

Reflex Responsibility of Agents

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- Background: the concept of responsibility
- Responsible for others' actions: reflex responsibility
- The logical structure of reflex responsibility
- Logical framework: semantics



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 - **Causal responsibility**: causal connection between the conduct of x and the effects of such a conduct
 - **Liability responsibility**: rules and conditions under which x may be held accountable (thus the focus is on conditions that lead to compensation, restitution, etc.)



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- Tortious liability: E.g., absent owners can be responsible for the management of their properties by well-intended helpers, without any agreement or contract taking place: the entrusted agent (the helper) is expected to behave in the interest of the principal, according to accepted standards.



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- Art. 1228 Italian Civil Code:

Unless differently agreed, the debtor, who in carrying out his duties avails of third parties performances, is liable for intentional or negligent conducts of such third parties.



The intuition



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Bob: "Hey mate, I'm leaving for holidays: may I count on you for keeping my garden clean?"

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But now suppose that Mike unintentionally misuses Bob's mower, which runs out of control and "crushes" Jane's chihuahua passing through the area nearby the garden....What?



The intuition



Who's liable for damages?



Remark

The **reflex responsibility** of a principal agent is based on a harmful act carried out by a helper agent upon the condition that a **dependence relation** between principal and helper occurs. For dependence to exist, the following two constitutive elements are required:

- 1 the principal intends that the helper carries out a function in the principal's interest, and
- 2 the helper counts as a subordinate of the principal w.r.t. the performance of such function, i.e., she acts in the interest of the principal and she believes that this is the intention of the principal.



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A multi-modal logic built by combining the following operators



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- $\text{Goal}_x A$: agent x has goal A
- $\text{Int}_x A$: agent x has the intention to make A
- $\text{Bel}_x A$: agent x has the belief that A
- $\text{Does}_x A$: x brings about that A
- $\text{Obl}_x A$: A is obligatory in the interest of x



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- $\text{Obl}_x A$: A is obligatory in the interest of x
- $\text{Int}_h^p A$: agent h (helper) intends A to become true in the interest of agent p (principal)
- $\text{Does}_h^p A$: agent h (helper) brings it about that A in the interest of agent p (principal)



Some axiom schemata for the new operators

$$\text{Does}_h^p A \rightarrow \text{Does}_h A \quad (1)$$

$$\text{Int}_h^p A \rightarrow \text{Int}_h A \quad (2)$$

$$\text{Int}_h^p \text{Does}_h A \equiv \text{Int}_h \text{Does}_h^p A \quad (3)$$



The dependence condition formalized

- the principal has the goal that A (e.g., “The garden is clean”)
- the principal intends that the helper does A in the interest of the principal
- the helper believes that the principal intends that the helper does A in the interest of the principal
- the helper intends to that A in the interest of the principal



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$$\text{Dep}_h^p A \equiv \text{Goal}_p A \wedge \text{Int}_p(\text{Does}_h^p A) \wedge (\text{Bel}_h(\text{Int}_p(\text{Does}_h^p A))) \wedge \text{Int}_h^p A \quad (4)$$



Reflex responsibility formalized

A principal is reflexively responsible for an action of the helper that brings about A iff

- there is the dependence relation $\text{Dep}_h^p A$
- the helper rather than the principal brings about that A ;
- all is conditioned to the fact that, by doing this, h causes a damage (if this does not hold, h 's action that brings A about is irrelevant):



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$$(\text{Does}_h A \rightarrow \text{Does}_h \text{Damage}) \rightarrow [(\text{Dep}_h^p A \wedge \text{Does}_h^p A \wedge \neg \text{Does}_p A) \equiv \text{Reflex}_h^p A] \quad (5)$$



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$$\text{Reflex}_h^p A \rightarrow \text{Obl}_t \text{Does}_p \text{Compensate}$$





$Goal_{Bob} Clean_Garden$

$Int_{Bob}(Does_{Mike}^{Bob} Clean_Garden)$

$Bel_{Mike}[Int_{Bob}(Does_{Mike}^{Bob} Clean_Garden)]$

$Does_{Mike}^{Bob} Clean_Garden$

$\neg Does_{Bob} Clean_Garden$

$Does_{Mike} A \rightarrow Does_{Mike} Damage$



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¬Does_{Bob} Clean_Garden

Does_{Mike}A → Does_{Mike}Damage

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Obl_{Jane}Does_{Bob}Compensate



Semantics (1)

$$\mathfrak{F} = \langle A, W, \{B_i\}_{i \in A}, \{G_i\}_{i \in A}, \{I_i\}_{i \in A}, \{O_i\}_{i \in A}, \{D_i\}_{i \in A}, \{I_i^k\}_{i,k \in A}, \{D_i^k\}_{i,k \in A} \rangle$$

- A is the finite set of agents;
- W is a set of situations, or points, or possible worlds;
- $\{B_i\}_{i \in A}$ is a set of accessibility relations wrt Bel, which are transitive, euclidean and serial;
- $\{G_i\}_{i \in A}$ is a set of accessibility relations wrt Goal, (standard K_n semantics);
- $\{I_i\}_{i \in A}$ is a set of accessibility relations wrt Int _{i} , which are serial;
- $\{O_i\}_{i \in A}$ is a set of accessibility relations wrt Obl _{i} , which are serial;
- $\{D_i\}_{i \in A}$ is a family of sets of accessibility relations D_i wrt Does _{i} , which are pointwise closed under intersection, reflexive and serial
- $\{I_i^k\}_{i,k \in A}$ is a set of accessibility relations wrt Int _{i} ^{k} , which are serial; and
- $\{D_i^k\}_{i,k \in A}$ is a family of sets of accessibility relations D_i^k wrt Does, which are pointwise closed under intersection, reflexive and serial



Semantics (2)

- standard evaluation for goal, intentions, beliefs, and obligations
- $v(w, \text{Does}_i A) = 1$ iff $\exists D_i \in D_i$ such that $\forall u(wD_i u$ iff $v(u, A) = 1$)
- $v(w, \text{Does}_i^k A) = 1$ iff $\exists D_i^k \in D_i^k$ such that $\forall u(wD_i^k u$ iff $v(u, A) = 1$)



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Additional conditions:

- $\forall w \in W, \forall I_i^k \in \{I_i^k\}_{i,k \in A} \forall I_i \in \{I_i\}_{i \in A}, I_i^k \subseteq I_i$
- $\forall w \in W, \forall D_i^k \in \{D_i^k\}_{i,k \in A} \exists \forall D_i \in \{D_i\}_{i \in A}$ such that $D_i^k(w) \subseteq D_i(w)$
- $\forall w, v \in W, \forall I_i^k \in \{I_i^k\}_{i,k \in A}, \forall I_i \in \{I_i\}_{i \in A}, \forall D_i^k \in \{D_i^k\}_{i,k \in A} \exists \forall D_i \in \{D_i\}_{i \in A}, v \in D_i(w)$ and $v \in D_i^k(w)$ iff $I_i^k(v) = I_i(v)$.



Conclusions and future work

- Logical analysis of reflex responsibility
- Multi-modal system: available results of completeness and decidability are currently confined to a fragment of the logic (action operators do not occur within the scope of other operators)
- Study other types of responsibility and show possible connections



Thank you!

