

Appraisal, Coping and High Level Emotions Aspects of Computational Emotional Thinking

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ABSTRACT

Turing genius anticipated current research in AI field for 65 years and stated that idea of intelligent machines “cannot be wholly ignored, because the idea of ‘intelligence’ is itself emotional rather than mathematical” (Turing, 1948). This is the second article dedicated to emotional thinking bases. In the first article, the authors (Talanov & Toshev, 2014) created overall picture and proposed framework for computational emotional thinking. They used 3 bases for their work: AI - six thinking levels model described in book “The emotion machine” (Minsky, 2007). Evolutionary psychology model: “Wheel of emotions” (Plutchik, 2001). Neuroscience (neurotransmission) theory of emotions by Lovheim “Cube of emotions” (Lovheim, 2012). Based on neurotransmitters impact the authors proposed to model emotional computing systems. Current work is dedicated to three aspects left not described in first article: appraisal: algorithm and predicates - how inbound stimulus is estimated to trigger proper emotional response, coping: the way human treat with emotional state triggered by stimulus appraisal and further thinking processes, high level emotions impact on system and its computational processes.

Keywords: Affective Computing, AI, Cognitive and Affective Modeling, Cognitive Architecture, Computing Emotions, Machine Thinking, Machine Understanding, Model of Emotional Feedback Loops, Model of Emotions, Neuromodulation, Neurotransmission

INTRODUCTION

There are three bases of computational emotions thinking theory presented in our previous (Talanov & Toshev, 2014) and current article: neuroscience: (Arbib & Fellous, 2004; Berridge & Robinson, 2003; Fellous, 1999; Lovheim, 2012; Plutchik, 2001), computer science: (Breazeal, 2002; Cambria & Hussain, 2012; Cambria, Livingstone, & Hussain, 2012; Kort, Reilly & Picard, 2001; Picard, 1995; Marsella, Gratch, & Petta, 2010; Lin, Spraragen, & Zyda, 2012; Gratch &

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Marsella, 2005; Larue, Poirier, & Nkambou, 2012) and evolutionary psychology: (Plutchik, 2001; Kelly, 2009; Tomkins, 1962, 1963, 1991, 1981).

Overall emotional process was described exhaustively in our previous article (Talanov & Toshev, 2014) and looks like following:

1. Inbound stimulus is appraised non-consciously (affective appraisal)
2. Neuromodulation is triggered and it actually switches the emotional state of the system. System feels emotion
3. Conscious processes are triggered: stimulus cognition with stimulus deliberation, stimulus reflective thinking, stimulus cognition reflection, stimulus cognition self-reflection, stimulus cognition self-conscious reflection (cognitive appraisal)
4. Parallel to conscious processes the instinctive behaviour could be triggered, it influencing the environment
5. Conscious processes described above triggers conscious behaviour and in its turn it influences the environment again

The neuromodulators influence in emotional processes was described in Lovheim article (Lovheim, 2012). We used Plutchik "wheel of emotions" (Plutchik, 2001) as base psychological model of emotions and adopted his emotional feedback loop processes to fit cognitive architecture "model of six" of Marvin Minsky (Minsky, 2007). We developed mapping of *neuromodulators impact on computational processes* (Talanov & Toshev, 2014)

1. Generic:
 - a. Computing power load: dopamine, serotonin
 - b. Computing power distribution: noradrenaline
 - c. Memory distribution (attention): noradrenaline
 - d. Learning: serotonin, dopamine
 - e. Storage: serotonin, dopamine
2. Decision making/reward processing:
 - a. Confidence: serotonin
 - b. Satisfaction: serotonin
 - c. Motivation, wanting: dopamine
 - d. Risky choices inclination: noradrenaline
 - e. Number of options to process: noradrenaline

Thus we identified psychological phenomena of emotions influence on computational processes. This could be used as base for further computational emotional thinking framework. We defined overall architecture of emotional processes but we left several aspects not described for further research. Current article is dedicated to cover those blank spots: emotional appraisal (non-conscious and conscious), coping and influence of high level emotions on computational processes.

ORCHESTRA OF EMOTIONS

Imagine the number of emotions we experience every day, every minute, starting from wake up in the morning till the late evening. Every action or significant change in environment is followed by emotional response. When we were kids and we could not control emotions expressions even

wake up and washing the teeth was an emotional scene. From psychology and neuroscience perspective (Arbib & Fellous, 2004; Fellous, 1999; Plutchik, 2001; Kelly, 2009) we could identify two types of emotional reactions: low level non-conscious (affective appraisal) and high level conscious reactions (cognitive appraisal, cognitive reappraisal, reflective thinking, etc).

Each time any stimulus comes in view of the system it is appraised firstly non-consciously (affective appraisal). Affective appraisal triggers neuromodulation that actually switches emotional state of the system and influences all the further processes. Stimulus is appraised second time consciously (cognitive appraisal). Later the result of cognitive appraisal could trigger coping strategy that in its turn influences environment or emotional state of the system.

The first stimulus triggers affective appraisal which in its turn switches the emotional state of the system from neutral to fear and initiates cognitive appraisal and reflective thinking. Second stimulus triggers second affective appraisal again and switches emotional state of the system from fear to terror and initiates second cognitive appraisal and instinctive coping behavior. Then first cognitive appraisal switches emotional state from terror to fear (system understood that stimulus is not so horrible as it seemed firstly) and initiates conscious coping behavior and cognitive reappraisal. Then reflective thinking terminates cognitive reappraisal and conscious coping and switches emotional state no neutral. Meanwhile instinctive coping acts over environment (for example system could run away from second stimulus that triggered terror) and effect of the action (system is in safe place) is interpreted as third stimulus that triggers affective appraisal again.

This is picture of the constant collaboration of thinking processes (Minsky, 2007), involved in emotional appraisal, coping and reflective thinking. We mapped appraisal processes described in (Smith & Kirby, 2009; Roseman, 1996; Scherer, 2001) over thinking model of six of Marvin Minsky (Minsky, 2007). Orchestra of emotions is a concept that emphasizes constant collaboration of low level instinctive processes with high level learned reactions, deliberative thinking and reflective thinking processes via switching emotional states and initiating/terminating thinking processes. We used orchestra analogy to identify always changing and intermittent nature of thinking processes and their collaboration that eventually combines in emotional personality, like subassemblies of musical instruments combines in overall sound of orchestra.

Appraisal Aspect

An overall appraisal process is depicted in Figure 2.

Figure 1. Orchestra of emotions picture

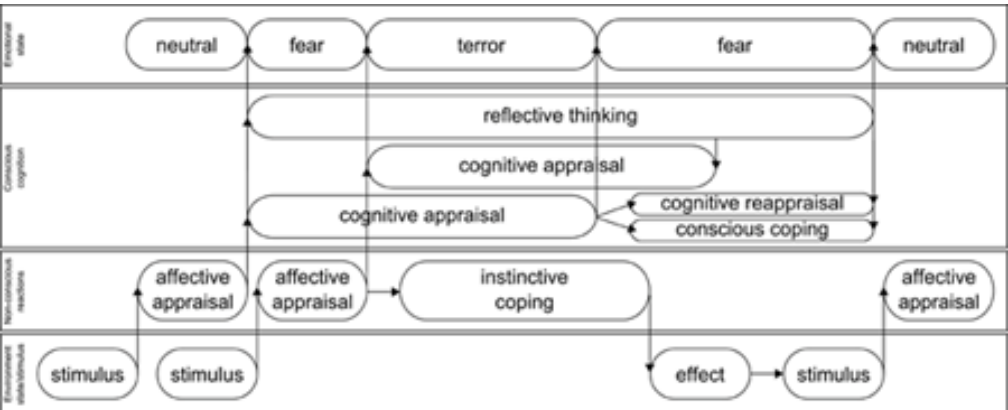
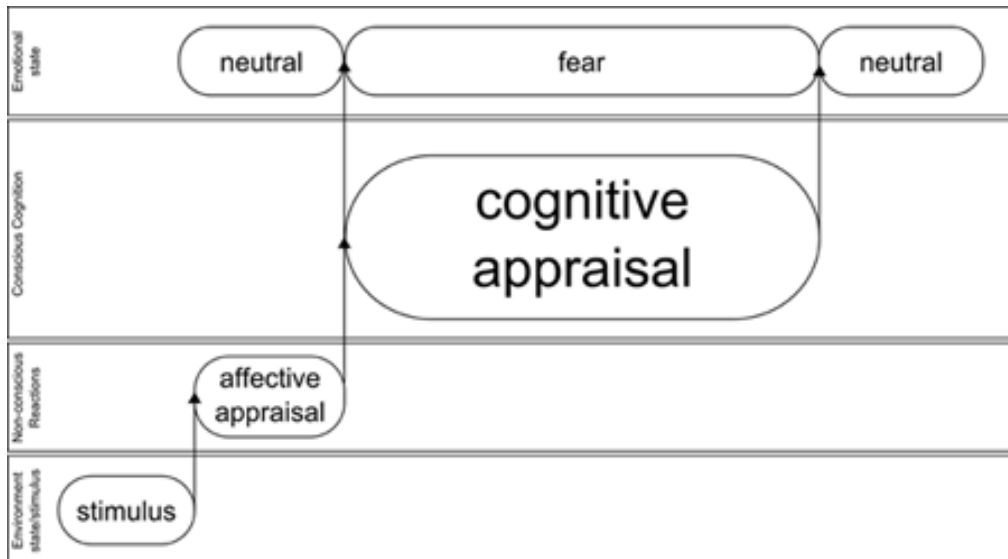


Figure 2. Appraisal and emotional states conscious and non-conscious



We correspond affective appraisal with instinctive layer of Minsky's thinking model (model of six) (Minsky, 2007). This is non-conscious appraisal triggers neuromodulation (Lovheim, 2012) and then cognitive appraisal which in its turn corresponds to learned reactions, deliberative, reflective thinking, self-reflective thinking, self-conscious reflections layers of Minsky's model of six (Talanov & Toshev, 2014). Cognitive appraisal usually is associated with much longer process than instinctive affective appraisals that could influence non-conscious processes (behavior) and emotional state. After this, cognitive reappraisal could change the emotional state taking in account some deliberative thinking of the stimulus and the personality relation with it.

NON-CONSCIOUS APPRAISAL

Lovheim uses Tomkins theory of affects that refer to innate emotional reactions we uses it as appraisal base for non-conscious emotional reactions. Tomkins theory (Tomkins, 1962, 1963, 1991, 1981) includes following affects:

1. Enjoyment/Joy
2. Interest/Excitement
3. Surprise
4. Anger/Rage
5. Disgust
6. Distress/Anguish
7. Fear/Terror
8. Shame/Humiliation

We use affective appraisal described in “A primer of affect psychology” (Kelly, 2009). The main factor that influences affective appraisal is CNS activity that has three main behaviour trends: increase, decrease or stay stable.

According to “A primer of affect psychology” (Kelly, 2009):

1. Quickest increase of brain activity triggers *surprise*, a bit slower increase - *fear/terror*; and most moderate - *interest/excitement*.
2. Moderate steady CNS activity triggers *distress/anguish*, while high steady activity triggers *anger/rage*, both of them negative. It worth to note that the higher distress CNS activity the easier is switch to anger. We could interpret this as following: the longer the person is in distress state the easier he/she could be switched to anger state
3. Decrease of CNS activity is considered as relief and triggers *enjoyment/joy*
4. *Disgust* NEGATIVE affect is inherently punishing and provides us some protection against eating poisonous or rotten food.” We consider this affect as unconditional rejection of inbound stimulus as something directly damaging the system. This could be understood as low level hard-coded predicate to protect system
5. *Shame/humiliation* affect is neither inherently punishing nor rewarding. It is like a computers reset button that rapidly clears the system and prepares us for whatever comes next...

Without the innate affect shame-humiliation, we would not be motivated to take action when we are deprived of interesting and enjoyable things.” This complex affect that appeared to be latest in evolutionary process of humans is triggered when system was prevented to get new interesting information

Conscious Appraisal

We use Tomkins theory that is based on innate affects which we correspond with Plutchik basic emotions (*Plutchik, 2001*). Our main assumption is: conscious and non-conscious appraisal could have different mechanisms for one reason: one is based on innate evolved system of emotions (affects) the later is based on nurture and learning/training and is learned during childhood. In-nate and quick affective appraisal is processed in automatic way mostly insensibly for human, it does not include long term deliberations, learned reactions or reflection thinking. In contrast to affective appraisal, conscious cognitive appraisal includes learned reactions, deliberations and reflective thinking. It could take some significant time that could exceed affective appraisal a few tens of times. These factors, especially involvement of learned reactions mechanisms defines nature of conscious appraisal. We suppose that main mechanism defining the conscious appraisal is nurture/learning of personality to react in some specific way on some specific stimulus. We use Scherer’s approach described in “Appraisal considered as process of multilevel sequential checking” (Scherer, 2001). We also use Plutchik (Plutchik, 2001) as model for conscious emotions. This model consists of 8 basic emotions grouped in pairs.

1. Joy - sorrow
2. Anger - fear
3. Surprise - expectancy
4. Acceptance - disgust

Scherer uses 16 Stimulus Evaluation Checks (SEC), they are organized in 4 groups: relevance detection, implication assessment, coping potential and normative significance. For

comprehensive SECs structure, see appendix. Each of stimulus evaluation checks has following set of possible values:

1. Very low (vl)
2. Low (l)
3. Medium (m)
4. High (h)
5. Very high (vh)
6. Open (o), check does not influences this specific emotion

Except for causal attribution check that has following possible values: intentional (int), other, natural (nat), negligence (neg), chance (ch); discrepancy from expectation check: consonant, dissonant and goal/need conduciveness check: high, obstruct.

Scherer uses 14 words to describe emotions in his analysis:

1. Enjoyment/happiness
2. Elation/joy
3. Displeasure/disgust
4. Contempt/scorn
5. Sadness/dejection
6. Despair
7. Anxiety/worry
8. Fear
9. Irritation/cold anger
10. Rage/hot anger
11. Boredom/indifference
12. Shame
13. Guilt
14. Pride

Scherer discovered 224 appraisal patterns that we used as the base for our appraisal predicates. 14 emotions described in Scherer's article do not match 8 Plutchik basic emotions, there are no: surprise, anticipation and trust. We used linear interpolation following Plutchik's idea to use color theory for representation of emotions to calculate values of SECs for these three basic emotions. Comprehensive list of conscious appraisal patterns/predicates is placed in appendix. Predicates should be considered probabilistic, each level: very low, low, medium, high, very high should be considered as range of the probabilities. Each time stimulus triggers a matching procedure, described in conscious appraisal algorithm section, the closest pattern triggers proper emotion.

Conscious Appraisal Algorithm

Scherer identifies (Scherer, 2001) sequence of appraisal objectives as following:

1. Relevance check including: novelty check, intrinsic pleasantness check, goal relevance check
2. Implication check including: causal attribution check, outcome probability check, discrepancy from expectation check, goal/need conduciveness check, urgency check

3. Coping potential including: control check, power check, adjustment check
4. Normative significance including: internal standards check, external standards check

All included checks are done in parallel during appraisal objectives checks, but objectives checks are done in sequential manner. Result values of checks are stored in so called registers that are updated each time new stimulus appraised.

COPING

The second aspect that is not described in previous article: what is done as response to emotional arousal (switch of emotional state), or how do humans cope with emotions? Marsella and Gratch in their article (Marsella & Gratch, 2003) identified 2 types of coping (emotion-focused coping and problem-focused coping) as main response on emotional arousal and appraisal and mentioned that coping plays central role in causal interpretation and emotional thinking life cycle.

Emotion-Focused Coping

The emotion-focused coping is identified as: “Emotion-focused coping works altering ones interpretation of circumstances, for example, discounting a potential threat or abandoning a cherished goal.” As the result of an emotion-focused coping system should change emotional state without any or with minimal impact over environment.

1. **Positive Reinterpretation:** Look for silver lining.
2. **Acceptance:** Accept stressor as real. Live with it.
3. **Seeking Social Support for Emotional Reasons:** Getting moral support, sympathy.
4. **Denial:** Denying the reality of event.
5. **Behavioral Disengagement:** Admit cannot deal.
6. **Mental Disengagement:** Use other activities to take mind off problem: daydreaming, sleeping.

Stimulus triggers affective appraisal then affective appraisal switches emotional state of the system from neutral to fear, initiates cognitive appraisal and instinctive behaviour. Cognitive appraisal initiates emotion-focused coping, that in its turn switches fear state to neutral (evaluating current situation as not so frightening via positive reinterpretation). Meanwhile instinctive behaviour influences environment and effect of this influence is appraised as stimulus with second affective appraisal.

Problem-Focused Coping

Problem-focused coping is defined in contrast to emotion-focused coping as “... acting on the environment”. Problem-focused coping includes: planning and suppression of competing activities.

Inbound stimulus triggers affective appraisal and it switches emotional state of the system from neutral to fear, then affective appraisal initiates cognitive appraisal. This appraisal usually includes several processes on learned, deliberative, reflective thinking and possibly self-reflective thinking levels. Result of cognitive appraisal and supplemental thinking processes could be understood as problem-focused coping. It worth to note that decision to use specific coping strategy could be gender dependent (Tamres, Janicki, & Helgeson, 2002). Later, during problem focused coping some strategy is selected (for example planning) and used. Actions of the strat-

Figure 3. Emotion-focused coping conscious and non-conscious

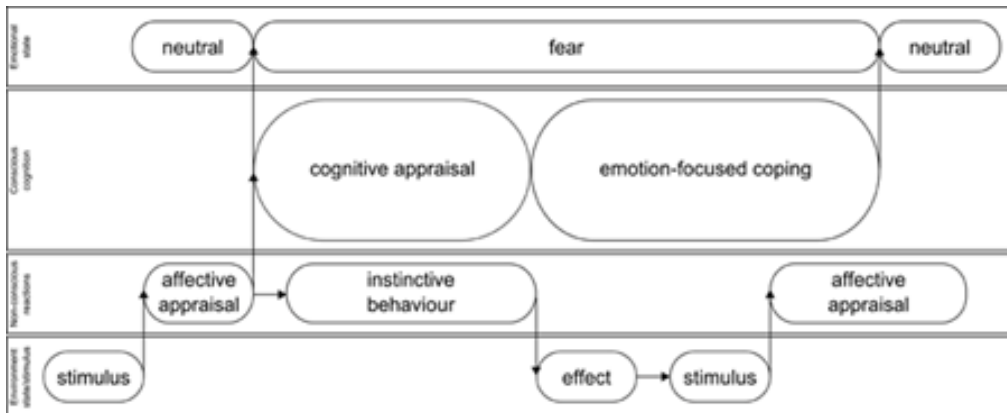
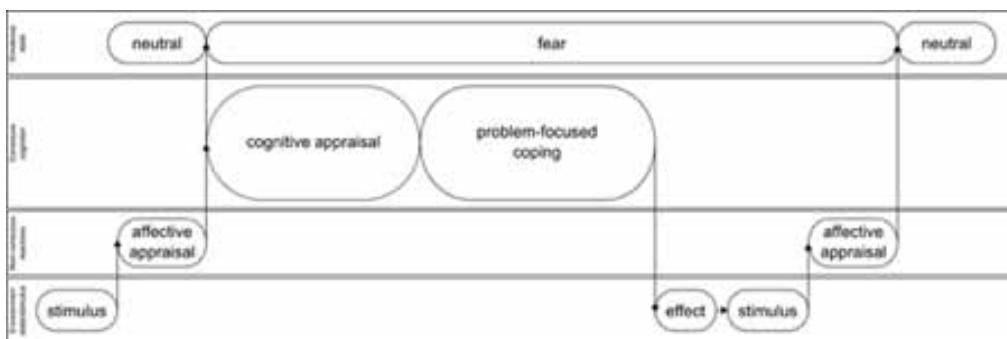


Figure 4. Problem-focused coping conscious and non-conscious



egy changes environment and system now faces effect as new stimulus to be appraised. Second affective appraisal switches system emotional state to neutral as the result of effect evaluation.

In this article we come close to questions of gender influence on decision making and coping strategy selection (Tamres et al., 2002). One more aspect that was not explicitly described here but still has significant influence on appraisal and coping is temperament.

CONCLUSION

In previous article (Talanov & Toshev, 2014) we described overall emotional process in Marvin Minsky cognitive architecture (Minsky, 2007).

We identified two types of appraisal: non-conscious affective and conscious cognitive. First is based on affect theory of Tomkins (Kelly, 2009) and takes in account only innate emotional reactions. Main parameter of non-conscious appraisal is CNS activity that influences appraisal as following:

1. Quickest increase of brain activity triggers *surprise*, a bit slower increase - *fear/terror*; and most moderate - *interest/excitement*

2. Moderate steady CNS activity triggers *distress/anguish*, while high steady activity triggers *anger/rage*
3. Decrease of CNS activity is considered as relief and triggers *enjoyment/joy*
4. *Disgust* - is understood as low level hard-coded predicate to protect system
5. *Shame/humiliation* this complex affect that appeared to be latest in evolutionary process of humans is triggered when system is prevented from getting new interesting information

The conscious appraisal is more complex and includes learned rules. It is based on Scherer sequential appraisal approach (Scherer, 2001). We adopted Scherer's sequential checks to Plutchik "Wheel of emotion" (Plutchik, 2001) model. Complete set of conscious appraisal predicates are listed in appendix. Conscious appraisal algorithm contains 4 steps of appraisal objective checks:

1. Relevance check including: novelty check, intrinsic pleasantness check, goal relevance
2. Implication check including: causal attribution check, outcome probability check, discrepancy from expectation check, goal/need conduciveness check, urgency check
3. Coping potential check including: control check, power check, adjustment check
4. Normative significance check including: internal standards check, external standards check

All included checks are done in parallel during appraisal objectives checks, but objectives checks are done in sequential manner. Result values of checks are stored in so called registers that are updated each time new stimulus appraised.

Coping is based on (Marsella & Gratch, 2003) and includes two main groups: problem-focused and emotion-focused coping strategies. The coping is main mechanism to process emotional state that was triggered during appraisal. It should be mentioned that decision to select specific coping strategy is considered to be done under influence of gender and temperament. Those are still open questions in our work.

We suppose that this work could be used as base of emotional cognitive architecture and could have practical use especially taking in account artificial emotional profiles that could be used in several domains:

1. Advertisement
2. Emotional behavior simulations
3. Robotics
4. Intellectual assistants
5. Estimating human behaviour
6. Caring for humans software and robotics

The social emotion is the core of making robotic agents seem more sympathetic, to make them less cold to interact with. Also, many of the more complex emotions humans exhibit can be traced to evolutionary origins, and human being a social animal. For example, feeling the pain of others is pretty well understood. It makes people help each other and thrive in cooperation. Also, those kinds of emotions make people understand the weights of goals of other people.

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APPENDIX

Comprehensive SECs structure

1. Relevance detection:
 - a. Novelty check:
 - i. Suddenness
 - ii. Familiarity
 - iii. Predictability
 - b. Intrinsic pleasantness check
 - c. Goal relevance
2. Implication assessment:
 - a. Causal Attribution check: intentional(int)/ other/ natural(nat)/ negligence(neg)/ chance(ch)
 - b. Outcome probability check
 - c. Discrepancy from expectation check: consonant/dissonant
 - d. Goal/need conduciveness check: high/obstruct
 - e. Urgency check
3. Coping potential determination
 - a. Control check
 - b. Power check
 - c. Adjustment check
4. Normative significance evaluation:
 - a. Internal standards check
 - b. External standards check

Conscious Appraisal predicates Joy

1. Relevance detection:
 - a. Novelty check:
 - i. Suddenness. = m-h
 - ii. Familiarity. = o
 - iii. Predictability. = l
 - b. Intrinsic pleasantness check. = o
 - c. Goal relevance. = h
2. Implication assessment:
 - a. Causal Attribution check
 - i. Cause: agent. = o
 - ii. Cause: motive. = ch
 - b. Outcome probability check. = vh
 - c. Discrepancy from expectation check. = o
 - d. Goal/need conduciveness check. = vh
 - e. Urgency check. = l
3. Coping potential:
 - a. Control check. = o
 - b. Power check. = o
 - c. Adjustment check. = m
4. Normative significance evaluation:
 - a. Internal standards check. = o
 - b. External standards check. = o

Anticipation

1. Relevance detection:
 - a. Novelty check:
 - i. Suddenness. = m
 - ii. Familiarity. = o
 - iii. Predictability. = l
 - b. Intrinsic pleasantness check. = o
 - c. Goal relevance. = h
2. Implication assessment:
 - a. Causal Attribution check
 - i. Cause: agent. = o
 - ii. Cause: motive. = int
 - b. Outcome probability check. = vh
 - c. Discrepancy from expectation check. = d
 - d. Goal/need conduciveness check. = h
 - e. Urgency check. = m
3. Coping potential:
 - a. Control check. = o
 - b. Power check. = o
 - c. Adjustment check. = o
4. Normative significance evaluation:
 - a. Internal standards check. = o
 - b. External standards check. = l

Anger

1. Relevance detection:
 - a. Novelty check:
 - i. Suddenness. = l-h
 - ii. Familiarity. = l
 - iii. Predictability. = l-m
 - b. Intrinsic pleasantness check. = o
 - c. Goal relevance. = m-h
2. Implication assessment:
 - a. Causal Attribution check
 - i. Cause: agent. = o, other
 - ii. Cause: motive. = int/neg
 - b. Outcome probability check. = vh
 - c. Discrepancy from expectation check. = d
 - d. Goal/need conduciveness check. = ob
 - e. Urgency check. = m-h
3. Coping potential:
 - a. Control check. = h
 - b. Power check. = m-h
 - c. Adjustment check. = h
4. Normative significance evaluation:
 - a. Internal standards check. = o
 - b. External standards check. = l

Disgust

1. Relevance detection:
 - a. Novelty check:
 - i. Suddenness. = o
 - ii. Familiarity. = l
 - iii. Predictability. = l
 - b. Intrinsic pleasantness check. = vl
 - c. Goal relevance. = l
2. Implication assessment:
 - a. Causal Attribution check
 - i. Cause: agent. = o
 - ii. Cause: motive. = o
 - b. Outcome probability check. = vh
 - c. Discrepancy from expectation check. = o
 - d. Goal/need conduciveness check. = o
 - e. Urgency check. = m
3. Coping potential:
 - a. Control check. = o
 - b. Power check. = o
 - c. Adjustment check. = o
4. Normative significance evaluation:
 - a. Internal standards check. = o
 - b. External standards check. = o

Sadness

1. Relevance detection:
 - a. Novelty check:
 - i. Suddenness. = l
 - ii. Familiarity. = l
 - iii. Predictability. = o
 - b. Intrinsic pleasantness check. = o
 - c. Goal relevance. = h
2. Implication assessment:
 - a. Causal Attribution check
 - i. Cause: agent. = o
 - ii. Cause: motive. = cha/neg
 - b. Outcome probability check. = vh
 - c. Discrepancy from expectation check. = o
 - d. Goal/need conduciveness check. = ob
 - e. Urgency check. = l
3. Coping potential:
 - a. Control check. = vl
 - b. Power check. = vl
 - c. Adjustment check. = m
4. Normative significance evaluation:
 - a. Internal standards check. = o
 - b. External standards check. = o

Surprise

1. Relevance detection:
 - a. Novelty check:
 - i. Suddenness. = m
 - ii. Familiarity. = l
 - iii. Predictability. = vl
 - b. Intrinsic pleasantness check. = vl
 - c. Goal relevance. = h
2. Implication assessment:
 - a. Causal Attribution check
 - i. Cause: agent. = oth/nat
 - ii. Cause: motive. = cha/neg
 - b. Outcome probability check. = vh
 - c. Discrepancy from expectation check. = d
 - d. Goal/need conduciveness check. = ob
 - e. Urgency check. = m
3. Coping potential:
 - a. Control check. = vl
 - b. Power check. = vl
 - c. Adjustment check. = m
4. Normative significance evaluation:
 - a. Internal standards check. = o
 - b. External standards check. = o

Fear

1. Relevance detection:
 - a. Novelty check:
 - i. Suddenness. = h
 - ii. Familiarity. = l
 - iii. Predictability. = l
 - b. Intrinsic pleasantness check. = l
 - c. Goal relevance. = h
2. Implication assessment:
 - a. Causal Attribution check
 - i. Cause: agent. = oth/nat
 - ii. Cause: motive. = o
 - b. Outcome probability check. = h
 - c. Discrepancy from expectation check. = d
 - d. Goal/need conduciveness check. = ob
 - e. Urgency check. = vh
3. Coping potential:
 - a. Control check. = o
 - b. Power check. = vl
 - c. Adjustment check. = l
4. Normative significance evaluation:
 - a. Internal standards check. = o
 - b. External standards check. = o

Trust

1. Relevance detection:
 - a. Novelty check:
 - i. Suddenness. = h
 - ii. Familiarity. = vl
 - iii. Predictability. = l
 - b. Intrinsic pleasantness check. = vl
 - c. Goal relevance. = h
2. Implication assessment:
 - a. Causal Attribution check
 - i. Cause: agent. = oth/nat
 - ii. Cause: motive. = ch
 - b. Outcome probability check. = vh
 - c. Discrepancy from expectation check. = c
 - d. Goal/need conduciveness check. = vh
 - e. Urgency check. = m
3. Coping potential:
 - a. Control check. = o
 - b. Power check. = vl
 - c. Adjustment check. = m
4. Normative significance evaluation:
 - a. Internal standards check. = o
 - b. External standards check. = o