When Anne met Sally: Formalising the Sally-Anne test in Dynamic Epistemic Logic

Thomas Bolander, DTU Compute, Technical University of Denmark
ILLC, Amsterdam, 5 Dec 2013
Theory of Mind (ToM): The ability of attributing mental states—beliefs, intentions, desires, etc.—to other agents.

Having a ToM is essential for successful social interaction in humans (Baron-Cohen, 1997).

The presence of a ToM in children is often tested through false-belief tasks, e.g. the Sally-Anne test.
**Goal of the present work**

**Goal**: To formalise the Sally-Anne task in Dynamic Epistemic Logic (DEL).
Goal of the present work

Goal: To formalise the Sally-Anne task in Dynamic Epistemic Logic (DEL).

But why?
Goal of the present work

Goal: To formalise the Sally-Anne task in Dynamic Epistemic Logic (DEL).

But why?

Three uses of logical formalisations of epistemic reasoning:

1. Specification, analysis and verification of agent systems (e.g. computer systems or security protocols).
2. Basis for reasoning engine of autonomous agents.
3. Providing formal models of human reasoning.

My focus is on 2. My ultimate aim is to construct planning agents (e.g. robots) with ToM capabilities. Trying to find out what it takes for a computer or robot to pass the Sally-Anne test is a good test case for this research aim.
Dynamic Epistemic Logic (DEL) by example

We use the **event models** of DEL [Baltag *et al.*, 1998] with added postconditions (ontic actions) as in [Ditmarsch *et al.*, 2008].
Dynamic Epistemic Logic (DEL) by example

We use the **event models** of DEL [Baltag et al., 1998] with added postconditions (ontic actions) as in [Ditmarsch et al., 2008].

**Example.** A hidden coin flip:

\[
i, u \\
\quad \text{black}
\]

- **Epistemic models:** Multi-agent $K$ models. Elements of domain called **worlds**. Actual world is colored green (●).
Dynamic Epistemic Logic (DEL) by example

We use the **event models** of DEL [Baltag *et al.*, 1998] with added postconditions (ontic actions) as in [Ditmarsch *et al.*, 2008].

**Example.** A hidden coin flip:

- **Epistemic models**: Multi-agent $K$ models. Elements of domain called **worlds**. Actual world is colored green ($\blacklozenge$).
- **Event model**: Represent the action of the hidden coin flip.
Dynamic Epistemic Logic (DEL) by example

We use the event models of DEL [Baltag et al., 1998] with added postconditions (ontic actions) as in [Ditmarsch et al., 2008].

Example. A hidden coin flip:

- **Epistemic models**: Multi-agent $K$ models. Elements of domain called worlds. Actual world is colored green (●).
- **Event model**: Represent the action of the hidden coin flip.
- **Product update**: The updated model represents the situation after the action has taken place.
ToM and no-ToM agents

- **ToM agent**: An agent with the ability of attributing mental states (beliefs, intentions, etc.) to other agents.
ToM and no-ToM agents

- **ToM agent**: An agent with the ability of attributing mental states (beliefs, intentions, etc.) to other agents.
- **No-ToM agent**: Agent without this ability. Could mean any of the following:
  1. The agent's model of the world only contains ontic facts, that is, is a 0th-order model.
  2. The agent's model of the world is a full epistemic model, but only the agent itself is represented in that model. So the agent can introspectively reason about her own knowledge, beliefs and ignorance, but not about the other agents' propositional attitudes.
  3. The agent's model of the world is a full multi-agent epistemic model, but the agent thinks that all other agents have the same model as herself. This is the “my preferences” type of agent that is introduced in [van Ditmarsch & Labuschagne, 2007].

2 and 3 are essentially equivalent—and both more expressive than 1. For technical reasons, we choose to consider no-ToM agents as agents of type 3.
ToM and no-ToM agents

- **ToM agent**: An agent with the ability of attributing mental states (beliefs, intentions, etc.) to other agents.

- **No-ToM agent**: Agent without this ability. Could mean any of the following:
  1. The agent’s model of the world only contain ontic facts, that is, is a 0th-order model.
ToM and no-ToM agents

- **ToM agent**: An agent with the ability of attributing mental states (beliefs, intentions, etc.) to other agents.
- **No-ToM agent**: Agent without this ability. Could mean any of the following:
  1. The agent’s model of the world only contain ontic facts, that is, is a 0th-order model.
  2. The agent’s model of the world is a full epistemic model, but only the agent itself is represented in that model. So the agent can introspectively reason about her own knowledge, beliefs and ignorance, but not about the other agents’ propositional attitudes.
ToM and no-ToM agents

- **ToM agent**: An agent with the ability of attributing mental states (beliefs, intentions, etc.) to other agents.
- **No-ToM agent**: Agent without this ability. Could mean any of the following:
  1. The agent’s model of the world only contain ontic facts, that is, is a 0th-order model.
  2. The agent’s model of the world is a full epistemic model, but only the agent itself is represented in that model. So the agent can introspectively reason about her own knowledge, beliefs and ignorance, but not about the other agents’ propositional attitudes.
  3. The agent's model of the world is a full multi-agent epistemic model, but the agent thinks that all other agents have the same model as herself. This is the “my preferences” type of agent that is introduced in [van Ditmarsch & Labuschagne, 2007].
ToM and no-ToM agents

- **ToM agent**: An agent with the ability of attributing mental states (beliefs, intentions, etc.) to other agents.

- **No-ToM agent**: Agent without this ability. Could mean any of the following:
  1. The agent’s model of the world only contain ontic facts, that is, is a 0th-order model.
  2. The agent’s model of the world is a full epistemic model, but only the agent itself is represented in that model. So the agent can introspectively reason about her own knowledge, beliefs and ignorance, but not about the other agents’ propositional attitudes.
  3. The agent’s model of the world is a full multi-agent epistemic model, but the agent thinks that all other agents have the same model as herself. This is the “my preferences” type of agent that is introduced in [van Ditmarsch & Labuschagne, 2007].
ToM and no-ToM agents

- **ToM agent**: An agent with the ability of attributing mental states (beliefs, intentions, etc.) to other agents.

- **No-ToM agent**: Agent without this ability. Could mean any of the following:
  1. The agent’s model of the world only contain ontic facts, that is, is a 0th-order model.
  2. The agent’s model of the world is a full epistemic model, but only the agent itself is represented in that model. So the agent can introspectively reason about her own knowledge, beliefs and ignorance, but not about the other agents’ propositional attitudes.
  3. The agent’s model of the world is a full multi-agent epistemic model, but the agent thinks that all other agents have the same model as herself. This is the “my preferences” type of agent that is introduced in [van Ditmarsch & Labuschagne, 2007].

2 and 3 are essentially equivalent—and both more expressive than 1. For technical reasons, we choose to consider no-ToM agents as agents of type 3.
Our version of Sally-Anne

The Sally-Anne test exists in many variants [Wellman et al., 2001]. We use the version where the observer (child) is asked:

“Where does Sally think the cube is?”.
Our version of Sally-Anne

The Sally-Anne test exists in many variants [Wellman et al., 2001]. We use the version where the observer (child) is asked:

“Where does Sally think the cube is?”.

We will interpret this as meaning:

“Where does Sally believe the cube to be?”
Sally-Anne for No-ToM agents

0. Initial state:
Sally-Anne for No-ToM agents

1. Sally places cube in large container:
Sally-Anne for No-ToM agents

2. Sally leaves the room:
Sally-Anne for No-ToM agents

3. Anne transfers cube to small container:
Sally-Anne for No-ToM agents

4. Sally re-enters:
Constants of modelling language

In the following we will use the following agent symbols:

- $O$: The Observer (the child/agent taking the Sally-Anne test).
- $S$: Sally.
- $A$: Anne.

We will use the following propositional symbols:

- $\text{large}$: The cube is in the large container.
- $\text{small}$: The cube is in the small container.
- $\text{sally}$: Sally is present in the room with Anne and the observer.

In epistemic models, we will use green nodes ($\bullet$) to denote the actual world.
0. Initial state:

\[ s_0 = \square^{O, S, A} sally \]
Modelling the No-ToM agent in DEL

1. Sally places cube in large container:

\[ s_0 = (O, S, A) \text{sally} \]

\[ a_1 = (O, S, A) \langle \neg small \land \neg large, large \rangle \]
1. Sally places cube in large container:

\[ s_0 = \bigcirc_{O, S, A} sally \]

\[ a_1 = \bigcirc_{O, S, A} (\neg small \land \neg large, large) \]

\[ s_1 = s_0 \otimes a_1 = \bigcirc_{O, S, A} large, sally \]
Modelling the No-ToM agent in DEL

2. Sally leaves the room:

\[ s_0 = \text{\textcolor{green}{$\circlearrowright O, S, A$}} \text{sally} \]

\[ a_1 = \text{\textcolor{green}{$\circlearrowright O, S, A$}} \langle \neg \text{small} \land \neg \text{large}, \text{large} \rangle \]

\[ s_1 = s_0 \otimes a_1 = \text{\textcolor{green}{$\circlearrowright O, S, A$}} \text{large, sally} \]

\[ a_2 = \text{\textcolor{green}{$\circlearrowright O, S, A$}} \langle \text{sally}, \neg \text{sally} \rangle \]
2. Sally leaves the room:

\[ s_0 = O, S, A \]
\[ a_1 = O, S, A \left\langle \neg small \land \neg large, large \right\rangle \]
\[ s_1 = s_0 \otimes a_1 = O, S, A large, sally \]
\[ a_2 = O, S, A \left\langle sally, \neg sally \right\rangle \]
\[ s_2 = s_1 \otimes a_2 = O, S, A large \]
Modelling the No-ToM agent in DEL

3. Anne transfers cube to small container:

\[ s_0 = \{O, S, A\} \]
\[ a_1 = \langle \neg \text{small} \land \neg \text{large}, \text{large} \rangle \]
\[ s_1 = s_0 \otimes a_1 = \{O, S, A\} \]
\[ a_2 = \langle O, S, A \rangle \]
\[ s_2 = s_1 \otimes a_2 = \{O, S, A\} \]
\[ a_3 = \langle O, S, A \rangle \]
\[ s_3 = s_2 \otimes a_3 = \{O, S, A\} \]
Modelling the No-ToM agent in DEL

3. Anne transfers cube to small container:

\[ s_0 = \bigcirc^{O,S,A}_{sally} \]

\[ a_1 = \bigcirc^{O,S,A}_{\langle \neg \text{small} \land \neg \text{large}, \text{large} \rangle} \]

\[ s_1 = s_0 \otimes a_1 = \bigcirc^{O,S,A}_{\text{large}, \text{sally}} \]

\[ a_2 = \bigcirc^{O,S,A}_{\langle \text{sally}, \neg \text{sally} \rangle} \]

\[ s_2 = s_1 \otimes a_2 = \bigcirc^{O,S,A}_{\text{large}} \]

\[ a_3 = \bigcirc^{O,S,A}_{\langle \text{large}, \neg \text{large} \land \text{small} \rangle} \]

\[ s_3 = s_2 \otimes a_3 = \bigcirc^{O,S,A}_{\text{small}} \]
Modelling the No-ToM agent in DEL

4. Sally re-enters:

\[
\begin{align*}
    s_0 &= O(S, A) \\
    a_1 &= O(S, A) \langle \neg \text{sally} \land \neg \text{large}, \text{large} \rangle \\
    s_1 &= s_0 \otimes a_1 = O(S, A) \langle \text{large}, \text{sally} \rangle \\
    a_2 &= O(S, A) \langle \text{sally}, \neg \text{sally} \rangle \\
    s_2 &= s_1 \otimes a_2 = O(S, A) \langle \text{large} \rangle \\
    a_3 &= O(S, A) \langle \text{large}, \neg \text{large} \land \text{small} \rangle \\
    s_3 &= s_2 \otimes a_3 = O(S, A) \langle \text{small} \rangle \\
    a_4 &= O(S, A) \langle \neg \text{sally}, \text{sally} \rangle
\end{align*}
\]
Modelling the No-ToM agent in DEL

4. Sally re-enters:

\[ s_0 = O, S, A \]

\[ a_1 = O, S, A \langle \neg \text{small} \land \neg \text{large}, \text{large} \rangle \]

\[ s_1 = s_0 \otimes a_1 = O, S, A \text{large, sally} \]

\[ a_2 = O, S, A \langle \text{sally}, \neg \text{sally} \rangle \]

\[ s_2 = s_1 \otimes a_2 = O, S, A \text{large} \]

\[ a_3 = O, S, A \langle \text{large}, \neg \text{large} \land \text{small} \rangle \]

\[ s_3 = s_2 \otimes a_3 = O, S, A \text{small} \]

\[ a_4 = O, S, A \langle \neg \text{sally}, \text{sally} \rangle \]

\[ s_4 = s_3 \otimes a_4 = O, S, A \text{small, sally} \]
Observations about the No-ToM agent

0. Initial state: \( s_0 = sally \)

1. Sally places cube in large container: \( a_1 = \langle \neg small \land \neg large, large \rangle \)

2. Sally leaves the room: \( a_2 = \langle sally, \neg sally \rangle \)

3. Anne transfers cube: \( a_3 = \langle large, \neg large \land small \rangle \)

4. Sally re-enters: \( a_4 = \langle \neg sally, sally \rangle \)

We have:

\[ s_4 = s_0 \otimes a_1 \otimes a_2 \otimes a_3 \otimes a_4 = \langle small, sally \rangle \]

Now note that \( s_0 \otimes a_1 \otimes a_3 = s_4 \). Thus Sally leaving and re-entering doesn’t have any effect on the model the no-ToM agent ends up with!
Observations about the No-ToM agent

0. Initial state: \( s_0 = sally \)

1. Sally places cube in large container: \( a_1 = \langle \neg \text{small} \land \neg \text{large}, \text{large} \rangle \)

2. Sally leaves the room: \( a_2 = \langle \text{sally}, \neg \text{sally} \rangle \)

3. Anne transfers cube: \( a_3 = \langle \text{large}, \neg \text{large} \land \text{small} \rangle \)

4. Sally re-enters: \( a_4 = \langle \neg \text{sally}, \text{sally} \rangle \)

We have:

\[ s_4 = s_0 \otimes a_1 \otimes a_2 \otimes a_3 \otimes a_4 = \langle \text{small}, \text{sally} \rangle \]

Now note that \( s_0 \otimes a_1 \otimes a_3 = s_4 \). Thus Sally leaving and re-entering doesn’t have any effect on the model the no-ToM agent ends up with!

We also have:

\[ s_4 \models BOB_s \text{small} \]

Hence the observer will answer the question “where does Sally believe the cube is” with “in the small container”.

Thomas Bolander, False-belief tasks, 5 Dec 2013 – p. 10/21
Sally-Anne for ToM agents

0. Initial state:
1. Sally places cube in large container:
2. Sally leaves the room:
Sally-Anne for ToM agents

3. Anne transfers cube to small container:
4. Sally re-enters:
1. Sally places cube in large container:

\[ s_1 = O, S, A \]

\[ large, sally \]
Modelling the ToM agent in DEL

2. Sally leaves the room:

\[ s_1 = O^{O,S,A} \langle \text{large}, \text{sally} \rangle \]

\[ a_2 = O^{O,S,A} \langle \text{sally}, \neg \text{sally} \rangle \]
Modelling the ToM agent in DEL

2. Sally leaves the room:

\[ s_1 = O, S, A \text{large, sally} \]

\[ a_2 = O, S, A \langle \text{sally, } \neg\text{sally} \rangle \]

\[ s_2 = s_1 \otimes a_2 = O, S, A \text{large} \]
Modelling the ToM agent in DEL

3. Anne transfers cube to small container:

\[ s_1 = O, S, A \text{large, sally} \]

\[ a_2 = O, S, A \langle \text{sally, } \neg \text{sally} \rangle \]

\[ s_2 = s_1 \otimes a_2 = O, S, A \text{large} \]

\[ a_3 = O, A, S \langle \text{large, } \neg \text{large } \land \text{small} \rangle \langle \top, \top \rangle \]

Thomas Bolander, False-belief tasks, 5 Dec 2013 – p. 12/21
Modelling the ToM agent in DEL

3. Anne transfers cube to small container:

\[ s_1 = \text{large, sally} \]

\[ a_2 = \langle \text{sally}, \neg \text{sally} \rangle \]

\[ s_2 = s_1 \otimes a_2 = \text{large} \]

\[ a_3 = \langle \text{large, } \neg \text{large} \land \text{small} \rangle \]

\[ s_3 = s_2 \otimes a_3 = \text{small} \]
4. Sally re-enters:

\[ s_1 = \bigcirc^{O, S, A}_{\text{large, sally}} \]

\[ a_2 = \bigcirc^{O, S, A}_{\langle \text{sally}, \neg \text{sally} \rangle} \]

\[ s_2 = s_1 \otimes a_2 = \bigcirc^{O, S, A}_{\text{large}} \]

\[ a_3 = \bigcirc^{O, A}_{\langle \text{large, } \neg \text{large} \land \text{small} \rangle} \bigcirc^{O, S, A}_{\langle \top, \top \rangle} \]

\[ s_3 = s_2 \otimes a_3 = \bigcirc^{O, A}_{\text{small}} \bigcirc^{O, S, A}_{\text{large}} \]

\[ a_4 = \bigcirc^{O, S, A}_{\langle \neg \text{sally}, \text{sally} \rangle} \]
Modelling the ToM agent in DEL

4. Sally re-enters:

\[ s_1 = O, S, A \text{large, sally} \]

\[ a_2 = O, S, A \langle \text{sally}, \neg \text{sally} \rangle \]

\[ s_2 = s_1 \otimes a_2 = O, S, A \text{large} \]

\[ a_3 = \langle \text{large, } \neg \text{large} \land \text{small} \rangle \]

\[ s_3 = s_2 \otimes a_3 = O, S, A \text{small} \]

\[ a_4 = O, S, A \langle \neg \text{sally}, \text{sally} \rangle \]

\[ s_4 = s_3 \otimes a_4 = O, S, A \langle \text{small, sally}, \text{large, sally} \rangle \]
Observations about the ToM agent

0. Initial state: $s_0 = O, S, A_sally$

1. Sally places cube in large container: $a_1 = O, S, A_{\neg small \land \neg large, large}$

2. Sally leaves the room: $a_2 = O, S, A_{sally, \neg sally}$

3. Anne transfers cube: $a_3 = O, A_{\neg large \land small} \quad O, S, A_{T, T}$

4. Sally re-enters: $a_4 = O, S, A_{\neg sally, sally}$

$$s_4 = s_0 \otimes a_1 \otimes a_2 \otimes a_3 \otimes a_4 = O, A_{small, sally} \quad O, S, A_{large, sally}$$

We have:

$$s_4 \models B_O B_S {\text{large}}$$

Thus the observer will answer the question “where does Sally believe the cube is” with “in the large container”, hence passing the Sally-Anne test!
Observations about the ToM agent

0. Initial state: \( s_0 = O, S, A sally \)

1. Sally places cube in large container: \( a_1 = O, S, A \langle \neg \text{small} \land \neg \text{large}, \text{large} \rangle \)

2. Sally leaves the room: \( a_2 = O, S, A \langle \text{sally}, \neg \text{sally} \rangle \)

3. Anne transfers cube: \( a_3 = O, A \langle \text{large}, \neg \text{large} \land \text{small} \rangle \langle \top, \top \rangle \)

4. Sally re-enters: \( a_4 = O, S, A \langle \neg \text{sally}, \text{sally} \rangle \)

\[
s_4 = s_0 \otimes a_1 \otimes a_2 \otimes a_3 \otimes a_4 = O, A \langle \text{small}, \text{sally} \rangle \rightarrow O, S, A \langle \text{large}, \text{sally} \rangle
\]

We have: \( s_4 \models BOBS_{\text{large}} \)

Thus the observer will answer the question “where does Sally believe the cube is” with “in the large container”, hence passing the Sally-Anne test!

But note: We still have \( s_0 \otimes a_1 \otimes a_3 = s_4 \). Something is not right!...
Consider the action “Anne transfers cube”.

- When all agents observe the action taking place:
  \[ \langle \top, \neg \text{large} \wedge \text{small} \rangle^{O, S, A} \]

- When only a subset \( B \) of the set of all agents \( A \) observe the action taking place:
  \[ \langle \text{large}, \neg \text{large} \wedge \text{small} \rangle^{B} \quad \langle \top, \top \rangle^{A \setminus B} \]

The lower event model is recognised as having the same structure as a private announcement to the group of agents \( B \) (called secure group-announcements in [Baltag et al., 1998]). However, since it is an ontic action, it should probably be called a private assignment.
Modelling attention and observability in DEL

Consider the action “Anne transfers cube”.

- When all agents observe the action taking place:
  \[ O_{O,S,A} \langle \top, \neg \text{large} \land \text{small} \rangle \]

- When only a subset \( B \) of the set of all agents \( A \) observe the action taking place:
  \[ O^B_{A-B} \langle \text{large}, \neg \text{large} \land \text{small} \rangle \quad O^A_{A-B} \langle \top, \top \rangle \]

The lower event model is recognised as having the same structure as a private announcement to the group of agents \( B \) (called secure group-announcements in [Baltag et al., 1998]). However, since it is an ontic action, it should probably be called a private assignment.

Which agents observe a given action taking place should be encoded in the state to which the action is applied. In the Sally-Anne test, the propositional symbol \( sally \) encodes whether sally observes the action “Anne transfers cube”.

Thomas Bolander, False-belief tasks, 5 Dec 2013 – p. 14/21
Modelling attention and observability in DEL

In the Sally-Anne test, a correct event model for “Anne transfers the cube” that works independent on where Sally is, is the following multi-pointed event model:

\[
\langle \text{large} \land \neg \text{sally}, \neg \text{large} \land \text{small} \rangle \quad \langle \neg \text{sally}, \top \rangle \quad \langle \text{large} \land \text{sally}, \neg \text{large} \land \text{small} \rangle
\]

But this is a bit ad hoc and only gives a solution to this concrete problem. We need something more principled...
Modelling attention and observability in DEL

Some recent approaches:

• [van Ditmarsch et al., LORI 2013]: For each agent $a$, introduce a proposition $h_a$ for ‘$a$ is paying attention’. $h_a$ plays essentially the same role as our sally proposition. But not general enough for our purpose: when $h_a$ is true, agent $a$ observes any action taking place.
Modelling attention and observability in DEL

Some recent approaches:

• [van Ditmarsch et al., LORI 2013]: For each agent $a$, introduce a proposition $h_a$ for ‘$a$ is paying attention’. $h_a$ plays essentially the same role as our sally proposition. But not general enough for our purpose: when $h_a$ is true, agent $a$ observes any action taking place.

• [Baral et al., NMR 2012]: Introduce axioms of the form

$$\mathcal{B} \text{ observes } a \text{ if } \phi,$$

where $\mathcal{B}$ is a set of agents, $a$ is an action, and $\phi$ is a formula. In the Sally-Anne example, we would then add the axiom

$$\mathcal{S} \text{ observes } a_3 \text{ if sally}.$$

This approach requires naming all actions and using axioms to generate event models.
Conclusion

- The Sally-Anne test can be formalised in DEL, and we can formalise the behaviour both of a non-ToM and a ToM agent.
The Sally-Anne test can be formalised in DEL, and we can formalise the behaviour both of a non-ToM and a ToM agent.

When the set of actions used in Sally-Anne has been formalised as event models, it is a very easy task for a computer to reason correctly about the consequences of executing any sequence of these actions.
Conclusion

- The Sally-Anne test can be formalised in DEL, and we can formalise the behaviour both of a non-ToM and a ToM agent.
- When the set of actions used in Sally-Anne has been formalised as event models, it is a very easy task for a computer to reason correctly about the consequences of executing any sequence of these actions.
- The current formalisation is however not entirely satisfactory.
Conclusion

- The Sally-Anne test can be formalised in DEL, and we can formalise the behaviour both of a non-ToM and a ToM agent.
- When the set of actions used in Sally-Anne has been formalised as event models, it is a very easy task for a computer to reason correctly about the consequences of executing any sequence of these actions.
- The current formalisation is however not entirely satisfactory.
- But looking for good formalisations of the Sally-Anne test in DEL can serve as one of the drivers of further developments of the DEL framework, e.g. developing suitable “observation theories”.
APPENDIX

About why it is essential to become able to construct AI agents (robots, personal digital assistants, NPCs in computer games, etc.) with Theory of Mind capabilities.
The child is *not* given any instructions beforehand.

(Waneken & Tomasello, Science, vol. 311, 2006)
The Hospital of Southern Jutland (Sygehus Sønderjylland) has since mid 2012 been experimenting with TUG hospital robots.
Anti-social TUG hospital robots (2009)

Frustrated users of hospital robots in USA:

- “TUG was a hospital worker, and its colleagues expected it to have some social smarts, the absence of which led to frustration—for example, when it always spoke in the same way in both quiet and busy situations.”

(Colin Barras, New Scientist, vol. 204, 2009)
Frustrated users of hospital robots in USA:

- “TUG was a hospital worker, and its colleagues expected it to have some social smarts, the absence of which led to frustration—for example, when it always spoke in the same way in both quiet and busy situations.”
- “I’m on the phone! If you say ‘TUG has arrived’ one more time I’m going to kick you in your camera.”

(Colin Barras, New Scientist, vol. 204, 2009)
Anti-social TUG hospital robots (2009)

Frustrated users of hospital robots in USA:

- “TUG was a hospital worker, and its colleagues expected it to have some social smarts, the absence of which led to frustration—for example, when it always spoke in the same way in both quiet and busy situations.”
- “I’m on the phone! If you say ’TUG has arrived’ one more time I’m going to kick you in your camera.”
- “It doesn’t have the manners we teach our children. I find it insulting that I stand out of the way for patients... but it just barrels right on.”

(Colin Barras, New Scientist, vol. 204, 2009)