ABDUCTION IN ARGUMENTATION FRAMEWORKS AND ITS USE IN DEBATE GAMES

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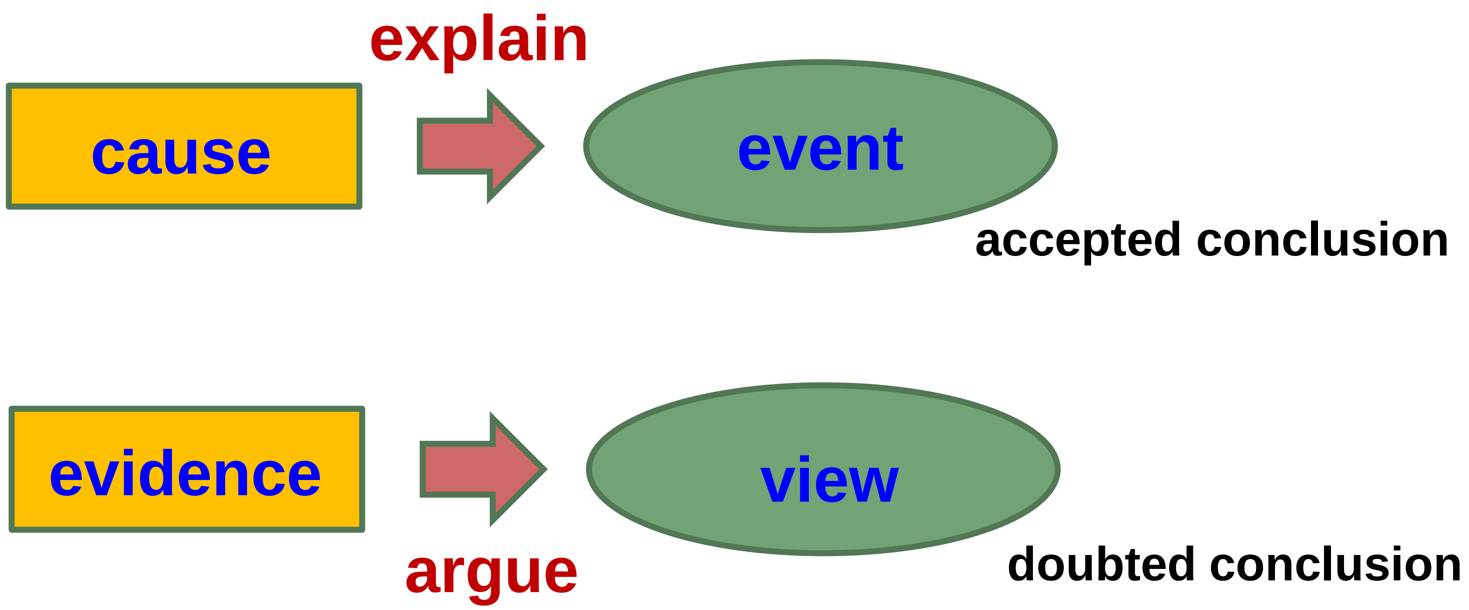
DIFFERENT ROLES OF ARGUMENT AND EXPLANATION

"The purpose of an **explanation** is to show ***why*** and ***how*** some phenomenon occurred or some event happened; the purpose of an **argument** is to show ***that*** some view or statement is correct or true."

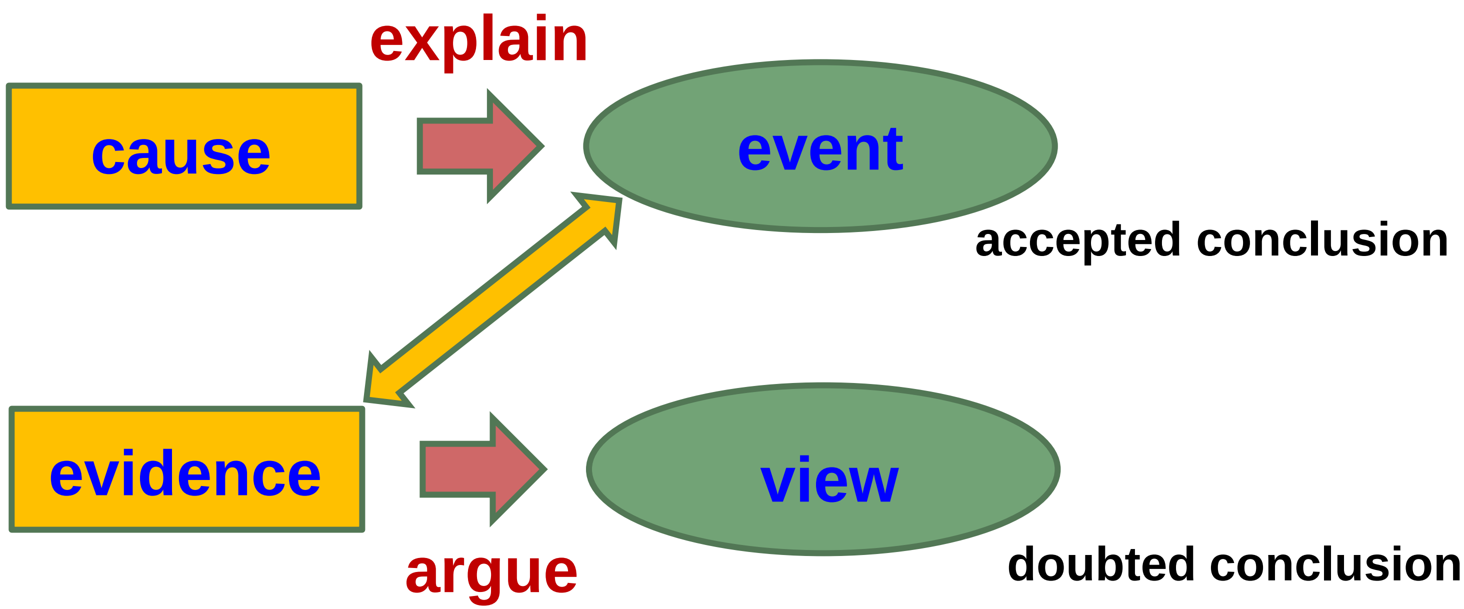
— ***Critical Thinking*** by W. Hughes (1992)



COMPLEMENTARY ROLES OF ARGUMENT AND EXPLANATION

“arguments and explanations have a complementary relationship and reasoning is normally perceived as incomplete when one occurs in the absence of the other” — ***Informal Logic*** by G. R. Mayes (2010)

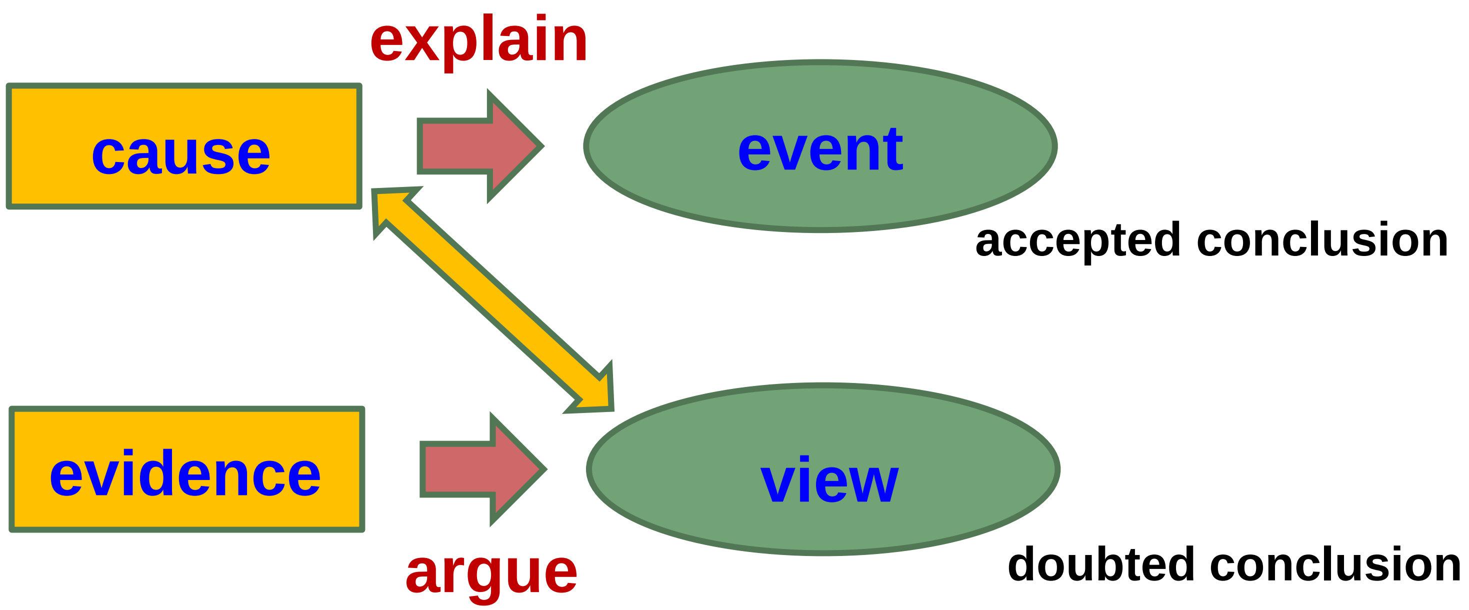
Explanation helps to understand how evidence occurs.



COMPLEMENTARY ROLES OF ARGUMENT AND EXPLANATION

“arguments and explanations have a complementary relationship and reasoning is normally perceived as incomplete when one occurs in the absence of the other” — ***Informal Logic*** by G. R. Mayes (2010)

Argument helps to know whether some view (or hypothesis) is true or not.



CONTRIBUTIONS

- **Argumentation framework** by Dung (1995) provides an abstract framework for argumentative reasoning, but it does not have a mechanism of explanatory reasoning.
- We propose an **abductive framework** based on Dung's argumentation framework.
- We apply the proposed framework to reasoning by players in **debate games**.

RELATED WORKS

	argumentation framework	abduction
Kakas & Moraitis, 2002	supportive argument	normal
Bex et al, 2007	evidential reasoning	normal
Dung et al, 2009	assumption-based AF	normal
Wakaki et al, 2010	Dung's AF associated with abductive logic programming	normal
Seselja et al, 2013	explanatory AF	normal
Our framework	Dung's abstract AF	extended

Normal abduction: addition of hypotheses

Extended abduction (Inoue & Sakama, IJCAI-95):

addition of hypotheses + deletion of hypotheses

ARGUMENTATION FRAMEWORK

(DUNG 1995; CAMINADA & GABBAY 2009)

- An **argumentation framework (AF)** is a pair (Ar, att) where Ar is a finite set of arguments and $att \subseteq Ar \times Ar$.
  An argument A **attacks** an argument B iff $(A,B) \in att$.

- $AF=(Ar, att)$ is represented by a directed graph where vertices are arguments in Ar and arcs from A to B exist whenever $(A,B) \in att$.

- A **labelling** of AF is a function $\mathtt{L}: Ar \rightarrow \{ in, out, undec \}$.

- A labelling $\mathtt{L}$ of AF is **complete labelling** if for each $A \in Ar$,
  - $\mathtt{L}(A)=in$ iff $\mathtt{L}(B)=out$ for every $B \in Ar$ s.t. $(B, A) \in att$.
  - $\mathtt{L}(A)=out$ iff $\mathtt{L}(B)=in$ for some $B \in Ar$ s.t. $(B, A) \in att$.
  - $\mathtt{L}(A)=undec$ iff $\mathtt{L}(A) \neq in$ and $\mathtt{L}(A) \neq out$.

ABDUCTION IN ARGUMENTATION FRAMEWORK

Alice: "I think Mary can speak Japanese because she has stayed in Japan."

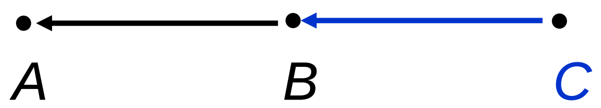
Bob: "I don't think so because her staying in Japan was too short to learn Japanese."

- The situation is represented by the argumentation framework $AF=(\{A,B\}, \{(B,A)\})$ where *A* and *B* represent arguments by Alice and Bob, respectively.

- *AF* has the complete labelling $\{ out(A), in(B) \}$ which means that the argument *A* is **rejected** and the argument *B* is **accepted**.

ABDUCTION IN ARGUMENTATION FRAMEWORK

- In another day, Bob observes that Mary speaks Japanese.
- To explain this, he assumes an argument *C* that Mary studied Japanese hard to be able to speak it well.
- The revised argumentation becomes *AF'* =({*A*,*B*,*C*}, {(*C*,*B*),(*B*,*A*)})



- *AF'* has the complete labelling { *in*(*A*), *out*(*B*), *in*(*C*) } where *A* and *C* are accepted and *B* is rejected.
- It illustrates the situation in which **a new argument is introduced** to explain a new observation.

ABDUCTION IN ARGUMENTATION FRAMEWORK

Alice: "I think the new iPhone will be selling well."

Bob: "I don't think so because few people will get interested in this new model."

- The situation is represented by the argumentation framework $AF=(\{A,B\}, \{(B,A)\})$ where *A* is rejected and *B* is accepted.
- Later it is observed that the new iPhone breaks the sales record. Bob then withdraws his argument *B* and the revised AF becomes $AF' =(\{A\}, \{\})$. Then, *A* is now accepted in *AF'*.
- It illustrates the situation in which **a previously believed argument is removed** in face of a new observation.

UNIVERSAL AF

- The **universal argumentation framework (UAF)** is an argumentation framework (U, att_U) where U is the set of all possible arguments and $att_U \subseteq U \times U$ is the fixed attack relations over U.

- An **agent** has $AF=(Ar, att)$ where $Ar \subseteq U$ and $att = att_U \cap (Ar \times Ar)$.

- The agent has a belief on the labelling of every argument in Ar based on the attack relations in att.

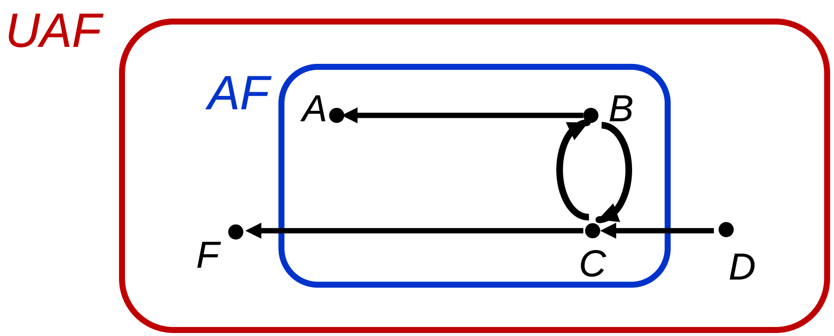
- The agent can recognize the possibility of arguments in $U \setminus Ar$, but does not know whether those arguments are valid or not.

OBSERVATION AND EXPLANATION

- Given $UAF=(U, att_U)$, an **observation** by AF is either
  $O=in(A)$ (there is an evidence for A) or
  $O=out(A)$ (there is an evidence against A)
  for some $A \in U$ such that $(A, A) \notin att_U$.
- An observation O is **skeptically** (resp. **credulously**) **explained** by $E=(I,J)$ under the labelling of AF_E if O is included in every (resp. some) labelling of the argumentation framework $AF_E=(Ar_E, att_E)$ s.t.
  - $Ar_E = (Ar \setminus J) \cup I$ where $I \subseteq U \setminus Ar$ and $J \subseteq Ar$
  - $att_E = att_U \cap (Ar_E \times Ar_E)$.
- An **explanation** $E=(I, J)$ of an observation O is **minimal** if $I' \subseteq I$ and $J' \subseteq J$ imply $I'=I$ and $J'=J$ for any explanation (I', J') of O. An explanation (I, J) is **empty** if $I=J=\{\ \}$.
- O is skeptically (or credulously) **justified** by AF iff O has the skeptical (or credulous) empty explanation.

EXAMPLE

- Let *UAF*=({ *A*,*B*,*C*,*D*,*F* }, { (*B*,*A*), (*B*,*C*), (*C*,*B*), (*D*,*C*), (*C*,*F*) }) and *AF*=({ *A*,*B*,*C* }, { (*B*,*A*), (*B*,*C*), (*C*,*B*) }).



- *AF* has 3 complete labellings: { *in*(*A*), *out*(*B*), *in*(*C*) }, { *out*(*A*), *in*(*B*), *out*(*C*) }, and { *undec*(*A*), *undec*(*B*), *undec*(*C*) }.
- Observations O_1=*in*(*A*) and O_2=*out*(*A*) have the single minimal credulous explanation *E*=({ },{ }).
- O_2 has 2 minimal skeptical explanations E_1=({ }, {*C*}) and E_2=({*D*}, { }).
- O_3=*in*(*F*) has 2 minimal skeptical explanations E_3=({*F*},{*C*}) and E_4=({*D*,*F*},{ }).

MOST PREFERRED EXPLANATION

- An explanation which minimally changes the labelling of the original AF is called a **preferred explanation**. A preferred explanation is **most preferred** if it is also a minimal explanation.

- If an observation *O* has an explanation in *AF*, then there is a most preferred explanation of *O* in *AF*.

- Computation of skeptical/credulous explanations in *AF* is done by transforming *AF* into a **logic program** (see the paper for detail).

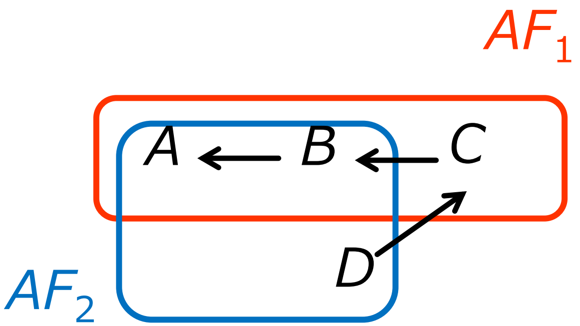
DEBATE GAME (SAKAMA, COMMA 2012)

A **debate game** provides an abstract model of debates between 2 players.

- Each player has background knowledge as an argumentation framework.
- Two players exchange a **claim** of the form:
  (*in*(*A*), _): "an argument *A* is labelled *in*" or
  (*out*(*A*), *in(B*)): "*A* is labelled *out* because *B* is labelled *in*".
- Each player can **learn** a new argument posed by the opponent, then **revises** its own AF by incorporating the new arguments and the corresponding attack relations.
- A player may claim **inaccurate** or even **false** arguments as a tactic to win a debate.

EXAMPLE

- *UAF* = ({ *A*, *B*, *C*, *D* }, { (*D*,*C*), (*C*,*B*), (*B*,*A*) }).
AF_1 = ({ *A*, *B*, *C* }, { (*C*,*B*), (*B*,*A*) }).
AF_2 = ({ *A*, *B*, *D* }, { (*B*,*A*) }).



- AF_1 has the complete labelling:
{ *in*(*A*), *out*(*B*), *in*(*C*) }

- AF_2 has the complete labelling:
{ *out*(*A*), *in*(*B*), *in*(*D*) }.

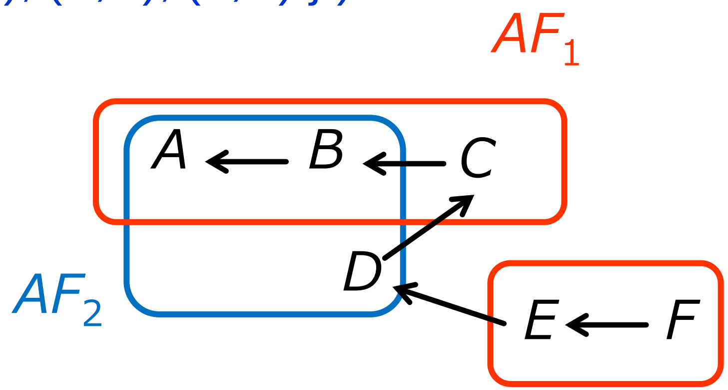
- A debate game for the argument *A* between two players proceeds as follows:

AF_1 : (*in*(*A*), _) "I claim that *A* is *in*"
AF_2 : (*out*(*A*), *in*(*B*)) "*A* is *out* because *B* is *in*"
AF_1 : (*out*(*B*), *in*(*C*)) "*B* is *out* because *C* is *in*"
⇒ Player 2 revises her AF as AF_2 =({ A,B,C,D }, { (D,C), (C,B), (B,A) }).
AF_2 : (out(C), in(D)) "*C* is *out* because *D* is *in*"
⇒ Player 1 revises his AF as AF_1 =({ A,B,C,D }, { (D,C), (C,B), (B,A) }).

- The player 1 cannot refute AF_2 , then the player 2 wins the game.

EXAMPLE

- *UAF* = ({ *A, B, C, D, E, F* }, { (*F,E*), (*E,D*), (*D,C*), (*C,B*), (*B,A*) }).
AF_1 = ({ *A, B, C, E, F* }, { (*F,E*), (*C,B*), (*B,A*) }).
AF_2 = ({ *A, B, D* }, { (*B,A*) }).



- AF_1 has the complete labelling:
{ *in*(*A*), *out*(*B*), *in*(*C*), *out*(*E*), *in*(*F*) }

- AF_2 has the complete labelling:
{ *out*(*A*), *in*(*B*), *in*(*D*) }.

- Suppose the debate game for the argument *A* :

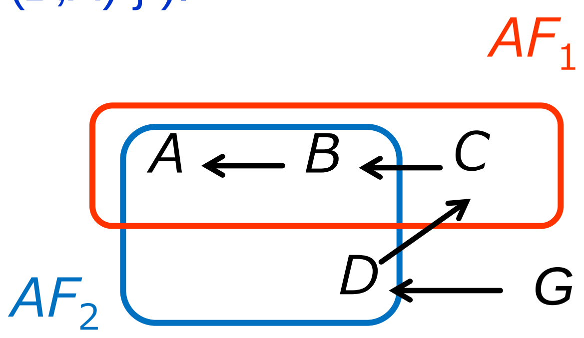
AF_1 : (*in*(*A*), _) "I claim that *A* is *in*"
AF_2 : (*out*(*A*), *in*(*B*)) "*A* is *out* because *B* is *in*"
AF_1 : (*out*(*B*), *in*(*C*)) "*B* is *out* because *C* is *in*"
AF_2 : (*out*(*C*), *in*(*D*)) "*C* is *out* because *D* is *in*"
AF_1 : (*out*(*D*), *in*(*E*)) "*D* is *out* because *E* is *in*"

- The player 2 cannot refute AF_1 , then the player 1 wins the game.

- The player 1 provides a false argument on *E* because *E* is *out*.

EXAMPLE

- $UAF = (\{A, B, C, D, G\}, \{(G,D), (D,C), (C,B), (B,A)\})$.
$AF_1 = (\{A, B, C\}, \{(C,B), (B,A)\})$.
$AF_2 = (\{A, B, D\}, \{(B,A)\})$.



- AF_1 has the complete labelling:
{ *in*(*A*), *out*(*B*), *in*(*C*) }

- AF_2 has the complete labelling:
{ *out*(*A*), *in*(*B*), *in*(*D*) }.

- Suppose the debate game for the argument *A* :

AF_1 : (*in*(*A*), _) "I claim that *A* is *in*"
AF_2 : (*out*(*A*), *in*(*B*)) "*A* is *out* because *B* is *in*"
AF_1 : (*out*(*B*), *in*(*C*)) "*B* is *out* because *C* is *in*"
AF_2 : (*out*(*C*), *in*(*D*)) "*C* is *out* because *D* is *in*"
AF_1 : (*out*(*D*), *in*(*G*)) "*D* is *out* because *G* is *in*"

- The player 2 cannot refute AF_1 , then the player 1 wins the game.

- The player 1 provides an inaccurate argument on *G* because *G* is not in AF_1 .

(DIS)HONEST CLAIMS

Let $UAF=(U, att_U)$ and $AF_i=(Ar,att)$ an AF of a player P_i.

- A claim $(in(A), \_)$ or $(out(B), in(A))$ is **honest** wrt AF_i if $A \in Ar$ and $\mathbf{L}(A)=in$ for some complete labelling $\mathbf{L}$ of AF_i .
- A claim $(in(A), \_)$ or $(out(B), in(A))$ is a **lie** wrt AF_i if $A \in Ar$ and $\mathbf{L}(A) \neq in$ for any complete labelling $\mathbf{L}$ of AF_i .
- A claim $(in(A), \_)$ or $(out(B), in(A))$ is **bullshit** wrt AF_i if $A \in U \setminus Ar$.
- A claim is **dishonest** if it is either a lie or bullshit.

COMPUTING (DISHONEST) CLAIMS BY ABDUCTION

Given a claim (*in*(*A*), _) or (*out*(*B*), *in*(*A*)) made by the player P_1,

- If *O*=*out*(*A*) has the **empty credulous explanation** in AF_2, then a player P_2 can make a **honest claim** (*out*(*A*), *in*(*C*)) that refutes the claim by P_1.
- Else if *O*=*out*(*A*) has no empty credulous explanation but has a **non-empty credulous explanation** *E* in AF_2, then a player P_2 cannot make a honest claim but can make a **dishonest claim** (*out*(*A*), *in*(*C*)) that refutes the claim by P_1.
- Otherwise, if *O*=*out*(*A*) has **no explanation**, then P_2 cannot refute the claim by P_1 and **loses** the game.

STRATEGIES FOR PLAYERS

- Try to make a **honest claim at first**.
- If there is no honest claim that can refute the opponent, make a **dishonest claim**. In this case,
  - **Avoid lie detection** (do not hide arguments which have already been used in previous claims).
  - **Prefer bullshit to lies** (arguments used in lies are believed false while truthfulness of arguments used in bullshit are unknown).