

Assessing the validity of appraisal-based models of emotion

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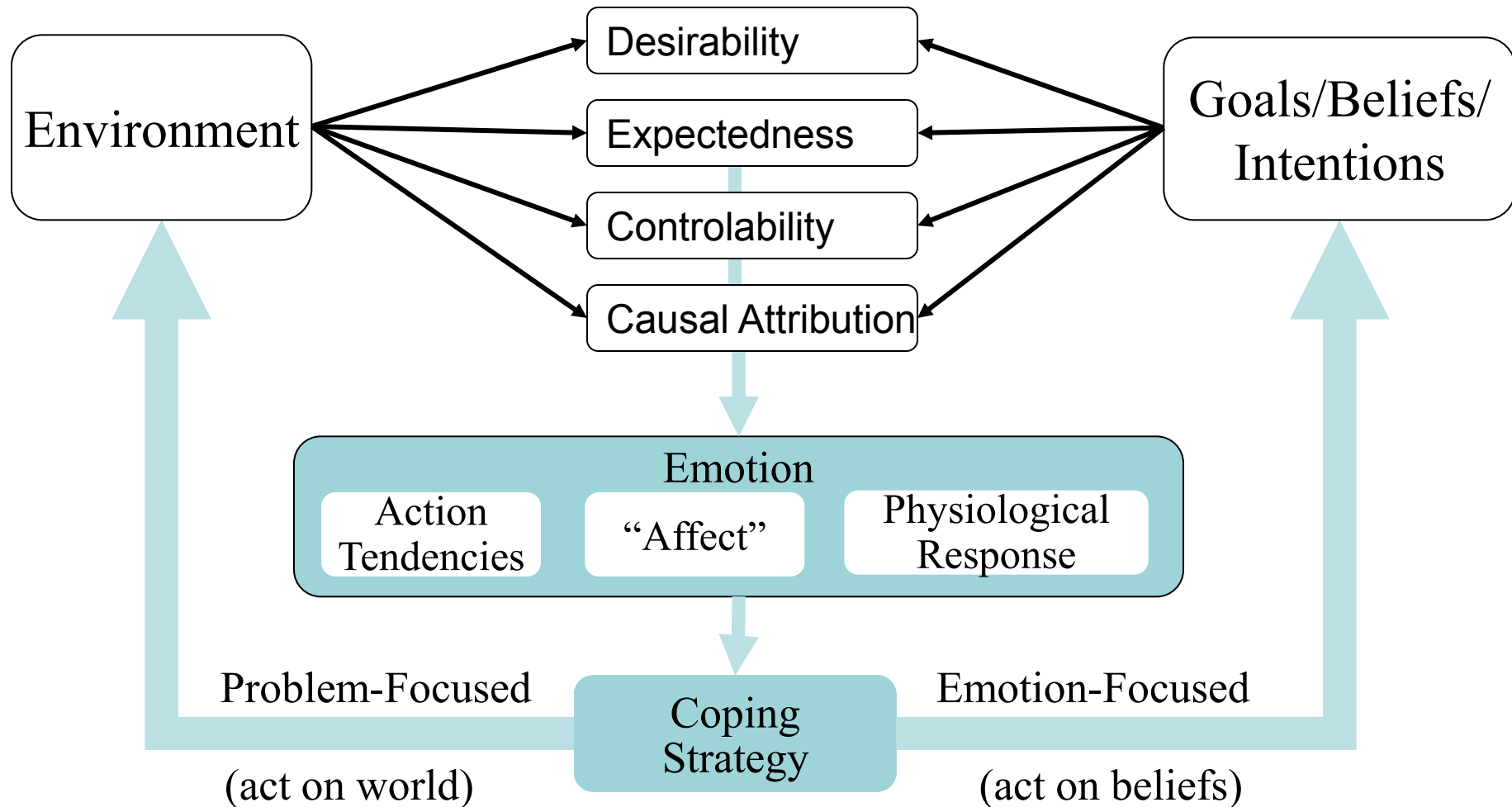
Computational models of human emotion

- **Goal: Build accurate models of cognitive antecedents and consequences of emotion**
 - To enhance predictive power of human decision-making models (Loewenstein & Lerner, 2003; Frank 1988; Busemeyer 2007)
 - To simulating human interpersonal behavior
For training (Swartout et al; Aylett et al; Paiva et al)
 - For user modeling (Conati)
 - Methodological tools for improving theories of emotion (Sanders&Scherer)

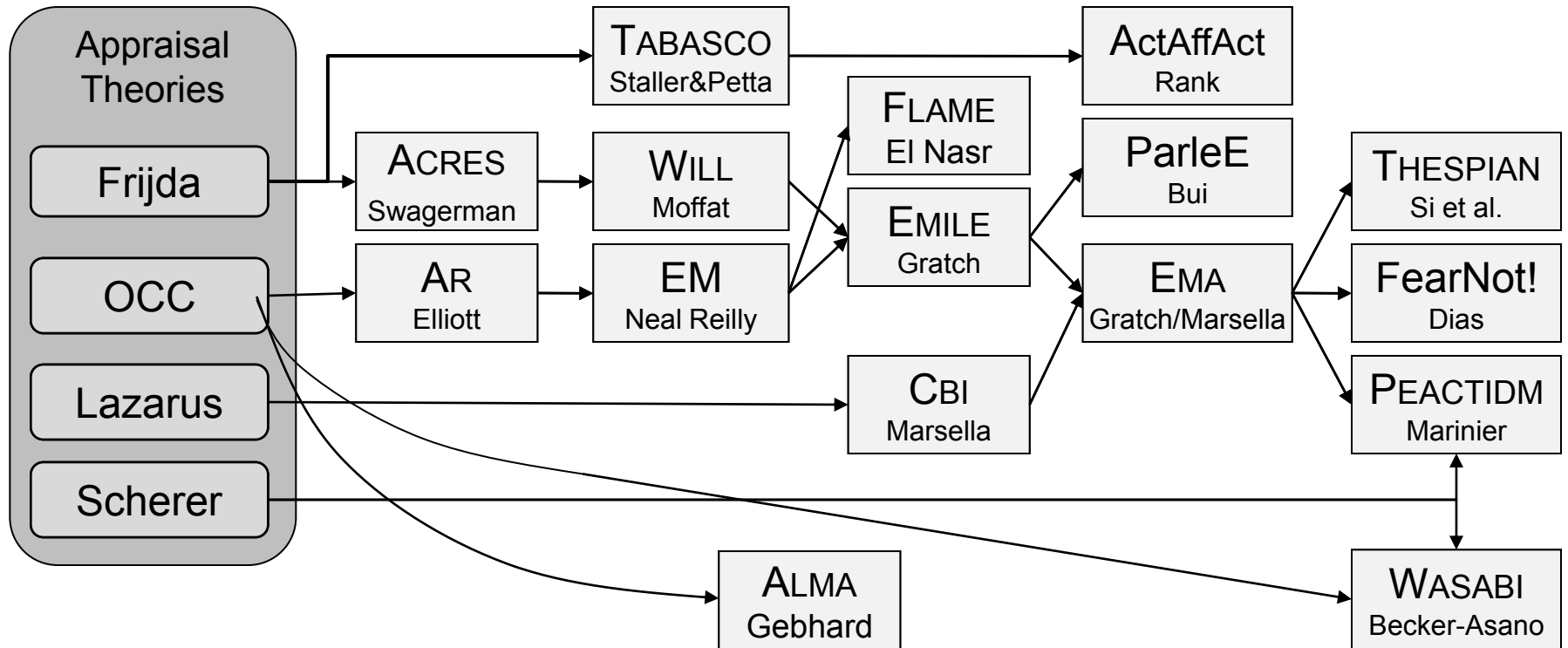


Theoretical Framework: Appraisal Theory

(Arnold, Lazarus, Frijda, Scherer, Ortony et al.)



Computational Appraisal Models



Many models, which is best?

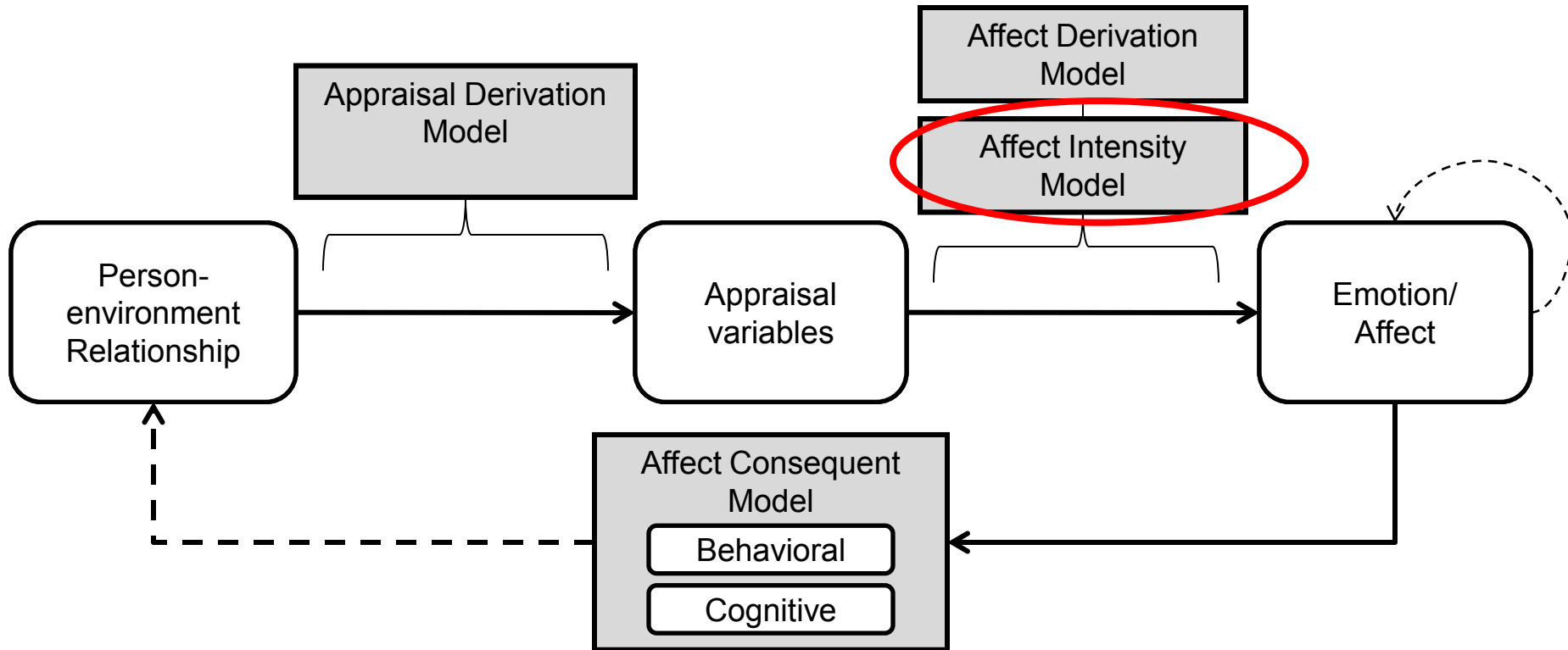
- **Few efforts have systematically evaluated model validity**
- **No efforts have directly compared models**
 - Models typically tested in context of application
 - or
 - Models appeal to empirical support of appraisal theory

BUT don't assess design choices in realizing theory

FURTHER, Models make many conflicting design choices and thus are difficult to directly compare

Our approach: break models into constituent design choices and evaluate these separately

A component model view of appraisal models



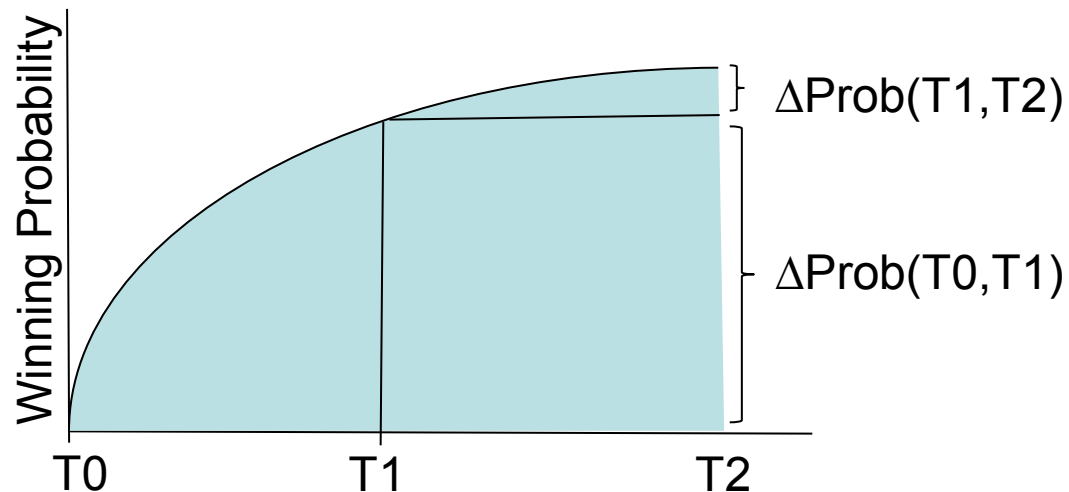
- **Question for today's talk**
 - What is mathematical relationship between appraisal and intensity of emotional response?

Alternative intensity models

Models make different predictions as events change over time

Expected Utility: hope determined by **amount** of certainty (EMA, FearNot!)

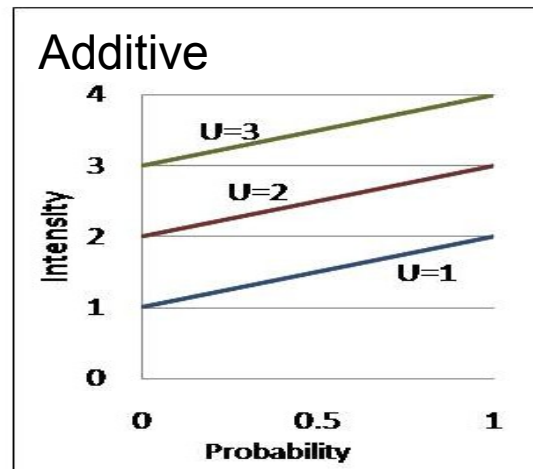
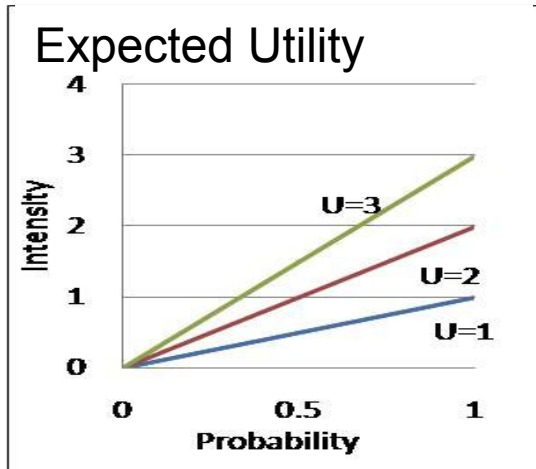
Expectation Change: hope determined by **change** in certainty (EM, PEACTIDM)



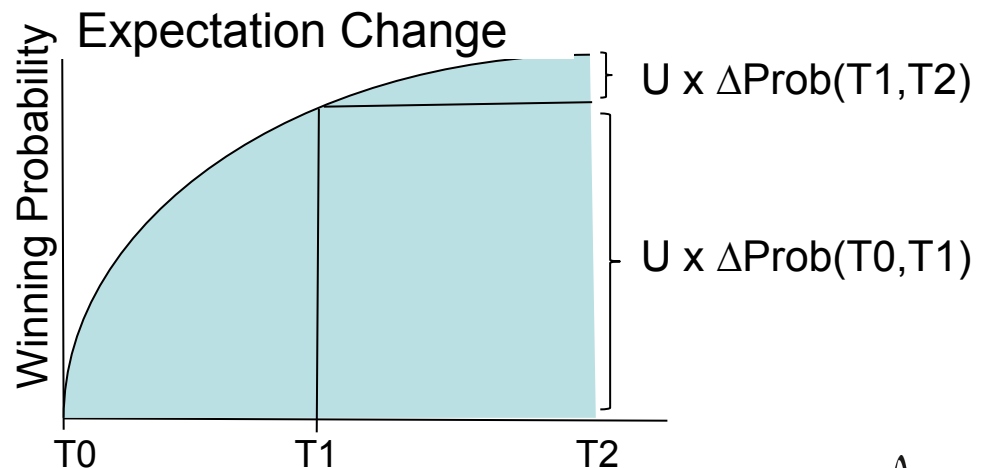
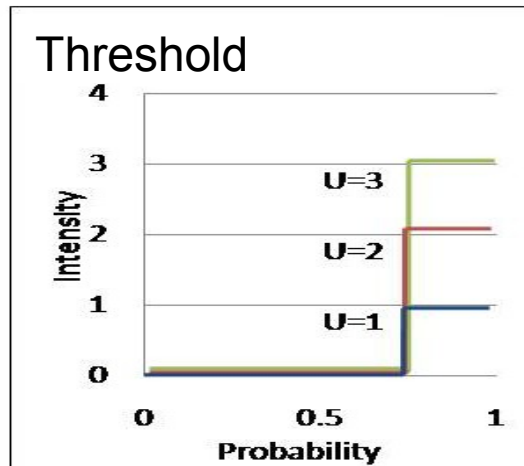
Expected Utility principle: hope *increases* over time

Expectation change principle: hope *decreases* over time

Alternative Intensity Models



Model emotion intensity as proportional to probability and utility of goal attainment



Emotion Intensity Hypotheses

	Hope	Joy	Fear	Sadness
Δ Expect Model	EM, PEACTIDM	ParleE, PEACTIDM	EM, PEACTIDM	ParleE, PEACTIDM
Expected Utility	EMA, Silverman, FearNot!		EMA Silverman	
Threshold Model		EMA, EM		EMA, EM
Additive Model	Cathexis, FLAME	Cathexis, FLAME	Cathexis, FLAME	Cathexis, FLAME
Hybrid Model	Price et al85	Price et al85 Silverman	Price et al85	Price et al85 Silverman

Empirical investigation desiderata

- **Assess behavioral fidelity of competing models**
consistent with human emotional responses in naturalistic settings?
 - Focus on appraisal variables of goal probability and utility
 - As these most commonly implicated
 - But explore other common variables
 - Generate data on appraisals and emotional intensity
 - Identify paradigm where emotion arises from task
 - In contrast to mood induction studies
 - Identify task where emotions unfold over time
 - As most models are intended to be dynamic
 - But most empirical findings in psychology focus on non-dynamic tasks

Study

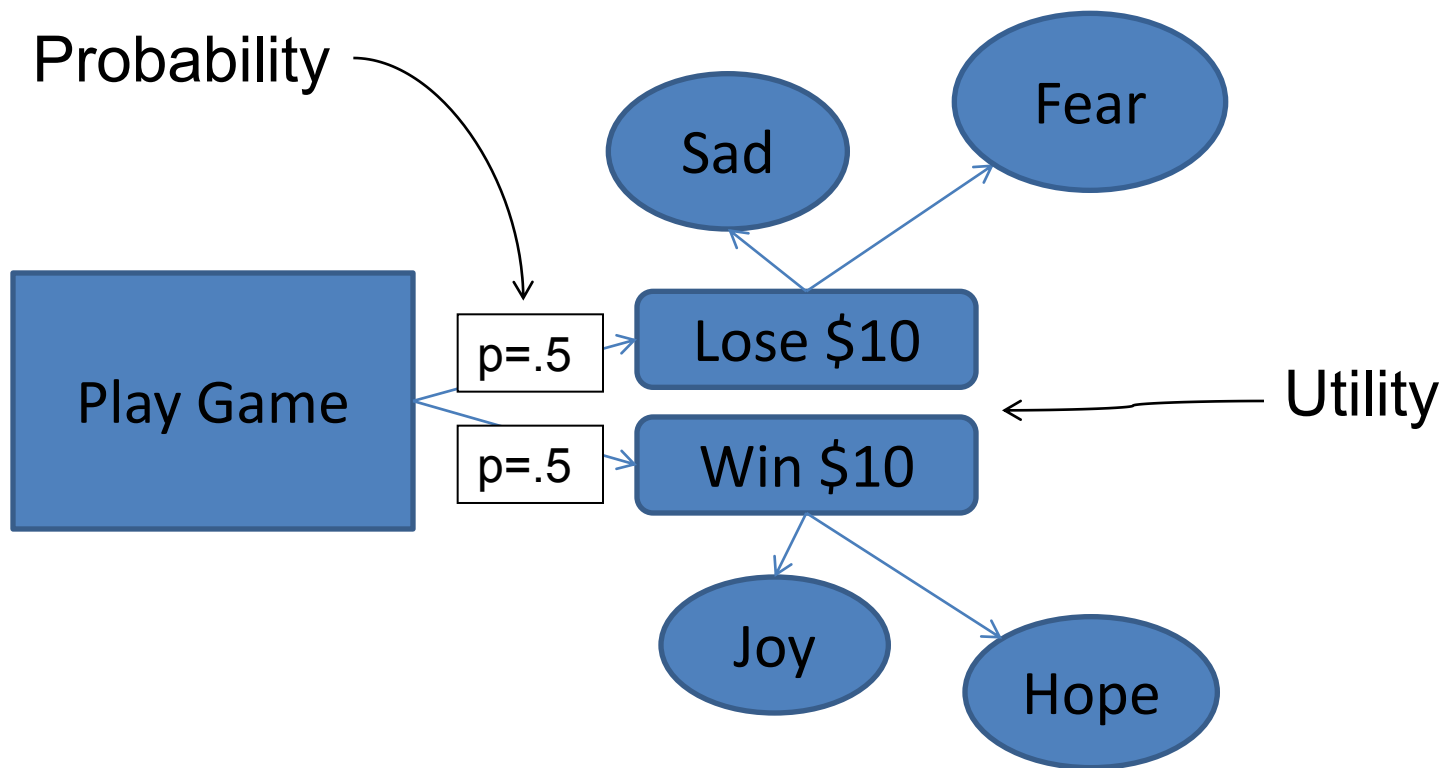
- **Competitive Turn-based strategy game**
 - Partial Observability
 - Dynamic: situation shifts over time



OBJECTIVE: examine dynamics of appraisal & coping responses as goal of WINNING facilitated or threatened

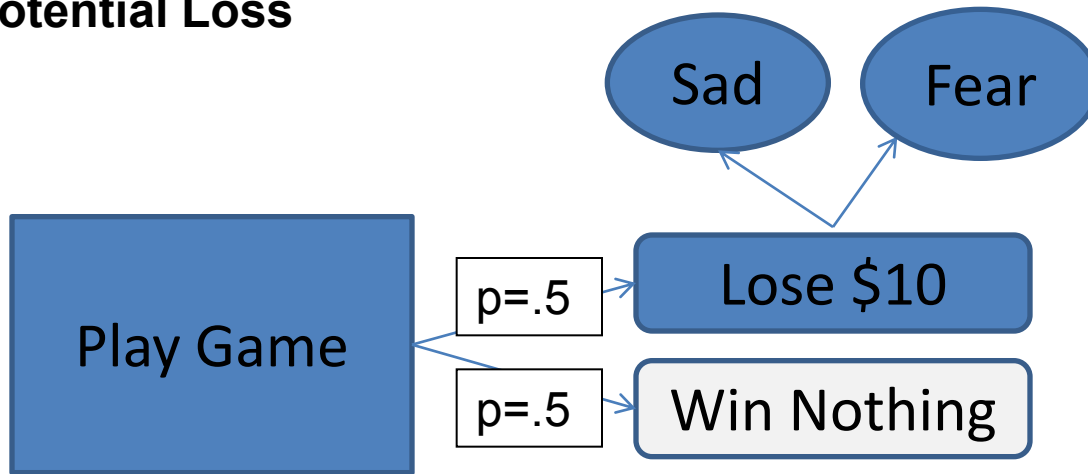
- Q1: How do appraisals relate to intensity of emotional response over time
- Q2: How do people cope with the emotions wining or losing gives rise to?
- Q3: Do appraisals uniquely determine emotional response?
- Do results corroborate EMA model predictions?

Modeling game play

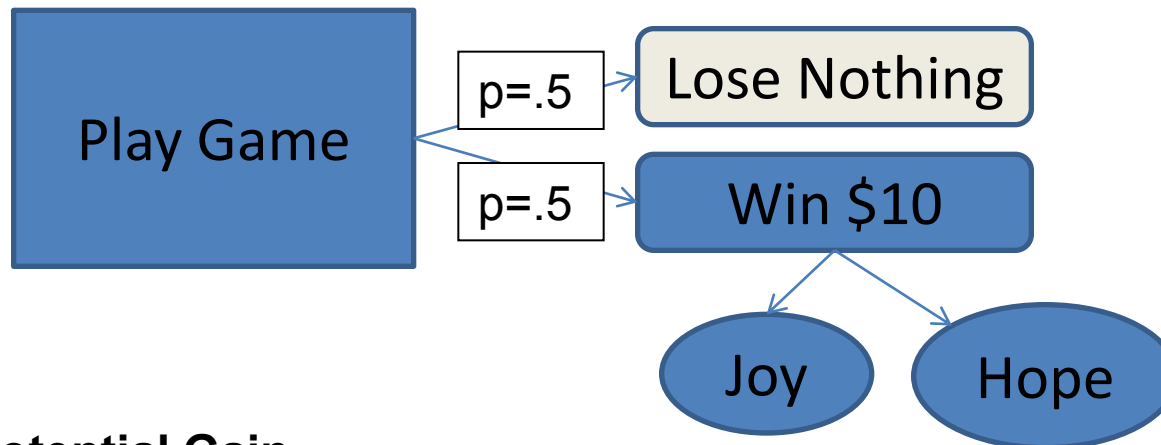


Manipulate Incentives (Utility) Kahneman, D., & Tversky, A. (1979).

Potential Loss

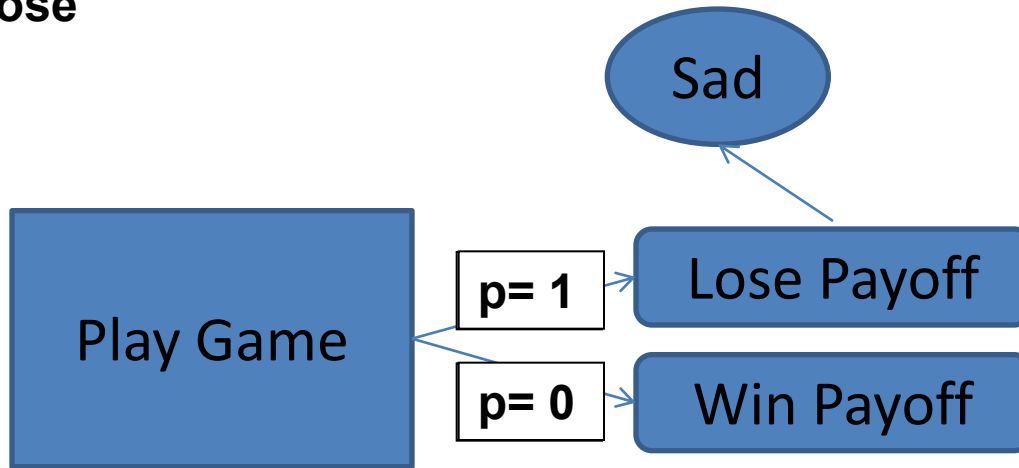


Potential Gain

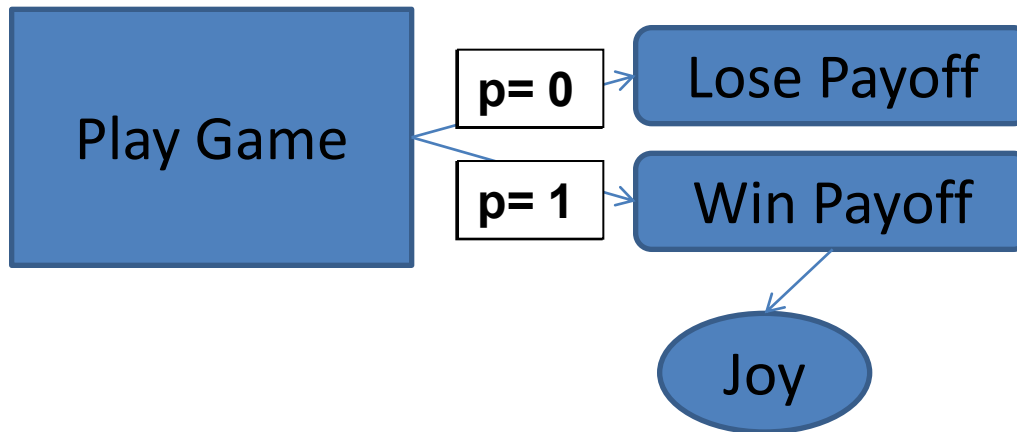


Manipulate Outcomes (Probability)

Lose

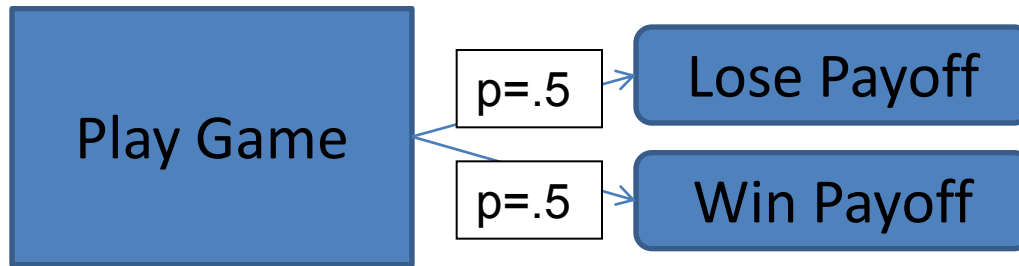


Win



Manipulate Probability of Winning over TIME

Start → Losing → Lost



Play Game

p=.5

Lose Payoff

p=.5

Win Payoff

Start → Winning → Won

2 x 2 x 3 design

Outcome and Incentive manipulated between subjects

Time manipulated within-subjects

		Outcome (win vs. lose)	
Incentive (Gain vs Loss)	Win \$	Win \$	Don't win \$
	Don't lose \$	Don't lose \$	Lose \$

Human subjects study 100 participants



Coping Questionnaire

Confederate



Subject



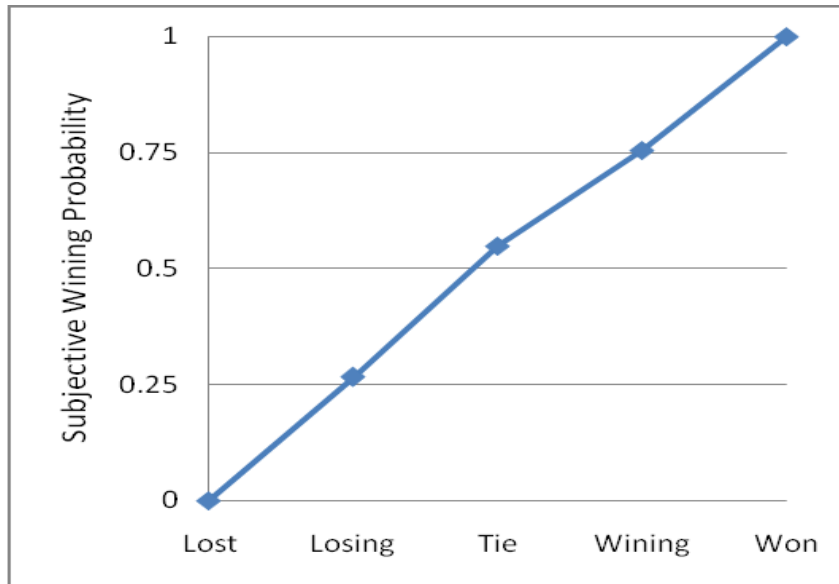
Hidden Camera

Measures

- **Demographic/Dispositional (start of experiment)**
 - Age, Education, Game experience
 - Social value orientation: measure of cooperative/competitive
- **Appraisals (repeated T1, T2, T3)**
 - Subjective value of winning
 - Subjective probability of winning
 - Subjective control over winning/losing
 - Subjective effort (how hard am I trying)
- **Emotion intensities (repeated T1, T2, T3)**
 - Prospective emotions: Hope, Fear
 - Retrospective emotions: Joy, Sadness
- **Presented as visual analog scales**

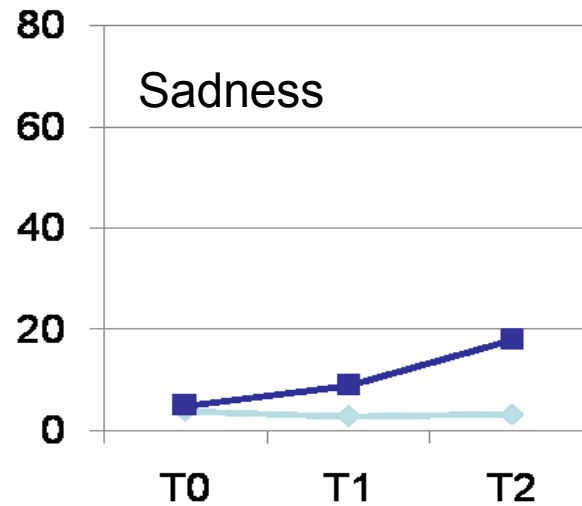
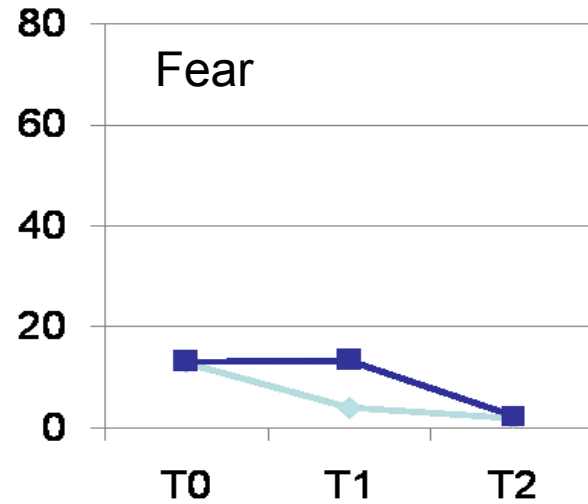
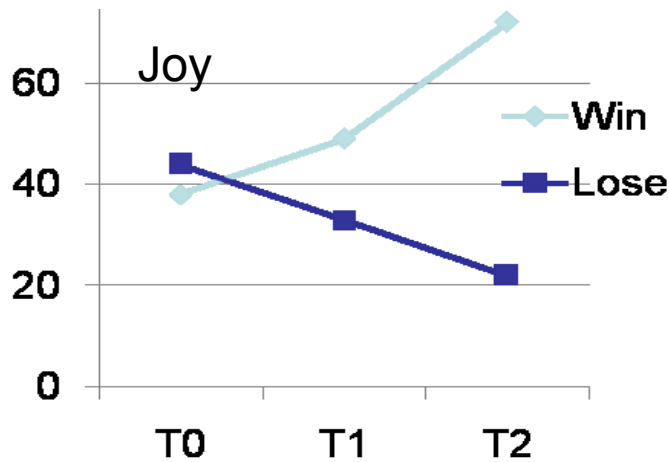
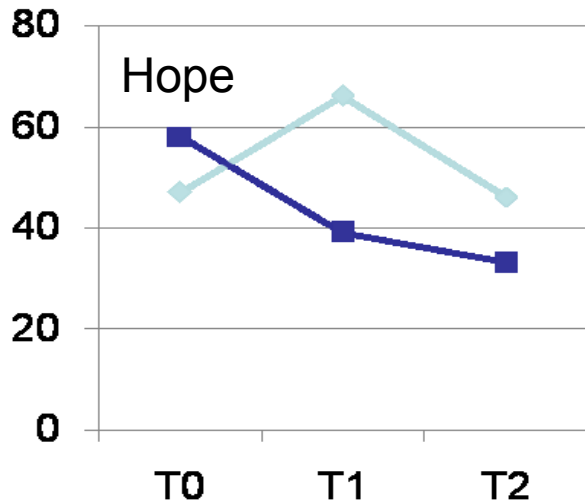
Manipulation check

- **Successfully manipulated perceived winning/losing over time**

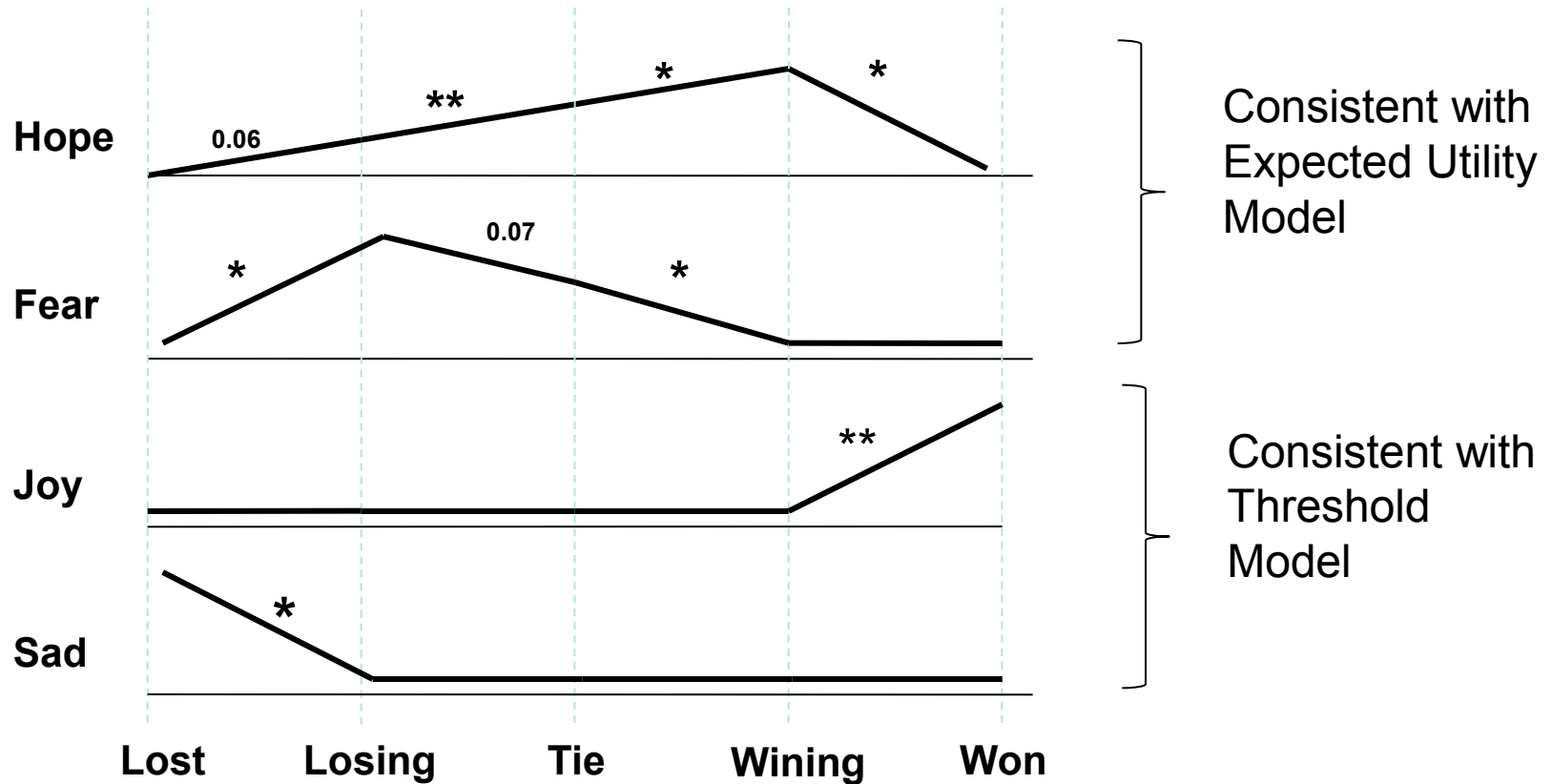


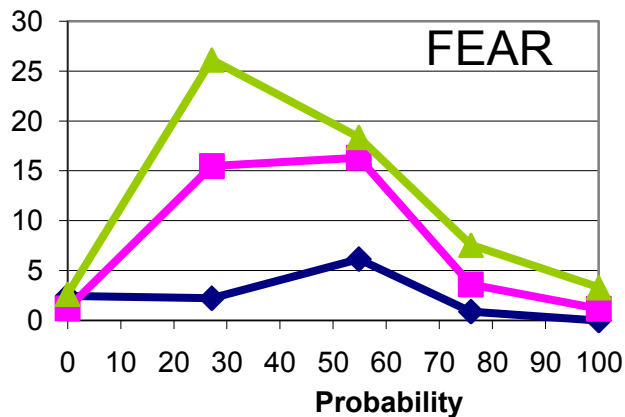
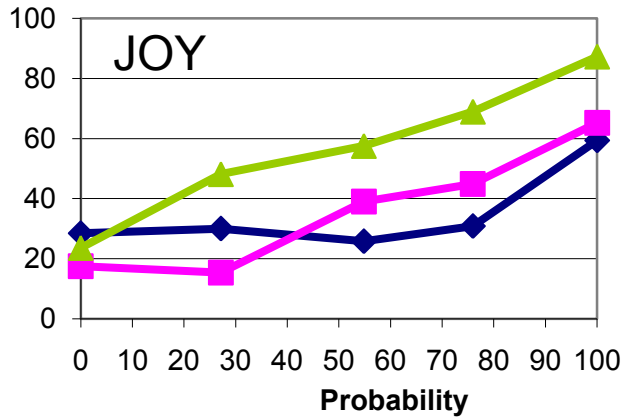
- **Failed to manipulate value of winning/losing (incentive)**
 - Did elicit positive and negative self-reported emotion
 - No significant differences in appraisals/emotions by incentive
 - Collapse data across incentive

Raw Emotion Intensity Scores

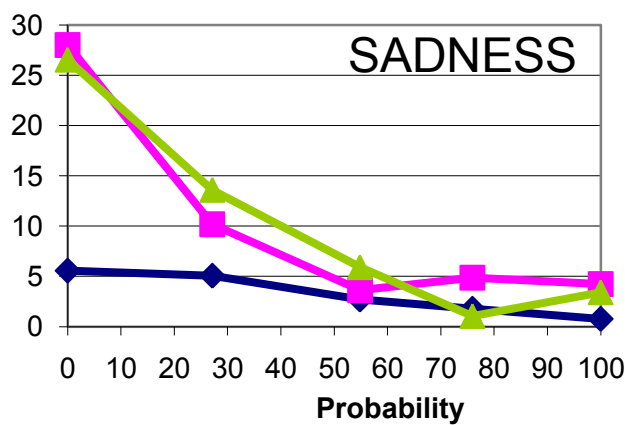
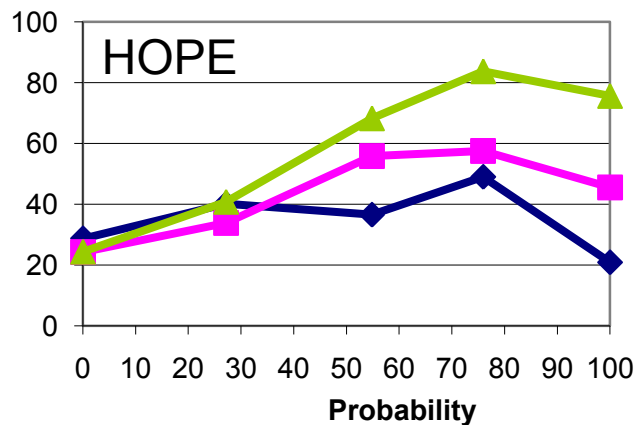


What are the significant changes in intensity as a function of probability





Model Fitting



Quantitative Fit

Joy = $1.41 \times \text{Utility}^{0.83} \times \text{Probability}^{1.54} + 2.37$ $(r^2 = 0.80)$

Sad = $0.60 \times \text{Utility}^{0.82} \times (1-\text{Probability})^{3.06} + 2.32$ $(r^2 = 0.83)$

Hope = $0.02 \times \text{Utility}^{1.45} \times \text{Probability}^{1.0} + 1.45$ where Probability < 1.0 $(r^2 = 0.93)$

Fear = $0.79 \times \text{Utility}^{0.98} \times (1-\text{Probability})^{1.21} + 30.38$ where Probability > 0.0 $(r^2 = 0.92)$

Q1: Emotion Intensity Results (nonlinear regression)

	Hope	Joy	Fear	Sadness
Realization Model	EM, PEACTIDM	ParleE, PEACTIDM	EM, PEACTIDM	ParleE, PEACTIDM
Expected Utility	EMA, Silverman, FearNot!		EMA Silverman	
Threshold Model		EMA, EM		EMA, EM
Additive Model	Cathexis, FLAME	Cathexis, FLAME	Cathexis, FLAME	Cathexis, FLAME
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RESULT: Strong support EMA (and date can refine model)

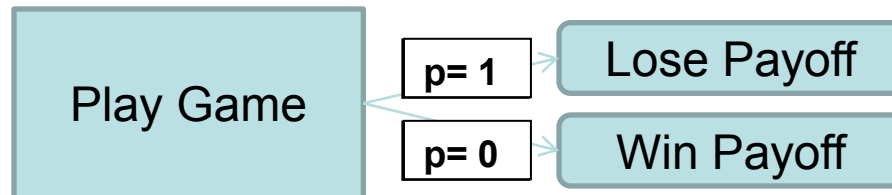
Discussion

- No effect of incentive framing
 - Possibly did a poor job of framing as win/loss
 - Subjects may not have understood the manipulation
 - Suggests people have other incentives than monetary reward
 - Competition with other
 - Fun of playing game
 - Social interaction
 - Future studies will explicitly examine other goals
 - E.g., Use Subjective Value Inventory (SVI, Curhan 2006)

Discussion

- **Granularity of representation**

- Our analysis assumes situation is construed by subjects as a single goal (win) and a single abstract action (play-game)



- Actually situation more complex
 - Subgoals: sink ships, plot next shot
- Would tend to skew some of the analysis
 - E.g., Joy when Winning could reflect the joy associated with obtaining subgoals
 - Suggests Joy, Sadness might be closer to threshold model than suggested by results

Discussion

- **Other appraisal factors**

- Some models consider several other intensity modifiers
- Probability and utility explained most of the variance in intensity
- No evidence that control or effort explained variance in intensity

- **Dynamics**

- Prior psychological studies show evidence for expectation change model in one-shot decision tasks (e.g., wheel of fortune)
- These models define change of probability against some reference point
- But this point not well defined if probability changes continuously over time
- Expectation change did not well-explain our data

Open issues (just starting to scratch surface)

- **Alternative explanations**
- **Decision dynamics**
 - Explored monotonically-evolving decisions (losing vs. winning)
 - Should explore other trajectories
 - does early failure impact future perceptions when circumstances improve?
- **Individual differences**
 - Subjects with low motivation to win show very different behavioral/coping patterns
 - Other appraisal/dispositional factors seem to improve predictions
 - Social Value Orientation
 - Personality
 - Cultural factors?
- **Social factors**
 - Battleship is a competitive game (theory of mind factors)

Conclusion

- **Identified that different models use different intensity fns.**
- **Constructed study to assess these against human data**
- **Evidence shows**
 - Expected utility good model for prospective emotions (hope/fear)
 - Retrospective emotions (Joy, Sadness) fall between an expected utility and threshold model
- **Results call into question the behavioral fidelity of several popular models and support some.**
- **Results particularly support EMA (Gratch and Marsella)**