea to excerpt "social" tuning abilities at such low level of an architecture is quite new. This module will work in close collaboration with the *Situation Awareness Module*.

3.2.2. Social Interpretation and Situation Awareness Module

This module will have the responsibility to interpret the situation, i.e. extract the social meaning of verbal and non-verbal interactions (such as face expressions, eye gaze, postures and gestures) to interpret what the user is doing and what happens in the scene. The social practice will allow for the interpretation of signs in the specific socio-cultural context. For example, in our shopping scenario actors should not speak while one of them is speaking. It will also target the development of ad-hoc perception-interpretation abilities given the social practice(s) we are playing with: e.g., if the shopkeeper is looking at me, he is available to answer my question; if the shopkeeper is already speaking, he is busy. We can exploit some existing components to achieve this. The first one relies on a classifier trained on a dataset of human postures and gestures [9], annotated according to their meaning and pertinence inside the different practices. The classifier processes the sequence of postures provided by the *Perception Module* to detect what is the intended user's action [9]. Another classifier trained on a proper lexicon can be used to detect the presence of sentiment/emotion in the verbal interaction [9]. All the processed information will feed both the agent belief models (see *Belief Management Module* and *Affective Module*) and would take into account the timing of the scene.

3.2.3. Belief Management Module

This module will be responsible for managing the robot's knowledge about itself and about the agent(s) it interacts with in accordance with the running social practice(s). The module will use the interpreted perceptions to detect when a particular social practice has begun, creating a new instance of it, and when it is terminated. The module will provide information about ongoing practices to the other modules, which includes the different roles that are involved in the active social practices, as well as social expectations about different actions and their associated ethical values and decision making parameters. This module will also maintain a model of the world for each of the agents and for each of their role(s) in the practices. To achieve its purpose, this module will contain two important knowledge structures. The first is a knowledge base that stores the robot's current beliefs about itself, others, and any object or concepts that exist in its environment. This beliefs will be kept as key-value pairs with a degree of certainty associated. They will be then updated according to the changes in the environment or changes in the social context that will trigger an interpretation shift. The second structure is an Autobiographical Memory that will have the responsibility of storing episodic information. More precisely, it will keep track of the events that happened in the past along with contextual information, including the social practice(s) that were active and the participants that were present.

3.2.4.Affective Module

This module will be responsible for creating an internal affective state for the robot. Several approaches have been followed to manage and show the emotional state of multimodal agents/robots [10, 11]. Similarly, this *Affective Module* will be focused on enabling the robot to detect emotional signals and to respond in a manner that conveys empathy. We can use an appraisal-based model of emotion, such as FAtiMA [12], which makes a series of value judgments about events like "Was it desirable for my goals?" or "Did it violate a norm?" in order to generate an emotion in the robot. Then, by applying the same judgments but from the perspective of others, the *Affective Module* will be able to predict what others are feeling. The accuracy of these predictions will be also increased by using the information obtained by the *Social Interpretation and Situation Awareness Module*. There are various benefits of adding the concept of social practices to an affective module. Firstly, by knowing which social practice is currently taking place, the module will know which norms it should pay attention to. Secondly, when an affective expression like a smile occurs, the module will be able to analyze the plan pattern of the social practice to see if it entails the performance of that expression. If that is the case, the robot will be less likely to assume that the person is genuinely feeling the associated emotion. On the other hand, when the smile occurs outside of the social practice's expectations, the robot will be more confident in assuming that the target person is happy. Finally, as social practices encode what is to be expected in a social context, it would also be used to determine how unexpected a given action is. Such metric is essential for generating the emotion of surprise as well as adding to the intensity of any other emotions. Consequentially, the emotional state of the robot would be more easily managed by adopting a social practice approach. The analysis of the interaction according to a proper formalization of the robot's expectations in a practice, will allow for an indirect induction of the robot's affective state, by avoiding to explicitly annotate all the possible actions and events.

3.2.5.Planning Module

This module will deliver a plan (or a combination of plans) taking into account Social Practices models and Ethics Rules. It should be able to take into account possible user preferences regarding a particular social practice(s) and social rules (which could lead to some plans that could be more or less desirable). It will use the information given by the *Belief Management Module* and the *Affective module*. It will be called by the *Deliberation Module* and *Supervision Module* that will then use the plan. It could be possibly a multi-level plan regarding the different roles that will be played by the agent at a given moment (and the given social practice(s) running): e.g. at Shopping scenario level, the robot and the children involved will have a particular role (as shopkeeper on one side and customer on the other side) and a particular goal (e.g. customer buys two products) and a given plan to achieve it. A planner such HATP (Human Aware Task Planner [13, 14, 15]) can be used and improved to satisfy these requirements. It already allows to propose a plan for several actors, at several levels of granularity (given it is HTN based) and taken into account costs and social rules.

3.2.6.Deliberation Module

This module will be responsible for the high level deliberation, allowing the robot to reason about its overall status. To do so, the idea is that the module compares the current situation with the social practice(s) that is currently being executed or that could be started (i.e. not a purely reactive mode (reacting to incoming events) nor a pro-active mode (just pursuing a goal until it is achieved or unachievable)). If a social practice is being executed and is running as expected it is continued. If deviations are discovered a reconsideration takes place and possibly a new practice or plan is followed. In every choice the consequences of the choice will be checked for ethical implications. It will implement the ethical reasoning framework and the explanation framework (cf. [8]) and when appropriate, will produce an explanation. However, social practices are assumed to be ethical and thus the amount of check points will be limited. The *Planning Module*, and the current affective state (provided by the *Affective Module)* will be used to guide the robot in choices within a social practice or when no social practice applied to the situation. Based on that deliberation, the *Deliberation Module* will be able to interrupt the current activities by alerting the *Supervision Module*. It will connect to the *Planning Module* to get alternative plans.

3.2.7.Supervision and Interaction Management Module

This module will be in charge of the supervision and interaction management to deal with joint action execution of a plan (*Planning module*) regarding relevant social practice model and ethical rules. It will work in close relationship with the *Deliberation Module* which would be able to interrupt its execution on demand with an explanation about the reason of this interruption and/or an alternative plan to pursue the goal. It will use the information given by the *Social Interpretation* and *Situation Awareness Module and Belief Management module*. The given plan should be adapted for execution regarding the running social practice(s) and ethical constraints (e.g. I do not interrupt somebody, I do not speak too loud in a classroom, I do not interrupt a running transaction, …). The supervision system should be able to tune actions or skills given a particular social practice(s), e.g. to give a product to the customer, I will take care to place it on the desk with the label visible (which would be a specialization of the "put"). The supervision system will also be in charge of the monitoring of the task (e.g. does the other agent follow the plan) and consequently will be able to give information whether

the chosen social practice(s) is(are) well adapted or not to the current context. For example, there is a number of rules that need to be followed in a shop (e.g. do not take all the items, do not break items, have enough money to pay). We have already envisioned joint action execution [16], and realized several implementations [15, 17, 18]. We have also worked on the purpose of interleaving (or mixing) communication and action through multi-modality [19]. Social practices will bring a new dimension to this work.

4. Discussion and Conclusion

In this paper we present the SPART reference architecture for social robots, a conceptual architecture which is based on the use of social practices to guide human-robot interactions in social setups. Social practices describe physical and social patterns of joint action as routinely performed in society and provide expectations about the course of events and the roles that are played in the practice. This architecture will bring several advantages in at least three areas: the robot's *social awareness*, its *social interaction skills* and *affective management*.

Social awareness will be improved by the use of electronic models of social practices, which will enable the robot to be aware of its role and relation to other parties, reasoning about the context and models of others and monitoring these elements. Roboticists have developed a number of components to take the human into account when sensing and acting. All these components help the robot to get situation and human-awareness of the context and to act jointly with the human it interacts with. Some research specifically focused on how robots should behave socially in interaction with humans is shown in [20, 21, 22, 23, 24]. However, most of the social aspects handled by these robots are encoded in the task itself and they do not exhibit a framework to handle a diversity of tasks in a diversity of (social) contexts. A relevant enhancement in our approach is that social practices will allow the robot not only to monitor its environment on the basis of the expected events of the social practice but also filter or prioritize its perceptions for those elements that are meaningful for a particular social context.

The robots' *interaction skills* will be also improved thanks to modules that will be enhanced to effectively use social practices. As our model of social practices will link the actions to the social effects, it will enable to make the robot socially aware and choose the most socially appropriate action at each stage in a practice. For instance, an enhanced robot's behavior-selection module will be able to use social practices to promote the behavioral patterns that are best suited for a given social context. In an interaction setting, social structures typically include interactions not only with the other actor(s) but also with the environment, the context and social facts. Existing approaches (i.e., multi-modal approaches, formal models, mark-up languages) generally use mental or interaction models as the "place" of these social structures. It leads to a high complexity to manage their entangled nature. Using social practice models, we think that our approach will be more expressive and flexible to deal with these social structures. Interactions will be more robust, because the robot will have an explicit context that will be used to recover from failures and unexpected events. Furthermore, the social practice will provide a basis for explanation of the robot's behavior. From the users' perspective, social-aware robots will be perceived as more socially realistic.

Finally, our architecture will provide a way to enhance *affective management*. On one side, social practices will improve the recognition of the humans' affective state by comparing the facial and body expressions perceived with the ones expected in the current situation according to the social practice. Social practices will provide contex-

tual cues tied to the nature of the social interaction itself and that can help the robot to, e.g., focus only on the detection of those cues that are relevant for the current social interaction. On the other side, the analysis of the current interaction according to a proper formalization of the robot's expectations in a practice, will allow for an indirect induction of the robot's affective state, and the generation of some affective responses (for instance, surprise or worry when current interaction is highly deviating from the expected one).

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