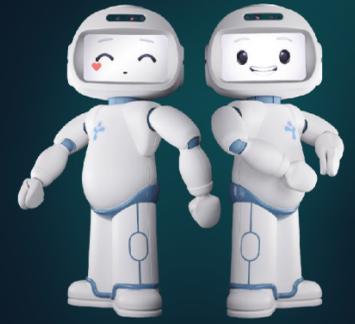


Information-First Design for Usable and Acceptable Social Robots:

Lessons from Dentistry

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social robots human-robot interaction dentistry healthcare robotics privacy trust cybersecurity



QRobot · LuxAI

Background

Social robots are increasingly proposed as affective support tools in healthcare, yet adoption is limited by poor contextual fit, unclear clinical value, and unresolved concerns around **privacy, trust, and security**. We argue that designing useful and acceptable social robots requires a shift from generic affect detection to context-sensitive, phase-aware, and privacy-minimal information collection.

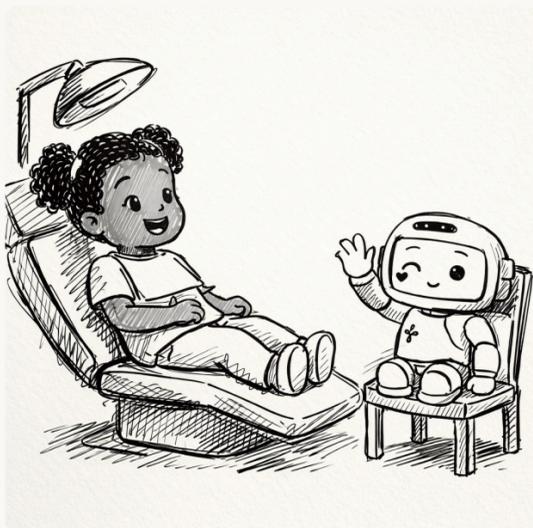
Why Dentistry?

Dentistry is a uniquely demanding HRI testbed: patients are conscious, physically constrained, often anxious, exposed to aversive sensory stimuli, and must make real-time consent decisions under stress — while clinicians manage high-stakes environments requiring speed and precision with no margin for distraction.

If a robot can operate safely and acceptably here, it is likely to function under less restrictive circumstances elsewhere — making dentistry a maximal-demand testbed for social robotics.

Dentistry as HRI Environment

- Constrained Communication**
Patients often cannot speak — non-verbal cues dominate interaction.
- High Affective Load**
Anxiety, fear, and pain anticipation fluctuate rapidly during procedures.
- Tight Spatial Choreography**
Narrow shared workspace with strict infection-control requirements.
- Real-Time Consent Under Stress**
Treatment decisions occur during heightened vulnerability.
- Strong Privacy Expectations**
Sensitive health data, intimate proximity, implicit trust.



Information Management Framework

Rather than treating data collection as an implementation detail, we frame it as a central design problem — structured around four elements:

① INTERACTION SIGNALS

Anxiety emerges as dynamic patterns — posture shifts, breath changes, micro-movements, hesitations, sudden stillness. Meaningful only when interpreted in context.

② PHASE AWARENESS

Distinct phases: arrival, settling, injection, active treatment, debrief. Robot behaviour must align temporally with clinical workflow.

③ WORKFLOW CONSTRAINTS

Spatial layout, sound peaks, staff movement — essential to prevent harm and disruption, not to optimise robot intelligence.

④ SECURITY & PRIVACY

Focus must shift from securing robots to constraining what information they are *allowed* to collect in the first place.

Key Interaction Signals

Moment-to-moment indicators of interactional strain — essential for helpful rather than disruptive intervention:

- Sudden muscle tension or physical withdrawal
- Changes in breathing rhythm and rate
- Repeated clarification requests or hesitation at consent points
- Non-verbal stop-signals when speech is impossible

The Central Question

"What information must a social robot collect in order to be helpful rather than disruptive — and how should that be constrained to remain acceptable to users?"

Broader Implications

Dentistry's constraints mirror many healthcare and consumer contexts with heightened affect, constrained interaction, and strong trust expectations. The tensions between relational continuity and data minimisation are fundamental design considerations, not technical problems.

*Our analysis shifts focus from **social expressiveness** to **selective, context-aware information use** — a principle that generalises well beyond oral healthcare.*

Security & Privacy by Design

Social robots in dentistry are simultaneously *social actors, clinical tools, and data-collecting systems*, creating tensions that require proactive governance from the outset.

APPLICABLE CYBERSECURITY FRAMEWORKS

ISO/IEC 27005 NIST CSF MITRE ATT&CK
 Cyber Kill Chain Diamond Model

PRIVACY BY DESIGN — USER ACCEPTANCE REQUIRES:

- 1 **Transparency** about what is sensed and why
- 2 **Tiered and revisable consent** mechanisms
- 3 **Minimal data capture** aligned with immediate purpose
- 4 **Strong security** without burdensome authentication

Conclusion

Designing useful and acceptable social robots for dentistry requires careful attention to **information ecology**, not just interaction design. By identifying the minimum necessary information for affective support in a high-intensity clinical environment, dentistry offers a powerful lens for advancing **socially responsible, trustworthy consumer robotics**.

This work-in-progress is intended to provoke discussion and invite interdisciplinary perspectives on designing social robots for environments where emotional vulnerability, clinical precision, and data sensitivity intersect.

