Modeling Emotion in Soar

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Outline

Human emotion can inform intelligent system design

- Inform ‘outer-directed’ behavior
  - Human Computer Interaction
- Inform ‘inner-directed’ behavior
  - Decision making of the intelligent system

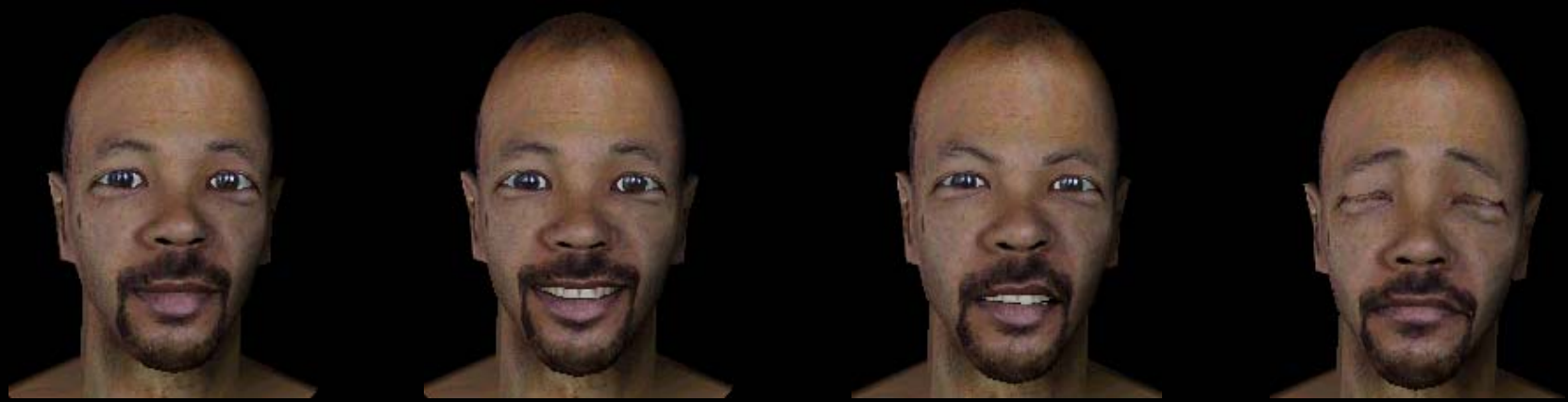
Ground discussion in application

- Mission Rehearsal Exercise system
- Cognitive Appraisal Theory
- Illustrate impact on architecture design

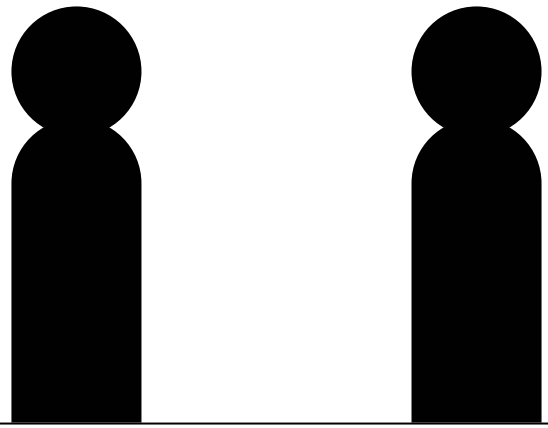
General implications for models of intelligence

Emotion as a External Behavior

- Users readily ‘read’ expressive behaviors
  - Communicate information
  - Can influence the interaction
- Can be leveraged by computer systems



Emotion from Patterns of Movement



People readily attribute (misattribute) emotion and inner beliefs

Effect stronger for anthropomorphic synthetic characters

Rimé, Boulanger, Laubin, Richir and Stroobants (1985)

Example Applications

- Education
  - Learning by teaching [promote framing effects] (Biswas)
  - Tutoring systems [evaluative feedback] (Lester)
  - Social skills training [evoke empathy] (Paiva)
- Psychotherapy
  - Coping with stress [induce emotional state] (Marsella)
  - Safe sex training [induce emotional state] (Miller)
  - Clinician training [evaluative feedback] (Henderson)
  - Social phobias [provoke social stress]
- Law enforcement
  - "Shoot/no-shoot" training [model reality] (Institute of Justice)
  - Interrogation training [model reality] (FBI)
  - Evacuation training [induce trust] (Isbister)

Emotion as Mental Behavior

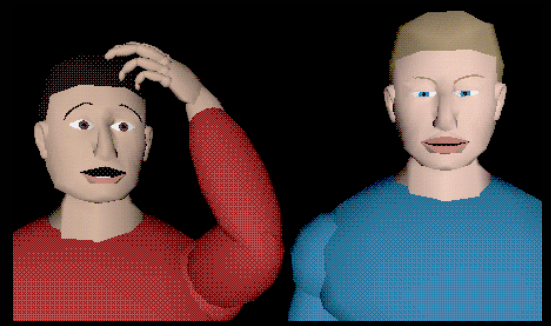
- Emotion influences human mental functions
  - Maintaining Homeostasis
  - Prioritizing goals
  - Focusing mental, sensory resources
  - Influencing beliefs
  - Biasing decision-making
  - Preparing action and reaction
- Can emotion research inform solutions for artificial minds

Grounding: Virtual Humans

- Interactive
  - Perceive the world
  - 'Think' for themselves
  - Speak

Marsella, Johnson & Labore

- Expressive
  - Use expressive behavior to influence or inform user interaction



Mission Rehearsal Exercise

Social Training Simulation

- Explore high-stakes social interactions in safety of VR

  Rickel, Marsella, Traum,
  Hill, Hovy, Johnson, Narayanan, Swartout, …

Mission Rehearsal Exercise

- Team decision-making in crisis situations:
  - Non-scripted real-time interactions
  - Planning, replanning, and plan execution
  - Teamwork, distributed authority and responsibility
  - Collaborative, mixed initiative dialogue
  - Multi-party conversations
  - Verbal and non-verbal communication
  - Emotionally-biased behavior

Mission Rehearsal Exercise

- Assumptions/Limitations:
  - Tightly focused task-related dialogue
  - Near-expert decision makers
  - Stylized vocabulary (military speak)
  - Stylized virtual environment

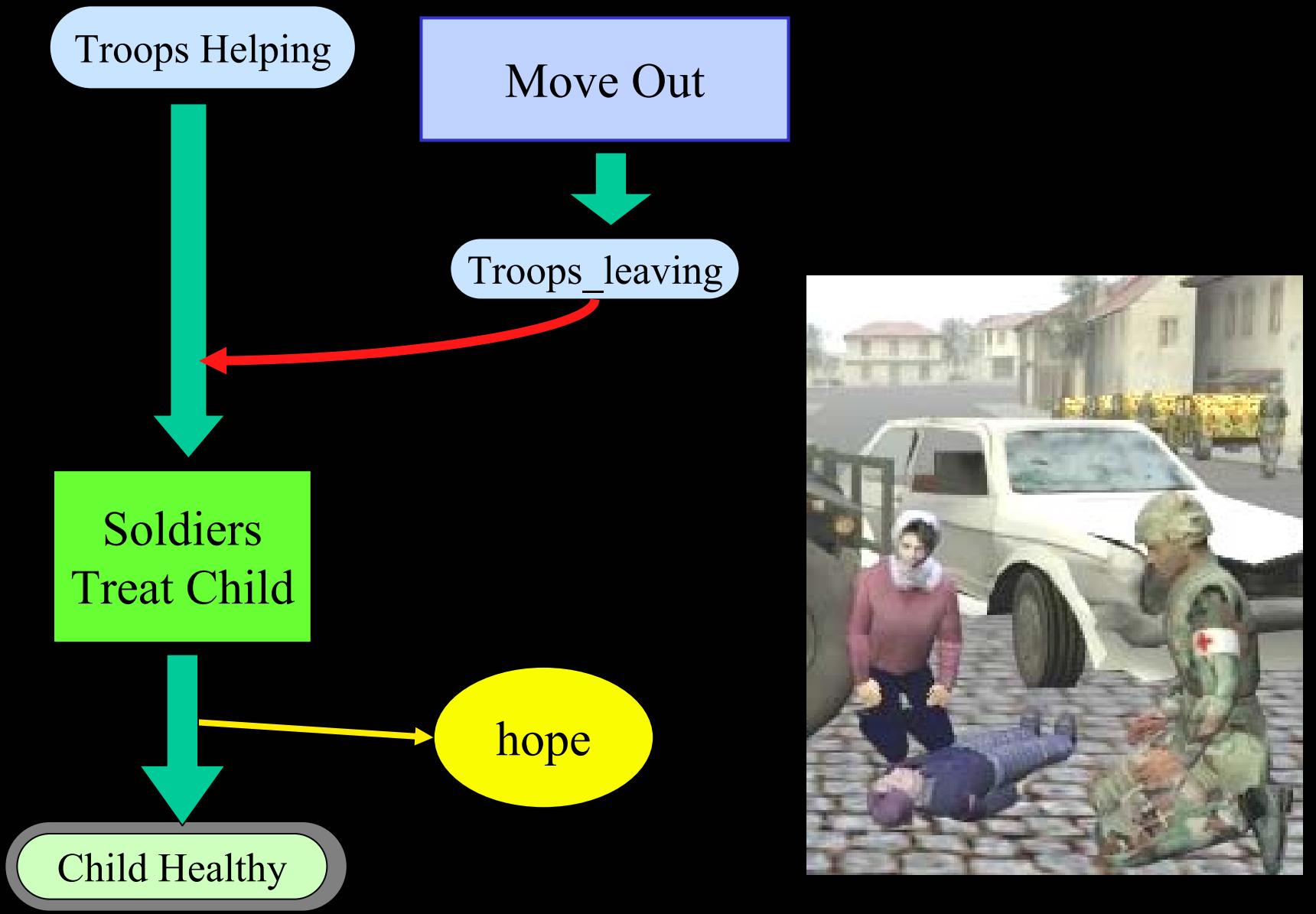
Mother's Plan

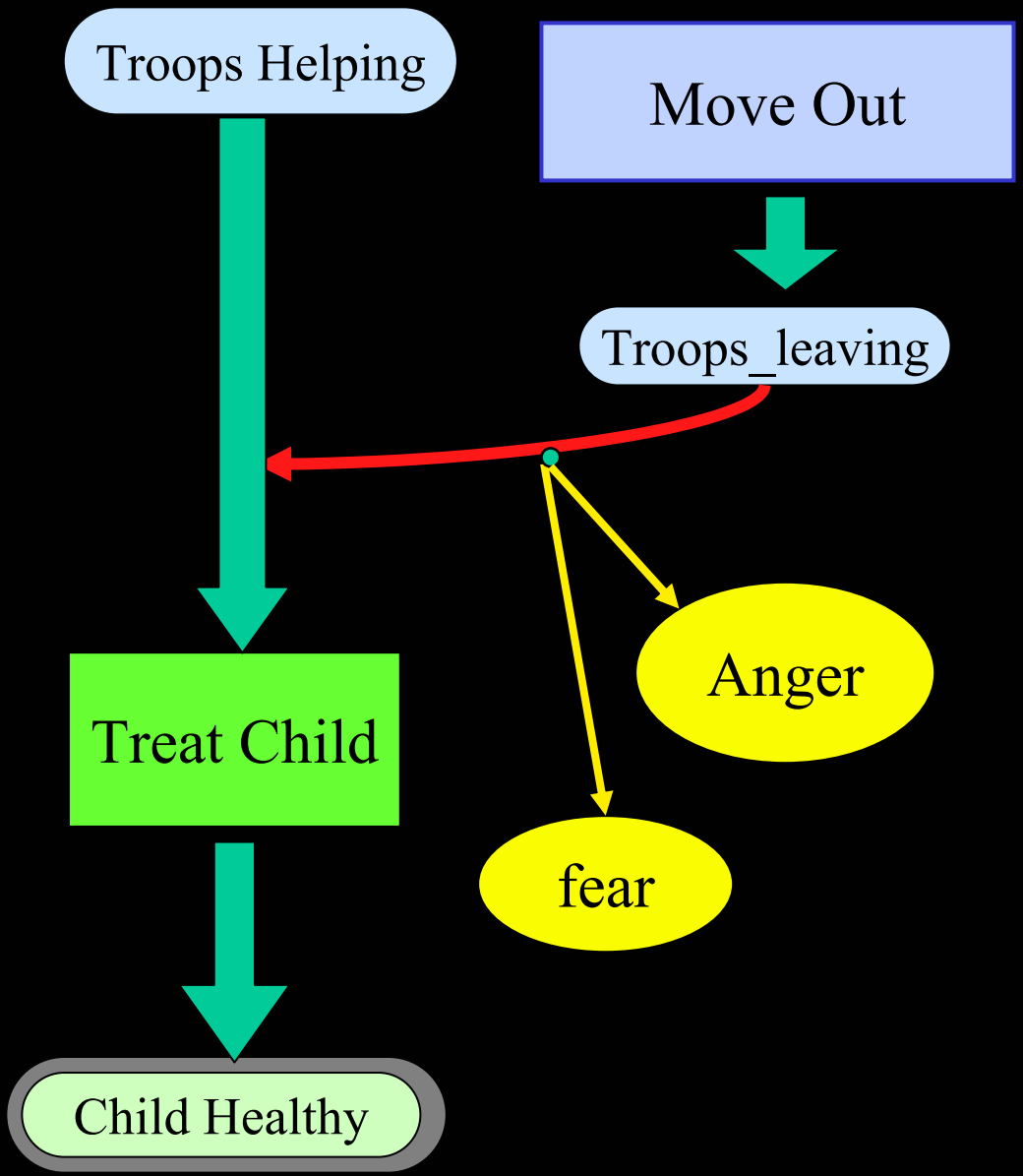
Troops Helping

Soldiers Treat Child

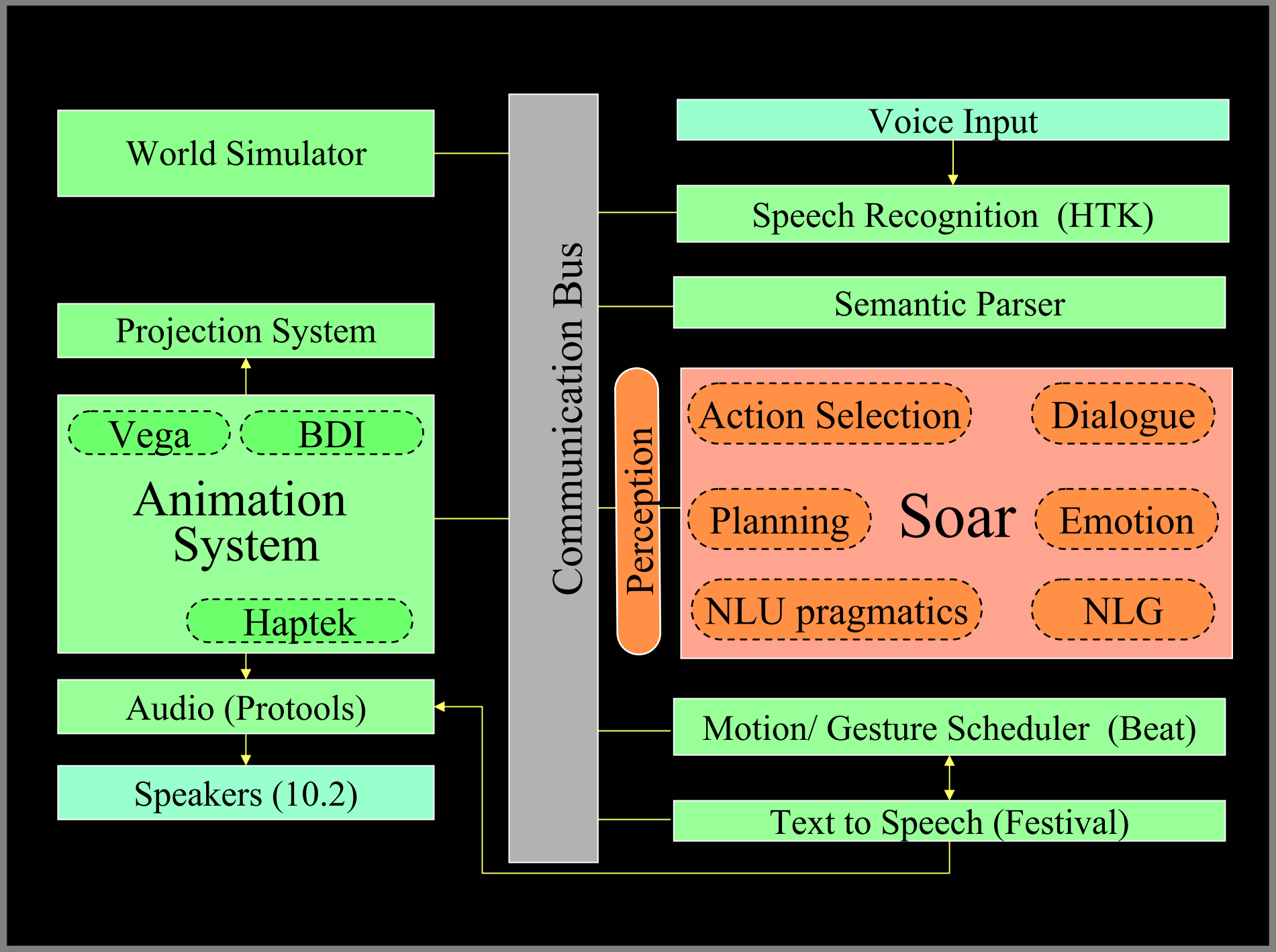
hope

Child Healthy

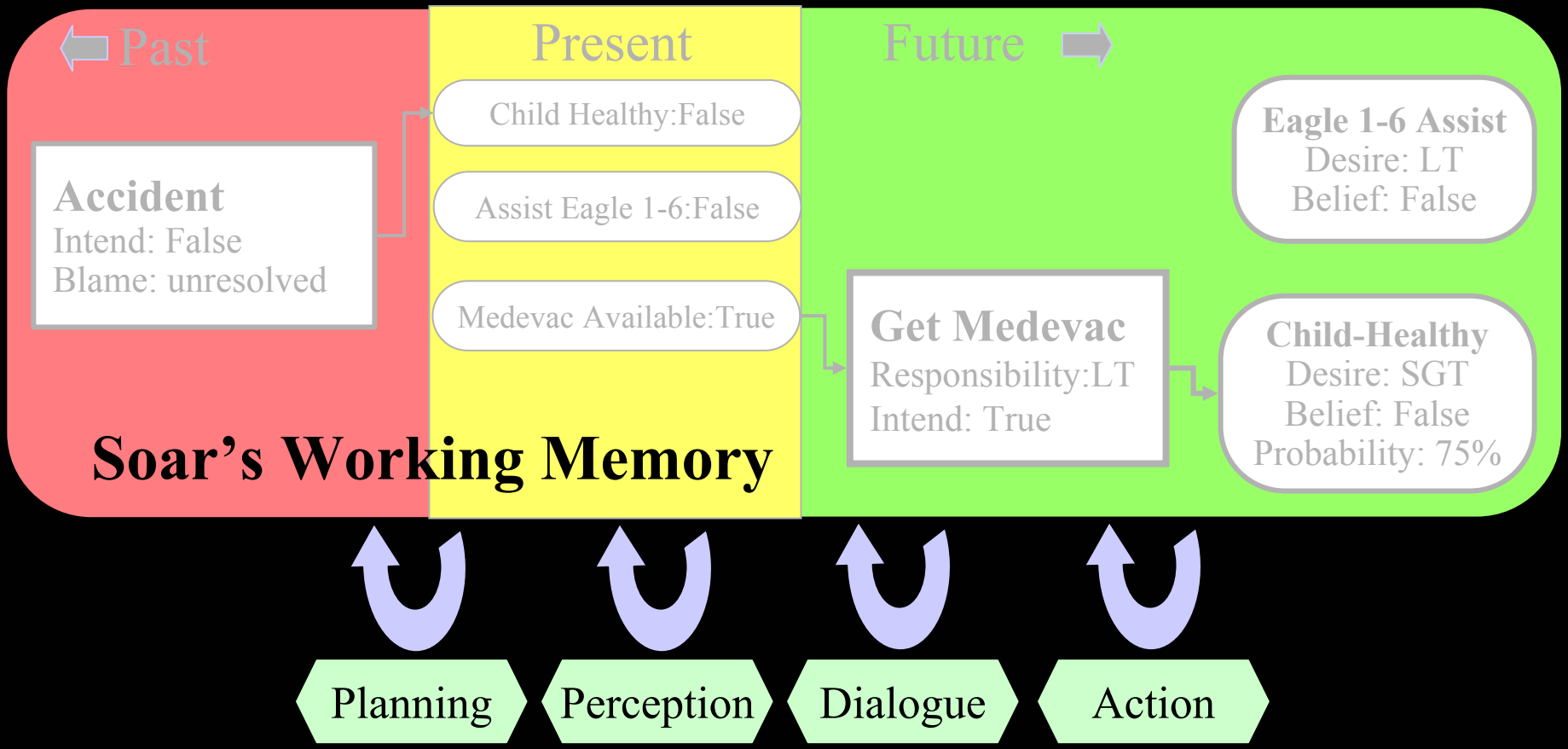

Troops Helping
Move Out
Troops_leaving
Soldiers
Treat Child
hope
Child Healthy


Troops Helping
Move Out
Troops_leaving
Anger
Treat Child
fear
Child Healthy

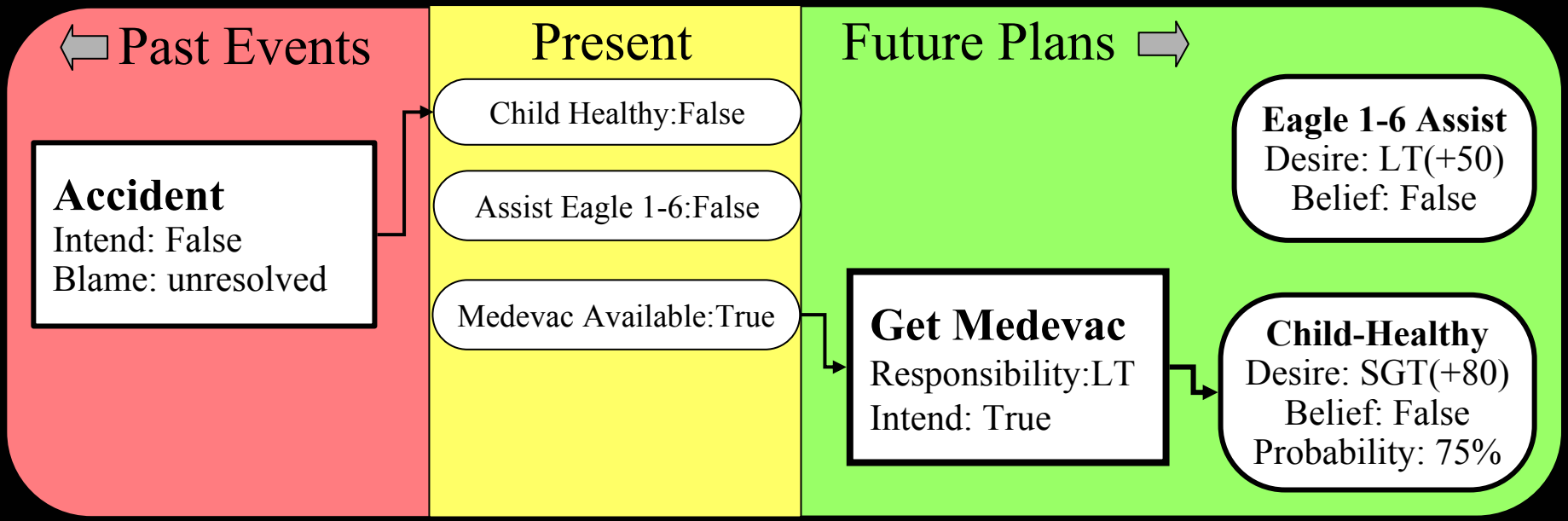
MRE: Leadership Training


World Simulator
Communication Bus
Voice Input
Speech Recognition (HTK)
Semantic Parser
Projection System
Vega
BDI
Animation System
Haptek
Perception
Action Selection
Dialogue
Planning
Soar
Emotion
NLU pragmatics
NLG
Audio (Protools)
Speakers (10.2)
Motion/ Gesture Scheduler (Beat)
Text to Speech (Festival)

Cognitive Representation

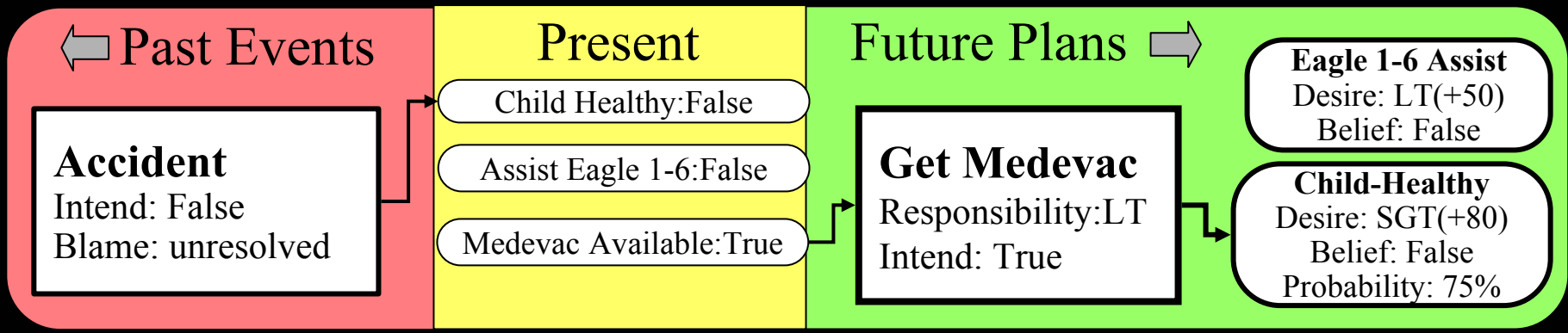


Cognitive Representation



- Causal Interpretation
  - Agent centric subjective view
  - Uniform representation of past, present, future
  - Combines decision-theoretic plans with models of belief and intention

Cognitive Representation



- "Cambridge style"
  - Representation stored on top state
  - Top-state operators change representation (add-step)
  - Almost no subgoaling
- I-supported rules:
  - Detect causal threats
  - Propagate probabilities and utilities
    - Probability action = product of probability of its preconditions

Architectural Role of Emotion

- Began with view "emotion as veneer"
  Ended up as central organizing construct
  - Initial problem:
    - how to convey emotion in *interactive* setting?
  - Built mechanism to infer plausible emotions
    - In response to simulation events
    - In response to user interventions
  - But discovered resolved architectural issues
    - Coherence is more than skin deep
    - Build it and they will come

How to convey emotion

- Mind/Body problem
  - Emotions arises from cognitive assessments
    - Aristotle, et. al
  - Emotions arise from sub-symbolic processes
    - William James, et. al
- Pragmatics
  - Artificial intelligence techniques largely symbolic
    - Planning
    - Explanation
    - Dialogue management
  - My models of emotion colored by technology

How to convey emotion

- Cognitive Appraisal Theory
  - Influential and well-established theory

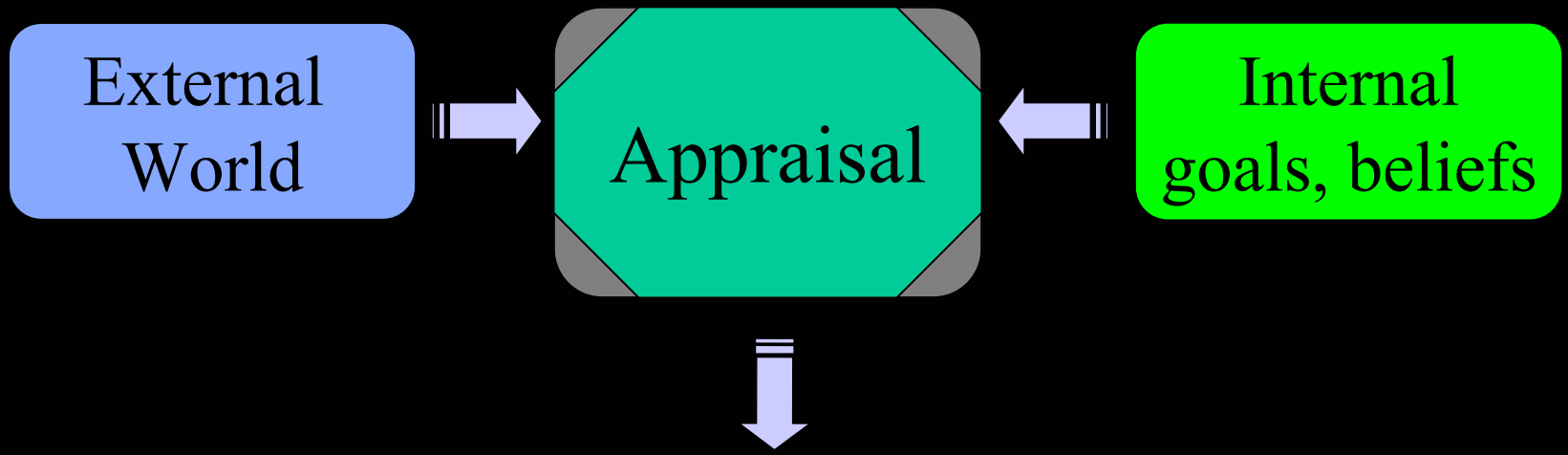
    Arnold, Frijda; Lazarus; Ortony, Clore & Collins; Scherer; Smith

  - Emphasizes tight coupling between
    - Emotion
    - Cognition
    - Motivation

Smith and Lazarus' cognitive-motivational-emotive system

Cognitive Appraisal Theory

Appraisal



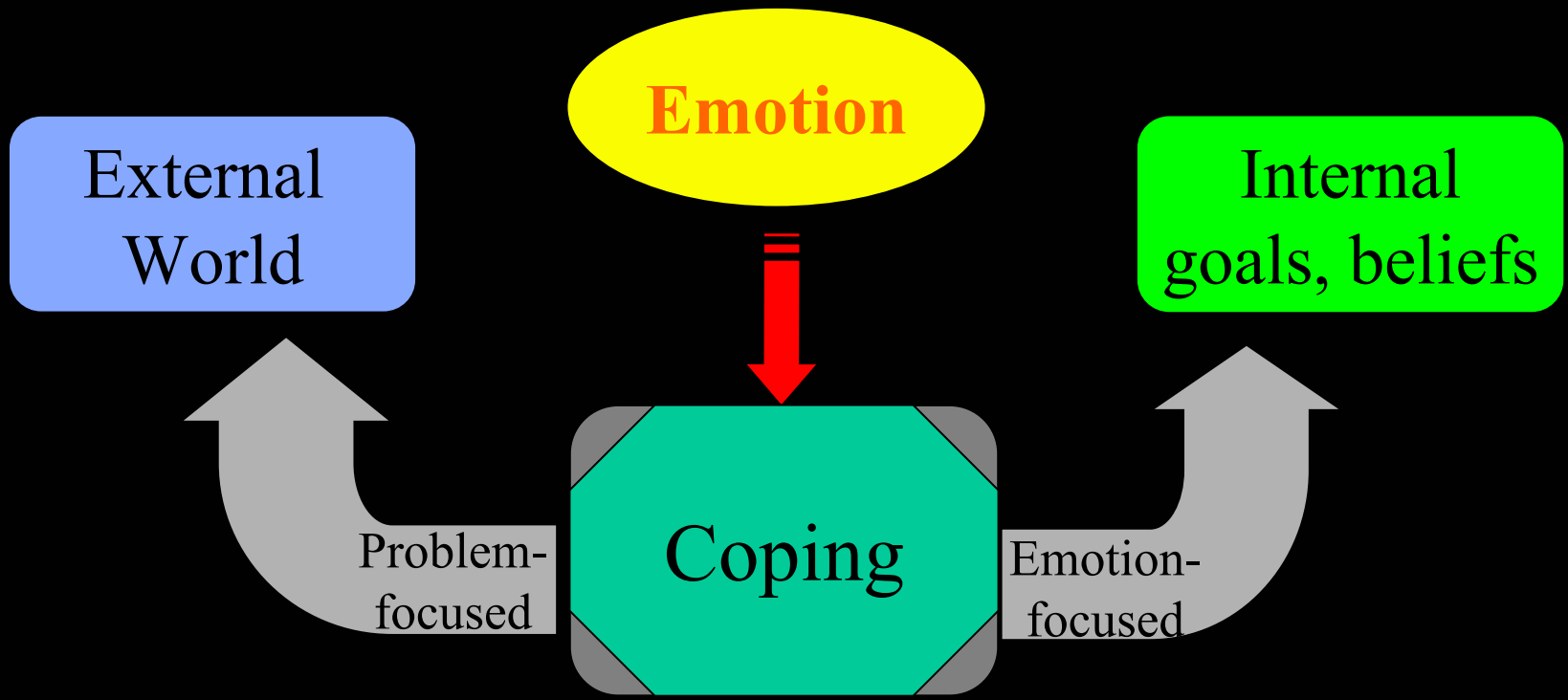
- Appraisal = Situation assessment
  - Compare beliefs, desires and intentions with external circumstances

Appraisal

- Characterize via *appraisal variables*
  - Desirability
  - Likelihood
  - Urgency
  - Unexpectedness
  - Causal attribution (causality, agency, blame/credit)
  - Coping potential (controllability, adaptability)
- Superset of criteria considered by intel systems
  - Decision theory: desirability, likelihood
  - Scheduling: desirability, urgency

Coping Strategies

- Coping = Response strategy
  - Characterized by ontology of coping strategies



Coping Strategies

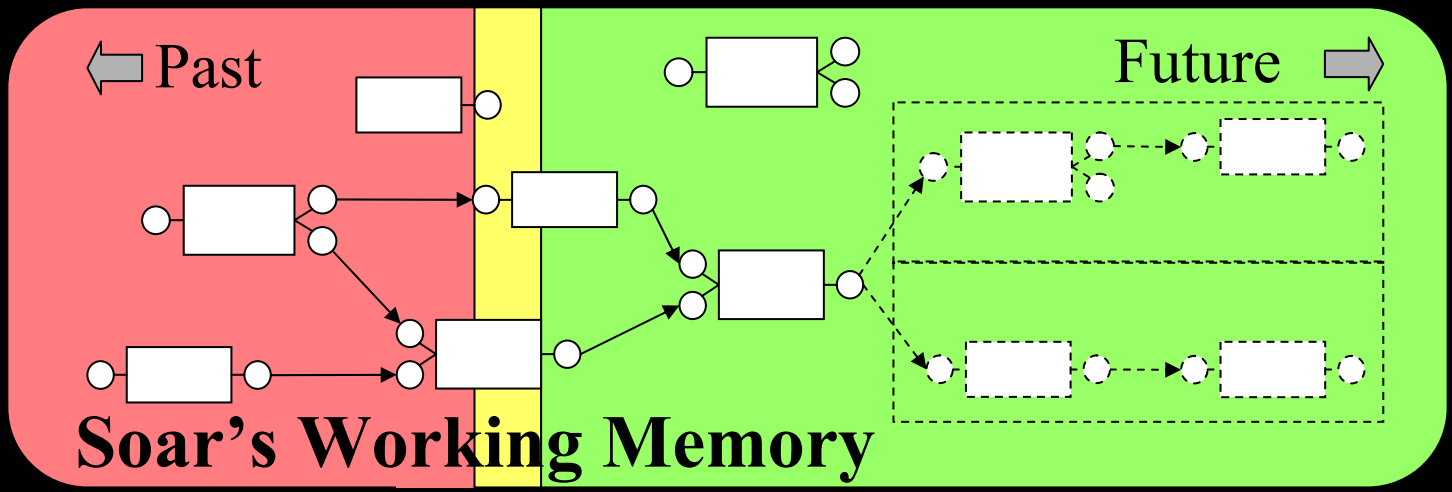
- Problem-focused (act on the world)
  - Action execution
  - Planning
  - Seek instrumental social support

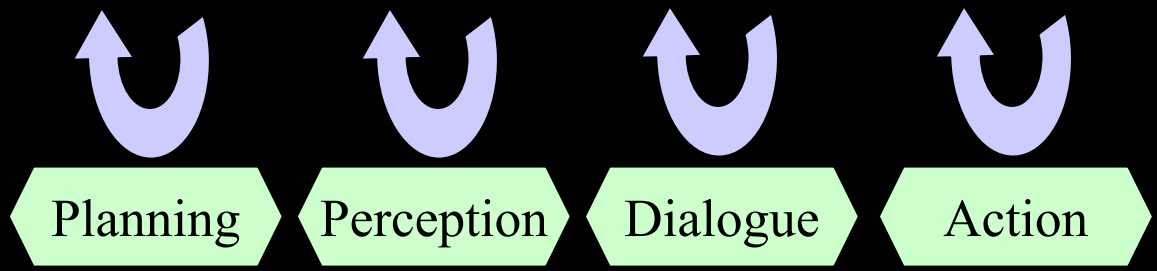
- Analogous to:
  - Deliberative or reactive problem solving
  - Team negotiation

Coping Strategies

- Emotion-focused (act on belief)
  - Denial
  - Find silver lining
  - Shift blame
  - Distancing
- Not typically considered by intelligent systems
  - More than a decision (e.g. abandon current plan)
    - Provides self-justification for why
    - Related to motivational / explanatory coherence
    - Leads to persistent change in behavior

Modeling Appraisal and Coping





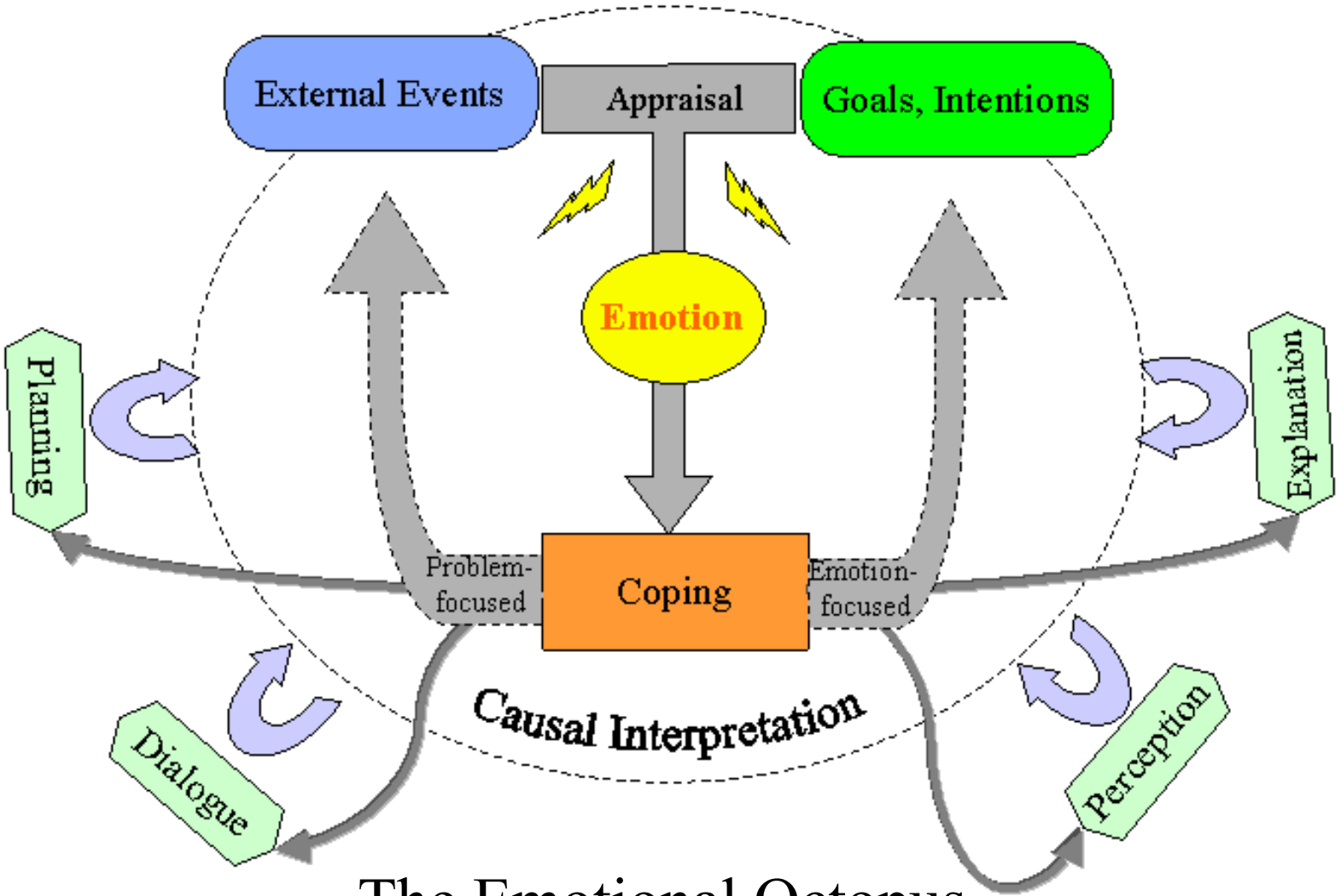
Soar Operators

Modeling Appraisal and Coping

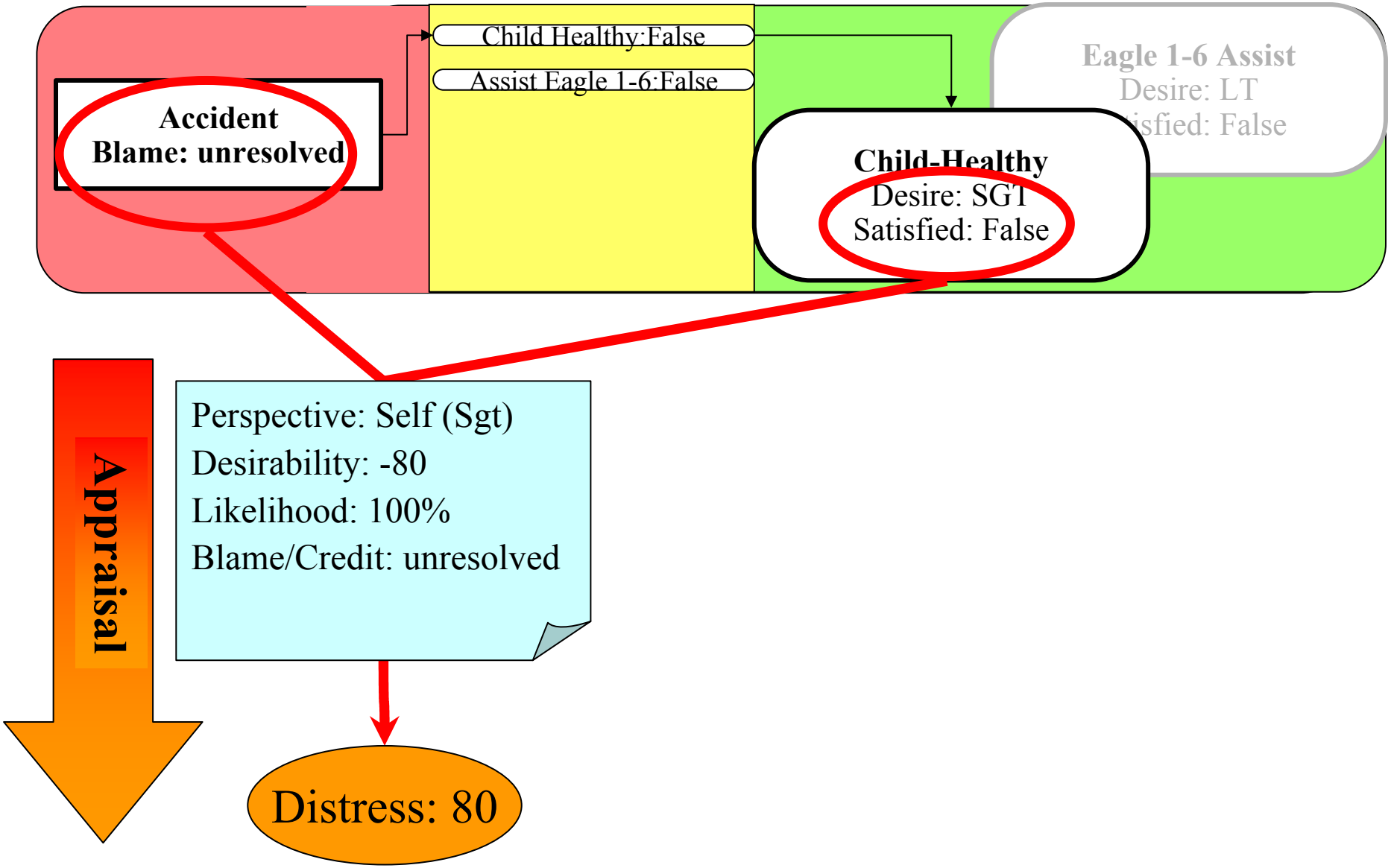
- Appraisal as plan-evaluation
  - Causal interpretation mediates agent-environment relationship
  - Define appraisal variables in terms of features of interpretation
  - Fast, reactive, parallel
- Coping as generalized plan critics

  Map to operators that change interpretation
  - Slow, sequential, deliberate
  - Problem-focused → execute step, add plan step
  - Emotion-focused
    - Denial → Change belief
    - Find silver lining → Change utilities
    - Shift blame → Change causal attribution
      → Dialogue moves
    - Distancing → Drop goal / intention

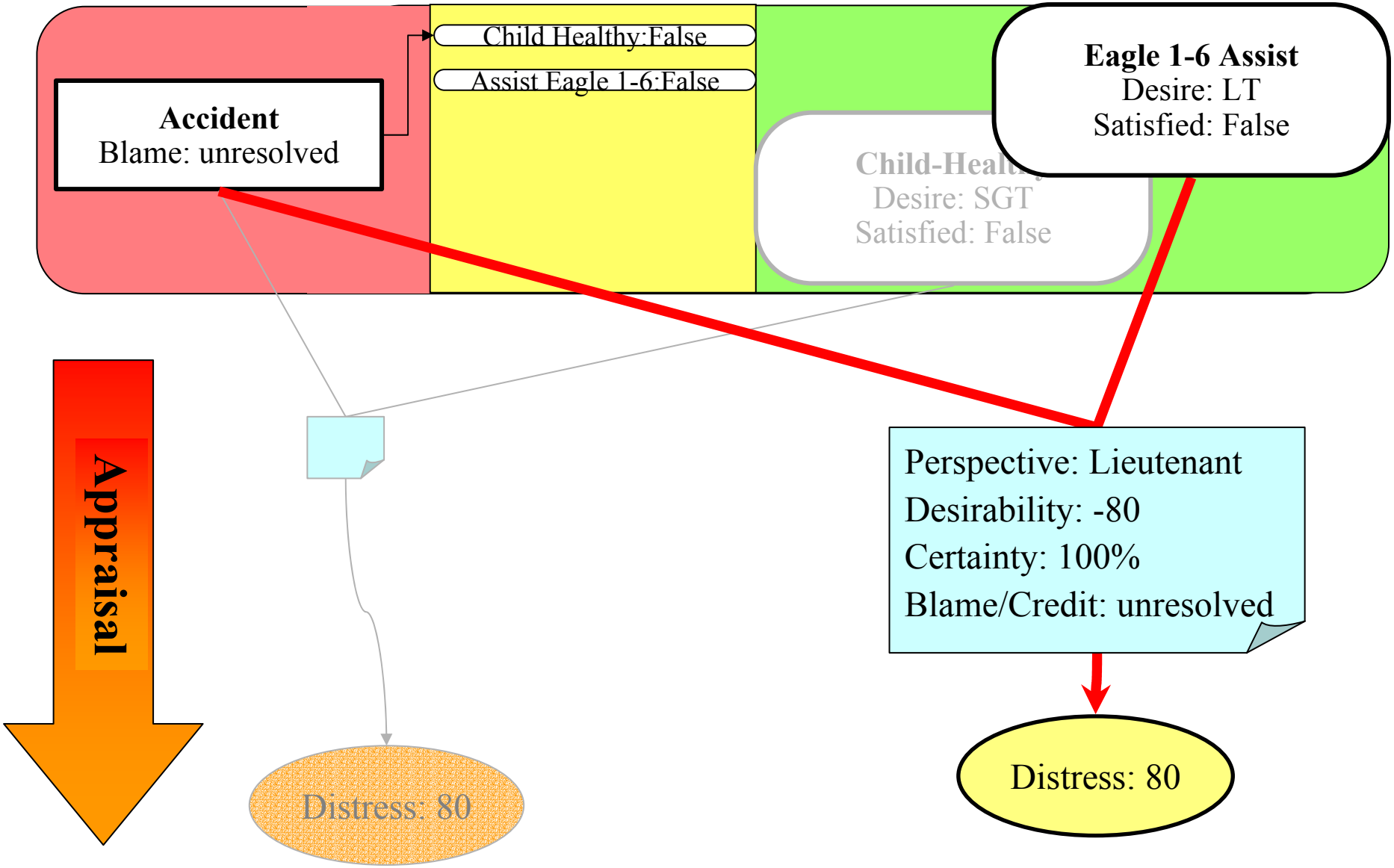
Ema: Architectural Manifestation



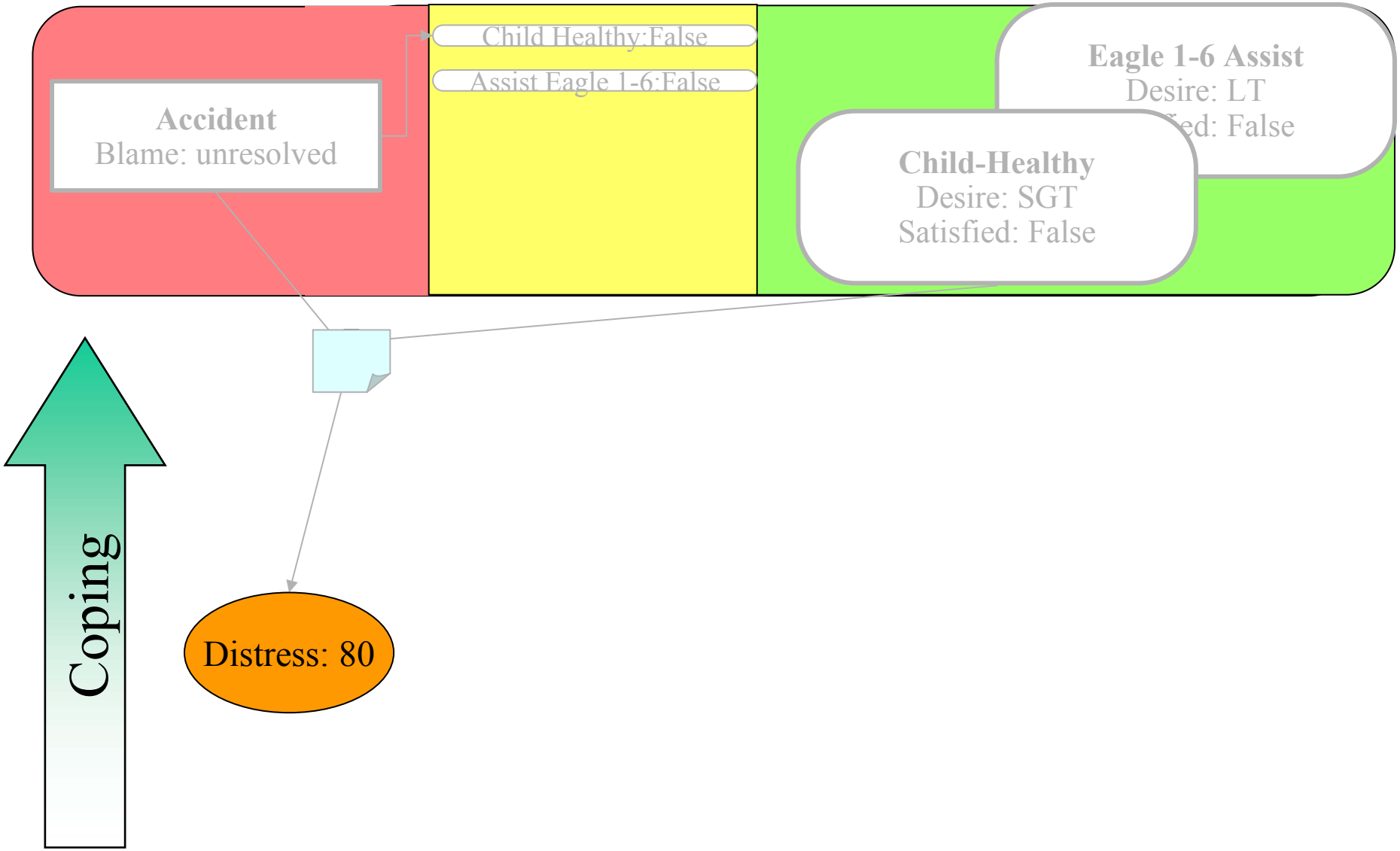
The Emotional Octopus

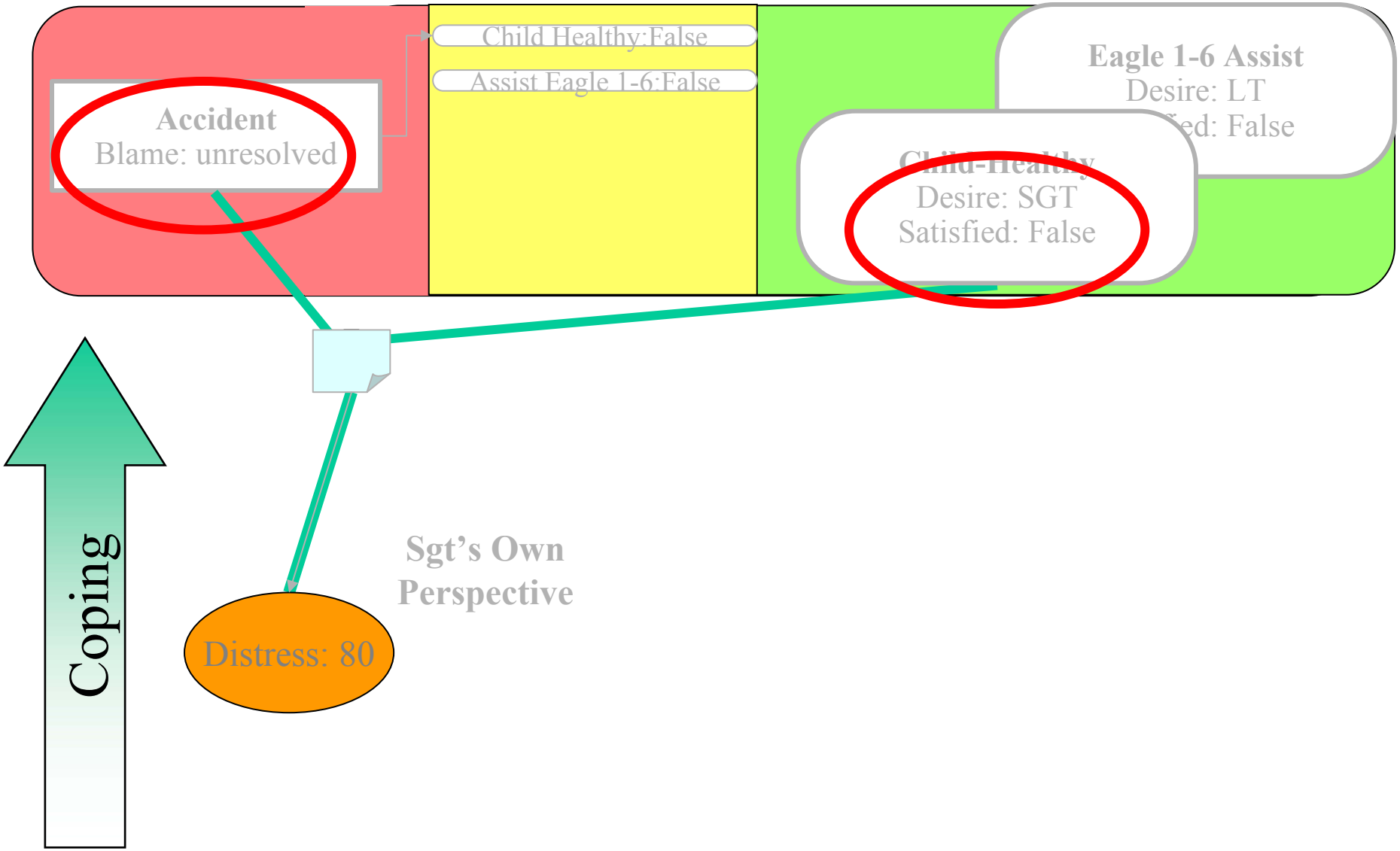


Sgt's Appraisal of Accident from his perspective



Sgt's Appraisal of Accident from Lieutenant's Perspective


Child Healthy:False
Assist Eagle 1-6:False
Accident
Blame: unresolved
Eagle 1-6 Assist
Desire: LT
ed: False
Child-Healthy
Desire: SGT
Satisfied: False
Coping
Distress: 80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Desire: LT
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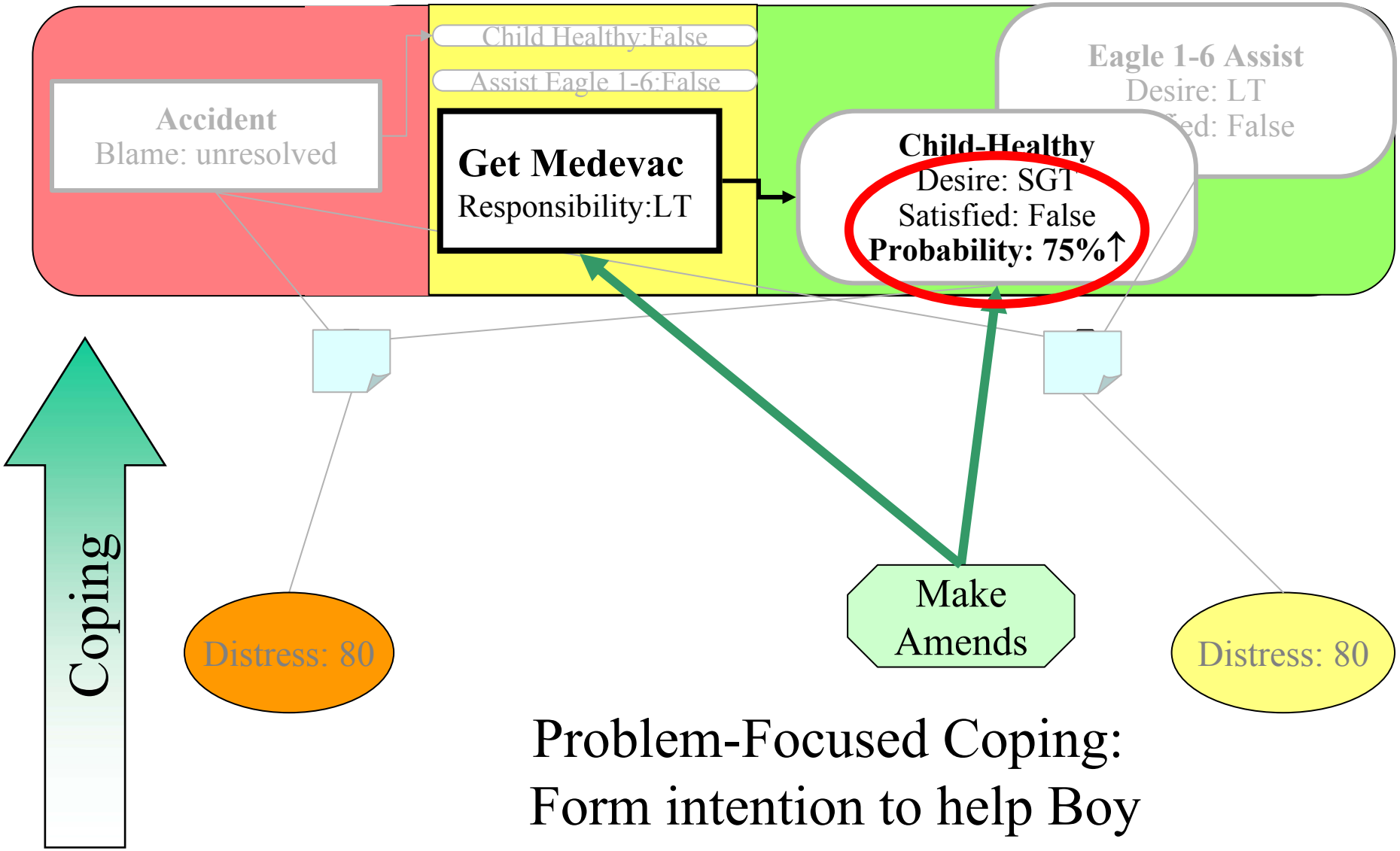
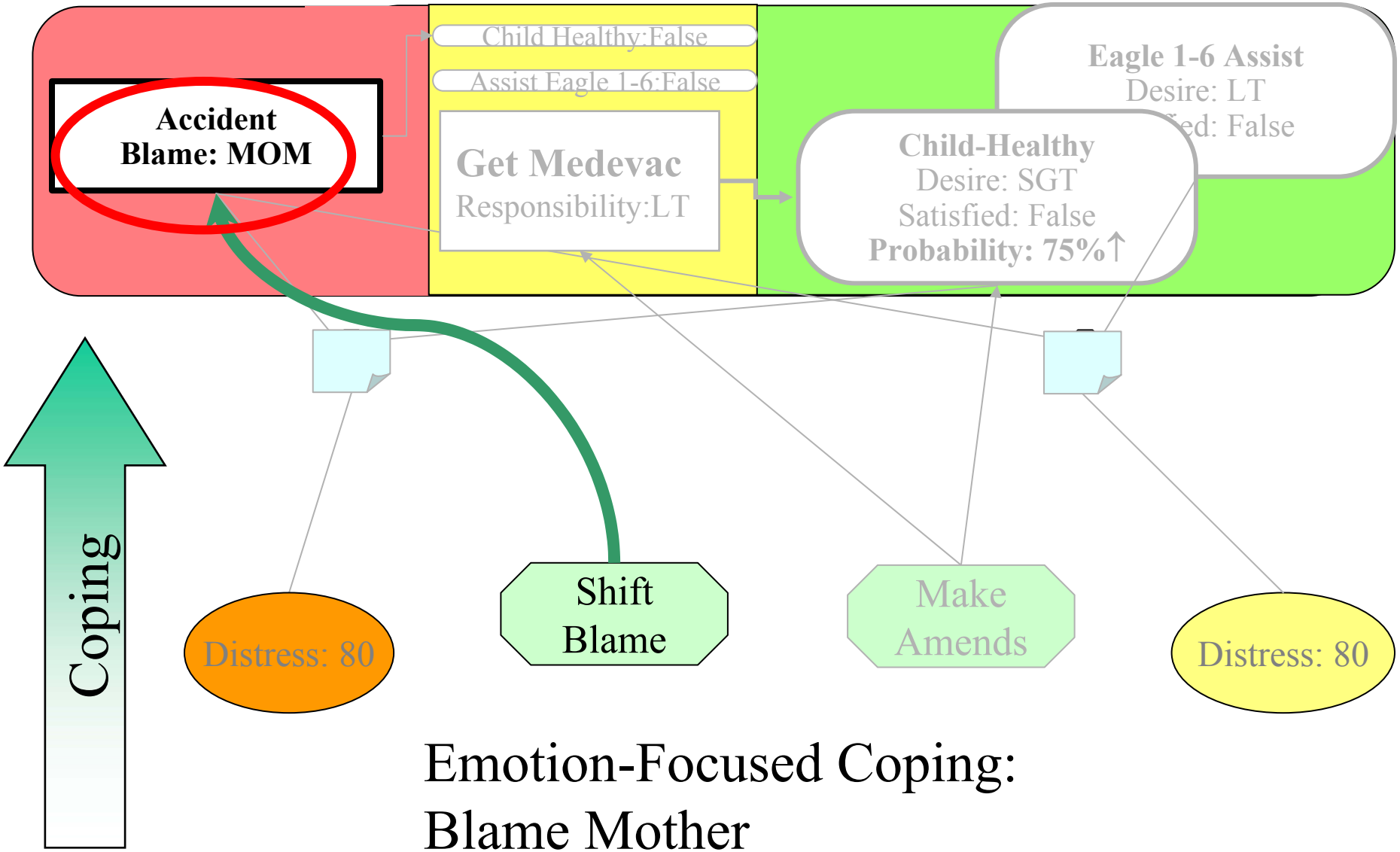
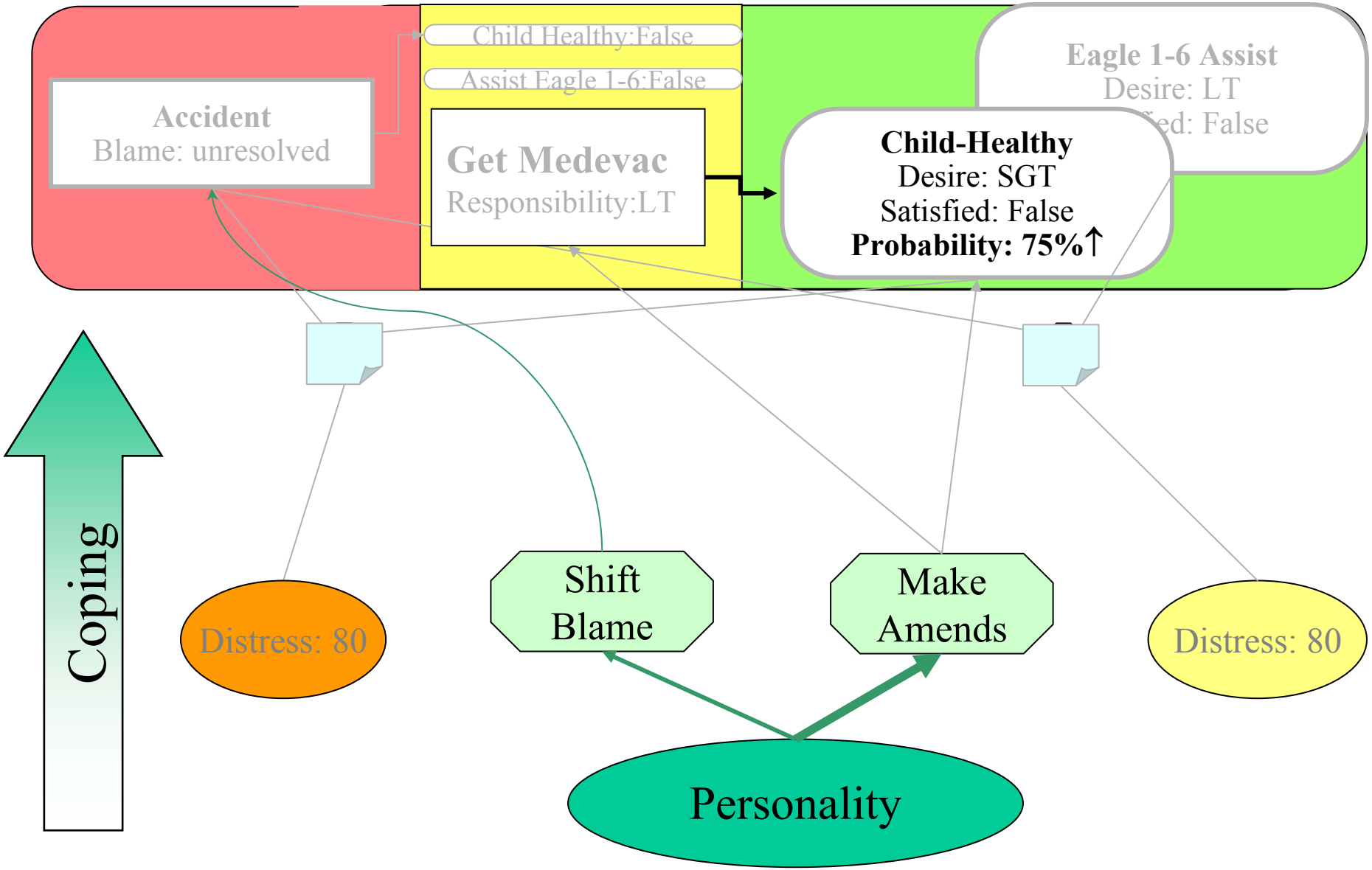
Child-Healthy
Desire: SGT
Satisfied: False
Coping
Sgt's Own
Perspective
Distress: 80



Problem-Focused Coping:
Form intention to help Boy



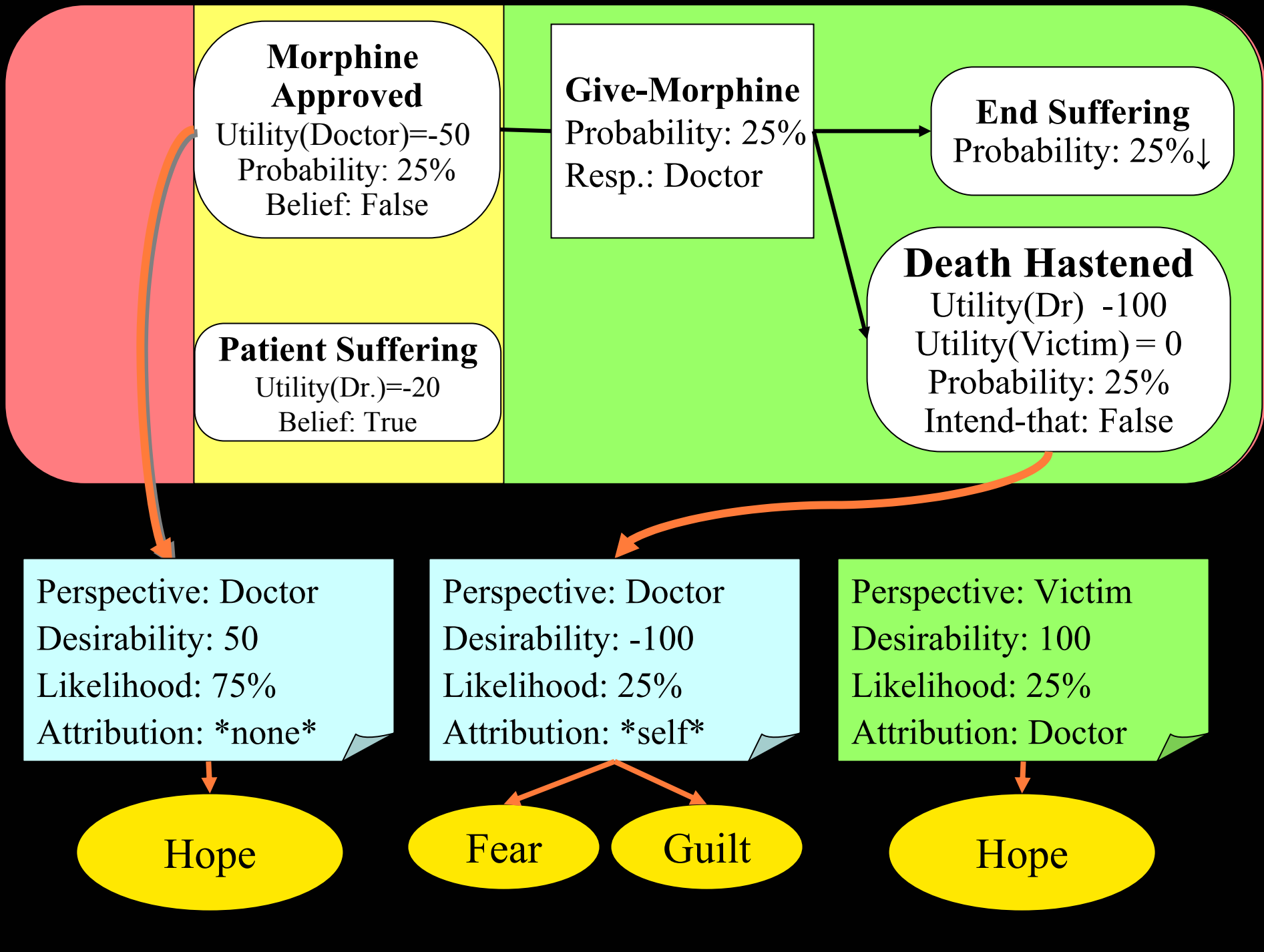
Emotion-Focused Coping:
Blame Mother


Child Healthy:False
Assist Eagle 1-6:False
Accident
Blame: unresolved
Get Medevac
Responsibility:LT
Eagle 1-6 Assist
Desire: LT
Child-Healthy
Desire: SGT
Satisfied: False
Probability: 75%↑
Coping
Distress: 80
Shift Blame
Make Amends
Distress: 80
Personality

MRE: Leadership Training

Focus of attention

- Multiple appraisals simultaneously active
- Which appraisals should impact behavior?
  - all?
  - some average?


Morphine Approved
Utility(Doctor)=-50
Probability: 25%
Belief: False
Give-Morphine
Probability: 25%
Resp.: Doctor
End Suffering
Probability: 25%↓
Death Hastened
Utility(Dr) -100
Utility(Victim) = 0
Probability: 25%
Intend-that: False
Patient Suffering
Utility(Dr.)=-20
Belief: True
Perspective: Doctor
Desirability: 50
Likelihood: 75%
Attribution: *none*
Perspective: Doctor
Desirability: -100
Likelihood: 25%
Attribution: *self*
Perspective: Victim
Desirability: 100
Likelihood: 25%
Attribution: Doctor
Hope
Fear
Guilt
Hope

Focus of attention

- Problem: too much information in memory
  - Could swap stuff in and out of working mem
  - Instead added focus of attention model
    - Soar operator proposals ‘touch’ WME
    - Associate with operator any appraisals associated with those WMEs
    - E.g. to answer “What happened here”, must access all events in causal history
    - Collect appraisals associated with each event
    - Pick most intense appraisal to modify behavior of operator

Focus of attention

- Problem: this too focused
  - Also aggregate all active appraisals into ‘mood’
  - Appraisals feed sub-symbolic layer (TCL)
  - Aggregate state attenuates physical actions
    - Facial expressions
    - Body language
  - Aggregate state also placed on input-link
  - Added to intensity of each appraisal when determining the max appraisal associated with a soar operator

Nuggets

- Lends itself to blackboard style
  - Facilitates integration of cognitive functions
  - Appraisal a fast reflexive process (i-support)
- Coping naturally represented as operator preferences
- Extensive use of JTMS function

- Adequate performance

Coal

- Focus of attention
  - No mechanism for swapping in/out plans/episodes/…
- Unstructured memory a problem
  - Data structure proliferation (spelunking)
  - Unintended interactions between modules
    - Function of Cambridge style?
- Barbie says “math is hard”
- Hard to profile, debug, maintain