Effect of Trust/Distrust on Social Emotions

A Logical Approach

Jean-François Bonnefon* Dominique Longin** Manh-Hung Nguyen***

*CNRS, CLLE, University of Toulouse, France

**CNRS, IRIT, University of Toulouse, France

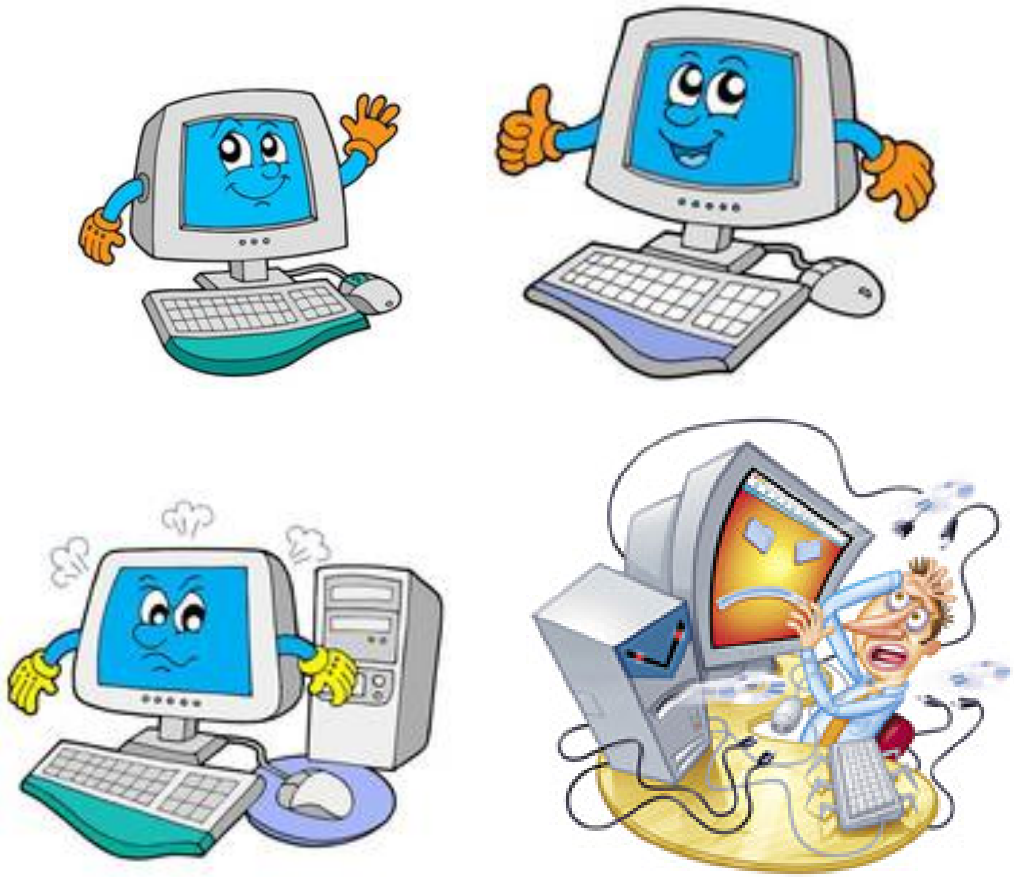
***UPS, IRIT, University of Toulouse, France

October 2009

Table of contents

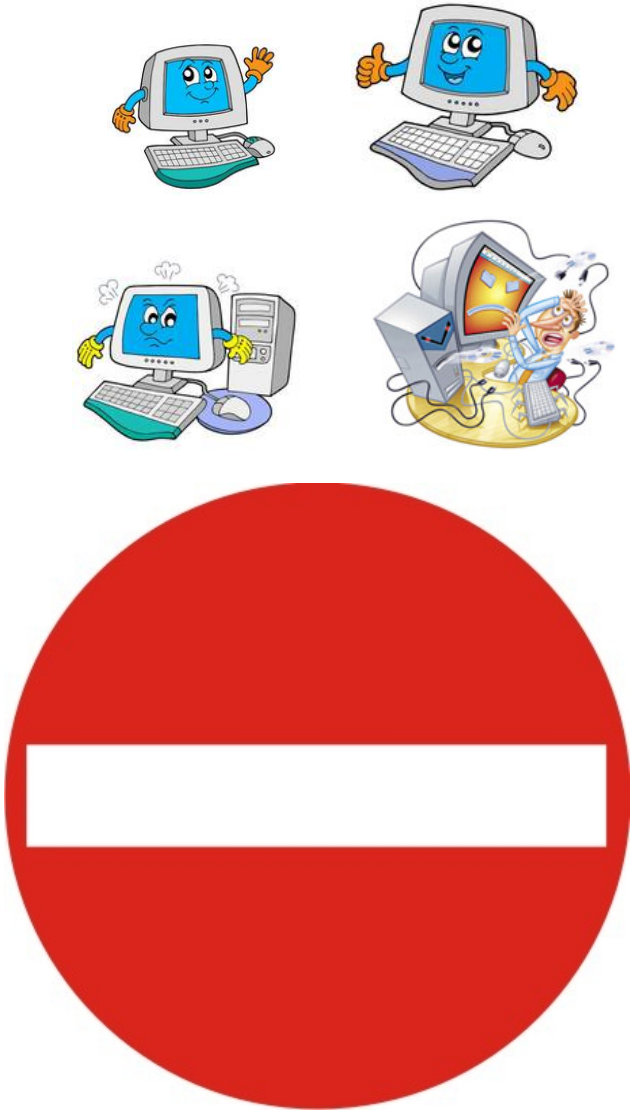
Plan

Making up emotions to computer?



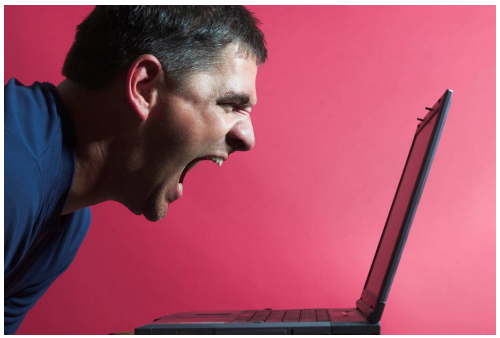
Images' source: Royalty Free (at photosearch.com)

- No!



Images' source: Royalty Free (at photosearch.com)

Why do emotions relate to computer?



Images' sources: Google's images

Objectives

Enabling computer to
distinguish,
recognize
and
reason
about emotions of users!

Plan

Gratitude

The cognitive structure of *Gratitude* is composed of:

- agent *i* believes that agent *j* has done a praiseworthy action α;
- the result φ of such an action is desired by agent *i*;
- agent *i* now experiences that in fact φ is true.

[Ortony et al. 1988, Frijda 1986, Lazarus 1991]

Anger

The cognitive structure of *Anger* is composed of:

- agent *i* believes that agent *j* has done a blameworthy action α;
- agent *i* had no desire for the action's outcome (for i, it is possible to avoid φ by not doing α);
- agent *i* now experiences the unexpected outcome of such an action.

[Ortony et al. 1988, Frijda 1986, Lazarus 1991]

Definition of Castelfranchi et al.

There are two agents *i* (trustor), *j* (trustee), an action α and a result φ of action α: *i* trusts *j* to do α with respect to the achievement of φ if and only if *i* believes that:

- *i* has a goal of achievement of φ, and
- φ is obtained after having done α, and
- *j* is capable to do α with respect to the achievement of φ, and
- *j* has intention to do α with respect to the achievement of φ

Example

A boss trust his secretary in preparing a report for a meeting because:

- The boss desires have the report, and
- The boss will have it if the secretary prepares it, and
- The boss believes that his secretary is able to prepare the report, and
- The boss believes that his secretary has intention to prepare the report.

A Counter Example

Counter Example

Imagine that a robber wants to steal something located on the 2^{nd} floor of a mansion. There is a nurse on the 1^{st} floor with a baby.

- The robber desires that the nurse stays where she is, because it makes his robbery possible;
- He believes that it is possible that the nurse will stay where she is;
- He also believes that it is actually her intention.

$\longrightarrow$ follow Castelfranchi et al., the robber trusts the nurse to stay where she is in order to allow for his stealing.

In fact, it is reliance only! The nurse does not know the robber's objective, and the robber does not ask the nurse to help him
$\longrightarrow$ There is no trust!

Cognitive Structure of Trust

i trusts *j* to do α with respect to the achievement of φ if and only if *i* believes that:

- *i* has a goal of achievement of φ, and
- φ is obtained after having done α, and
- *j* is capable to do α with respect to the achievement of φ, and
- *j* has intention to do α with respect to the achievement of φ
- there is a public ground between *i* and *j* that *j* will do action α.

Cognitive Structure of DisTrust

The cognitive structure of *Distrust* is composed of:

- agent *i* desires to achieve φ;
- agent *i* believes that at least:
  - agent *j* is not in the capacity to do action α to bring about φ; or
  - agent *j* is able to do α but *j* has no intention to do α.

[Castelfranchi et al. 2001, 2008]

Plan

Language

$$\varphi ::= p \mid \textit{do-}i{:}\alpha \mid \neg\varphi \mid \varphi \vee \varphi \mid \mathtt{X}\varphi \mid \mathtt{X}^{-1}\varphi \mid \mathtt{G}\varphi \mid$$
$$\mathtt{Bel}_i\,\varphi \mid \mathtt{Choice}_i\,\varphi \mid \mathtt{Idl}_i\,\varphi \mid \mathtt{Grd}_I\varphi$$

where p and $\textit{do-}i{:}\alpha$ range over ATM, $i{:}\alpha$ ranges over $\mathit{AGT} \times \mathit{EVT}$ and $I \subseteq \mathit{AGT}$.

- $\textit{do-}i{:}\alpha$ reads "agent i is just about to perform the action α";
- $\mathtt{X}\varphi$ reads "φ will be true next time";
- $\mathtt{X}^{-1}\varphi$ reads "φ was true at the previous time";
- $\mathtt{G}\varphi$ reads "henceforth, φ is true";
- $\mathtt{Bel}_i\,\varphi$ reads "agent i believes that φ is true";
- $\mathtt{Choice}_i\,\varphi$ reads "agent i prefers that φ be true";
- $\mathtt{Idl}_i\,\varphi$ reads "It is ideal for agent i to bring about φ";
- $\mathtt{Grd}_I\varphi$ reads "φ is publicly grounded between all agents in group I".

Abbreviations

$$\textit{done-}i{:}\alpha \stackrel{def}{=} \mathrm{X}^{-1}\textit{do-}i{:}\alpha$$

$$\mathtt{After}_{i:\alpha}\varphi \stackrel{def}{=} \textit{do-}i{:}\alpha \rightarrow \mathrm{X}\varphi$$

$$\mathtt{Done}_{i:\alpha}\varphi \stackrel{def}{=} \textit{done-}i{:}\alpha \wedge \mathrm{X}^{-1}\varphi$$

$$\mathrm{F}\varphi \stackrel{def}{=} \neg\mathrm{G}\neg\varphi$$

$$\mathtt{Goal}_i\,\varphi \stackrel{def}{=} \mathtt{Choice}_i\,\mathtt{FBel}_i\,\varphi$$

$$\mathtt{Intend}_i\,(i{:}\alpha) \stackrel{def}{=} \mathtt{Choice}_i\,\mathrm{F}\textit{do-}i{:}\alpha$$

$$\mathtt{Capable}_i(i{:}\alpha) \stackrel{def}{=} \neg\mathtt{After}_{i:\alpha}\bot$$

$$\mathtt{Possible}_i\varphi \stackrel{def}{=} \neg\mathtt{Bel}_i\,\neg\varphi$$

$$\mathtt{Awareness}_i\varphi \stackrel{def}{=} \mathrm{X}^{-1}\neg\mathtt{Bel}_i\,\varphi \wedge \mathtt{Bel}_i\,\varphi$$

Frame

A **frame** $\mathcal{F}$ is a 5-tuple $\langle H, \mathscr{B}, \mathscr{C}, \mathscr{I}, \mathscr{G} \rangle$:

- H is a set of histories h that are represented as sequences of time points, where each time point is identified by an integer $z \in \mathbb{Z}$, called a situation $< h, z >$;
- $\mathscr{B}_i(h, z)$ denotes the set of histories believed as being possible by the agent i in the situation $< h, z >$;
- $\mathscr{C}_i(h, z)$ denotes the set of histories chosen by the agent i in the situation $< h, z >$;
- $\mathscr{I}_i(h, z)$ denotes the set of ideal histories for the agent i in the situation $< h, z >$;
- $\mathscr{G}_I(h, z)$ denotes the set of histories which are publicly grounded between all agents in group I in the situation $< h, z >$;

Truth conditions

$\mathcal{M}, h, z \models p$ iff $(h, z) \in \mathcal{V}(p)$

$\mathcal{M}, h, z \models \mathtt{X}\varphi$ iff $\mathcal{M}, h, z+1 \models \varphi$

$\mathcal{M}, h, z \models \mathtt{X}^{-1}\varphi$ iff $\mathcal{M}, h, z-1 \models \varphi$

$\mathcal{M}, h, z \models \mathtt{G}\varphi$ iff $\mathcal{M}, h, z' \models \varphi$ for every $z' \geq z$;

$\mathcal{M}, h, z \models \mathtt{Bel}_i\,\varphi$ iff $\mathcal{M}, h', z \models \varphi$ for every $(h', z) \in \mathscr{B}_i(h, z)$;

$\mathcal{M}, h, z \models \mathtt{Choice}_i\,\varphi$ iff $\mathcal{M}, h', z \models \varphi$ for every $(h', z) \in \mathscr{C}_i(h, z)$;

$\mathcal{M}, h, z \models \mathtt{Idl}_i\,\varphi$ iff $\mathcal{M}, h', z \models \varphi$ for every $(h', z) \in \mathscr{I}_i(h, z)$;

$\mathcal{M}, h, z \models \mathtt{Grd}_I\varphi$ iff $\mathcal{M}, h', z \models \varphi$ for every $(h', z) \in \mathscr{G}_I(h, z)$

so that $\mathscr{G}_I = (\bigcup_{i \in I} \mathscr{B}_i)^+$

Axiomatization

All principles of modal logic KD45 and positive/negative introspection for every $\texttt{Bel}_i$
All principles of modal logic KD and positive/negative introspection for every $\texttt{Choice}_i$ and $\texttt{Idl}_i$
The sound and complete axiomatization of $\texttt{Grd}_I$ operator is defined two following axioms:

$$\texttt{Grd}_I\varphi \leftrightarrow (EB_I\varphi \wedge EB_I\texttt{Grd}_I\varphi) \quad \text{(FP)}$$

$$(EB_I\varphi \wedge \texttt{Grd}_I(\varphi \rightarrow EB_I\varphi)) \rightarrow \texttt{Grd}_I\varphi \quad \text{(LFP)}$$

where $EB_I\varphi \stackrel{def}{=} \bigwedge_{i\in I} \texttt{Bel}_i\,\varphi$.

$$\texttt{Grd}_I\varphi \leftrightarrow \texttt{Bel}_i\,\texttt{Grd}_I\varphi \quad (4_{BG})$$

$$\texttt{Bel}_i\,\neg\texttt{Grd}_I\varphi \rightarrow \neg\texttt{Grd}_I\varphi \quad (5_{BG})$$

$$\texttt{Grd}_I\varphi \rightarrow \texttt{Bel}_i\,\varphi \wedge \texttt{Bel}_j\,\varphi \quad (1)$$

$$\texttt{Grd}_I\varphi \rightarrow \texttt{Bel}_i\,\texttt{Bel}_j\,\varphi \wedge \texttt{Bel}_j\,\texttt{Bel}_i\,\varphi \quad (2)$$

$$\texttt{Grd}_I\varphi \rightarrow \texttt{Bel}_i\,\texttt{Bel}_j\,\texttt{Bel}_i\,\varphi \wedge \texttt{Bel}_j\,\texttt{Bel}_i\,\texttt{Bel}_j\,\varphi \quad (3)$$

Plan

Formalization of Trust

The cognitive structure of Trust has factors:

- Agent *i* has a goal to achieve φ: $\texttt{Goal}_i\,\varphi$
- Agent *i* believes that the event φ will be happened after having done α: $\texttt{Bel}_i\,\texttt{After}_{j:\alpha}\varphi$
- Agent *i* believes that *j* is capable to do α: $\texttt{Bel}_i\,\texttt{Capable}_{j:\alpha}$
- Agent *i* believes that *j* has intention to do α: $\texttt{Bel}_i\,\texttt{Intend}_j\,(j{:}\alpha)$
- There is a public ground between *j* and *i* that *j* will do action α: $\texttt{Grd}_{\{i,j\}}\texttt{F}\,\textit{do-j}{:}\alpha$

Formulas of Trust

$$\texttt{Trust}(i,j,\alpha,\varphi) \overset{\textit{def}}{=} \texttt{Goal}_i\,\varphi \wedge \texttt{Bel}_i\,\texttt{After}_{j:\alpha}\varphi \wedge \texttt{Bel}_i\,\texttt{Capable}_{j:\alpha} \wedge \texttt{Bel}_i\,\texttt{Intend}_j\,(j{:}\alpha) \wedge \texttt{Grd}_{\{i,j\}}\texttt{F}\,\textit{do-j}{:}\alpha$$

Formalization of Distrust

The cognitive structure of *Distrust* is composed of:

- agent *i* desires to achieve φ: $\texttt{Goal}_i\,\varphi$;
- agent *i* believes that at least:
  - agent *j* is not in the capacity to do action α to bring about φ: $\texttt{Bel}_i\,\neg\texttt{After}_{j:\alpha}\varphi$; or
  - agent *j* is able to do α but *j* has no intention to do α: $\texttt{Bel}_i\,\texttt{After}_{j:\alpha}\varphi \wedge \texttt{Bel}_i\,\texttt{Intend}_j\,(j{:}\sim\alpha)$.

$$\texttt{DisTrust}(i,j,j{:}\alpha,\varphi) \stackrel{def}{=} \texttt{Goal}_i\,\varphi \wedge \big(\texttt{Bel}_i\,\neg\texttt{After}_{j:\alpha}\varphi \vee (\texttt{Bel}_i\,\texttt{After}_{j:\alpha}\varphi \wedge \texttt{Bel}_i\,\texttt{Intend}_j\,(j{:}\sim\alpha))\big)$$

Gratitude

The cognitive structure of *Gratitude* is composed of:

- agent *i* believes that agent *j* has done a praiseworthy (ideal) action α: $\mathtt{Idl}_j\,(j{:}\alpha)$;
- the result φ of such an action is desired by agent *i*: $\mathtt{Goal}_i\,\varphi \wedge \mathtt{Bel}_i\,\mathtt{After}_{j:\alpha}\varphi$;
- agent *i* now experiences that in fact φ is true: $\mathtt{Awareness}_i\varphi$.

$$\mathtt{Gratitude}(i,j,j{:}\alpha,\varphi) \stackrel{def}{=} \mathtt{Bel}_i\,\mathtt{Done}_{j:\alpha}(\mathtt{Goal}_i\,\varphi \wedge \mathtt{Idl}_j\,(j{:}\alpha) \wedge \mathtt{Bel}_i\,\mathtt{After}_{j:\alpha}\varphi) \wedge \mathtt{Awareness}_i\varphi$$

Anger

The cognitive structure of *Anger* is composed of:

- agent *i* believes that agent *j* has done a blameworthy action (it is ideal to not do such an action) α: $\mathtt{Idl}_j\,(j{:}\sim\alpha)$;
- agent *i* had no desire (formalized as desire of $\neg\varphi$) for the action's outcome (for i, it is possible to avoid φ by not doing α): $\mathtt{Goal}_i\,\neg\varphi \wedge \mathtt{Possible}_i\mathtt{After}_{j:\sim\alpha}\neg\varphi$;
- agent *i* now experiences the unexpected outcome of such an action: $\mathtt{Awareness}_i\varphi$.

$$\mathtt{Anger}(i,j,j{:}\alpha,\varphi) \stackrel{def}{=} \mathtt{Bel}_i\,\mathtt{Done}_{j:\alpha}(\mathtt{Goal}_i\,\neg\varphi \wedge \mathtt{Idl}_j\,(j{:}\sim\alpha) \wedge \mathtt{Possible}_i\mathtt{After}_{j:\sim\alpha}\neg\varphi) \wedge \mathtt{Awareness}_i\varphi$$

Betrayal of Trust implies Anger

Proposition

$$\texttt{Bel}_i\,\texttt{Done}_{j:\alpha}(\texttt{Trust}(i,j,j{:}\sim\alpha,\neg\varphi)\wedge\texttt{Idl}_j\,(j{:}\sim\alpha))\wedge\texttt{Bel}_i\,\varphi \rightarrow\texttt{Anger}(i,j,j{:}\alpha,\varphi)$$

Non-intention-based Distrust implies Gratitude

Non-intention-based Distrust:

$$\texttt{I-DisTrust}(i,j,j{:}\alpha,\varphi) \stackrel{def}{=} \texttt{Goal}_i\,\varphi \wedge \texttt{Bel}_i\,\texttt{After}_{j:\alpha}\varphi \wedge \texttt{Bel}_i\,\texttt{Intend}_j\,(j{:}\sim\alpha)$$

Proposition

$$\texttt{Bel}_i\,\texttt{Done}_{j:\alpha}(\texttt{I-DisTrust}(i,j,j{:}\alpha,\varphi) \wedge \texttt{Idl}_j\,(j{:}\alpha)) \wedge \texttt{Bel}_i\,\varphi \rightarrow \texttt{Gratitude}(i,j,j{:}\alpha,\varphi)$$

Plan

Analysis

Hypothesis

Trust → betrayal → anger
So, if there is no anger → there is no trust

Variables

We need to test the effect of variable "public ground":

- Value: yes or no (boolean)
- Action outcome is always failed!

A Scenario

Charles and Matthew are two neighboring farmers. Charles is a good hunter. Recently, a wolf attacked their lambs. Matthew would kill the wolf but he can not shoot.
Charles leaves his house with a gun but Matthew does not ask him to kill the wolf. Matthew believes that Charles is able to use his gun and that he has intention to kill the wolf.
The day after the return of Charles, Matthew discovers that Charles has not yet killed the wolf. What does he feel vis-à-vis Charles?

Évaluation	not at all					absolutely
Satisfaction	○	○	○	○	○	○
Disappointment	○	○	○	○	○	○
Gratitude	○	○	○	○	○	○
Anger	○	○	○	○	○	○
Relief	○	○	○	○	○	○

Analysis

- We keep the variable "intention" and "capacity" in being always present. So, there are 1 variables of boolean values $\rightarrow$ 2 scenarios
- We put 2 scenarios into 2 groups. Each group has 4 stories with the same scenario.
- 5 tested emotions for all scenarios, including Anger
- Each option is noted in range from -2.5 to +2.5 (6-scale).

Statistics

- 263 participants, 241 responses
- Failed outcome brings negative emotions: Disappointment and Anger

Anger and disappointment

Public ground	Anger	Disappointment
No	-0.3 (1.3)	1.5 (1.2)
Yes	**1.5 (1.2)**	2.0 (1.1)

Table: Influence of variable "public ground" on Anger and Disappointment

	F	p
Public Ground	14.5	.000

Observation: If there is no public ground, there is no anger!

Plan

Analysis

Variables

We need to test the interaction of two mains variables:

- The outcome of action (success or fail)
- The trust or distrust before that. Trust/Distrust is divided into three sub-variables:
  - *j*'s capacity to do α (yes or no)
  - *j*'s intention to do α (yes or no)
  - public ground between *i* and *j* that *j* will do α (yes or no).

A Scenario

Mr. Boss is the marketing director of a big company. He needs an important financial report before a meeting tomorrow morning, but he has no time to write it because of other priorities. He asks Mr. Support to prepare it and put it on his desk before tomorrow morning.

- *Mr. Boss believes that Mr. Support has the intention to prepare the report in time.*
- *Mr. Boss believes that Mr. Support is able to prepare the report in time.*

The morning after, Mr. Boss finds the report on his desk when he arrives. In your opinion, what does he feel?

Évaluation	not at all					absolutely
Satisfaction	○	○	○	○	○	○
Disappointment	○	○	○	○	○	○
Gratitude	○	○	○	○	○	○
Anger	○	○	○	○	○	○
Relief	○	○	○	○	○	○

Analysis

- We keep the variable "public ground in being always present. So, there are 3 variables of boolean values $\rightarrow$ 8 scenarios
- 5 tested emotions for all scenarios, including: Gratitude and Anger
- Each option is noted in range from 1 to 6.

Statistics

- 221 participants, 152 responses
- Success outcome brings positive emotions, failed outcome brings negative emotions

Anger

	Trust	Distrust
Success	1.1 (0.3)	1.2 (0.8)
Failure	**3.9 (1.8)**	2.7 (1.5)

Table: Influence of Trust and DisTrust on Anger

	F	p
Intention	16.21	.000
Capacity	35.81	.000
Intention * Capacity	10.72	.002

Gratitude

	Trust	Distrust
Success	3.7 (1.7)	**4.3 (1.7)**
Failure	1.2 (0.6)	1.4 (0.9)

Table: Influence of Trust and DisTrust on Gratitude

	F	p
Intention	20.45	.000
Capacity	0.29	.590
Intention * Capacity	4.73	.033

Conclusion

Summary

- Formalization of Gratitude, Anger
- Formalization of Trust, Distrust
- Formalization of relations: *Trust* $\longrightarrow$ *Anger* and *Distrust* $\longrightarrow$ *Gratitude*
- Behavioral validation of:
  - the factor "public ground" in the cognitive structure of Trust
  - relations: *Trust* $\longrightarrow$ *Anger* and *Distrust* $\longrightarrow$ *Gratitude*

Perspectives

- Running experiments to precise the concept of "praiseworthiness" and "blameworthiness" in social emotions.
- Formalization of the effect of social emotions on Trust/DisTrust.

Thanks for your attention!

Effect of Trust/Distrust on Social Emotions

A Logical Approach

Jean-François Bonnefon* Dominique Longin** Manh-Hung Nguyen***

*CNRS, CLLE, University of Toulouse, France

**CNRS, IRIT, University of Toulouse, France

***UPS, IRIT, University of Toulouse, France

October 2009