Temporal Dynamics of Uncertainty Cause Anxiety and Avoidance

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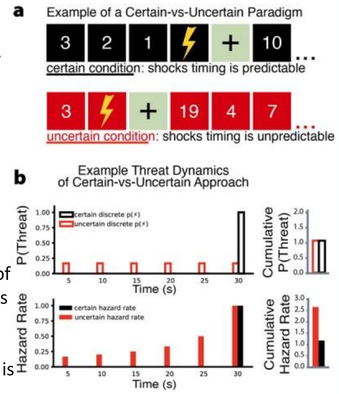
Introduction

Uncertainty during the anticipation of aversive events causes anxiety, but how is unclear.

Many past studies compare temporally certain and uncertain threats to show this (Fig. 1a).

We identified a confound with these studies: they manipulate probability of threat AND its ***hazard rate***- a measure of probability over time (Fig. 1b, Equations 1 and 2).

We hypothesize that a high **hazard rate** is sufficient to increase anxiety related behavior and self reported anxiety.



What is hazard rate?

The probability of an aversive event occurring given that it hasn't happened yet.

$$h(t) = \frac{p(t)}{1-P(t)}$$

Equation 1: Hazard rate

$$P(t) = \sum_{i=0}^{t} p(i)$$

Equation 2: Cumulative probability

Variable key:
h(t) = hazard rate
p(t) = probability
P(t) = cumulative probability
t = a specific moment in time

Example

One of your collaborators said they will approach your poster within the next 5 minutes. (They end up approaching you during minute 5)

p(t) = 1/5 h(t) = 1/5 | p(t) = 1/5 h(t) = 1/4 | p(t) = 1/5 h(t) = 1/3 | p(t) = 1/5 h(t) = 1/2 | p(t) = 1/5 h(t) = 1

Threat Dynamics

In our task we created two conditions that differed in hazard rate while keeping the probability distribution as similar as possible (Fig. 2a).

Between 10 and 25 seconds, the **probability** of shock is the same… (Fig. 2b, top)

… but the **hazard rate** of the early condition is *always* higher! (Fig. 2b, bottom)

Also, **cumulative probability** is matched between conditions, while **cumulative hazard rate** is higher in the early condition (Fig. 2 a, b).

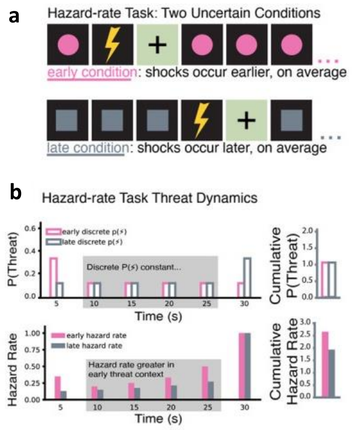


Figure 2: Hazard rate task conditions (a) and probability of threat / hazard rate distributions (b).

Methods

Task Structure

Part 1: The Learning Phase (Fig. 3a)

- Participants were told to pay attention to the timing of the shocks, and that there may be average differences between the two shapes
- After this phase participants estimated the probability of shock for each shape in each 5 second time window

Part 2: The Testing Phase (Fig. 3b)

- Participants repeated the learning phase task with two notable differences:
- They could now "escape" from the shock after the first 5 seconds of each trial by pressing a button.
- They were now earning $0.01 for each second that they did not escape from shock

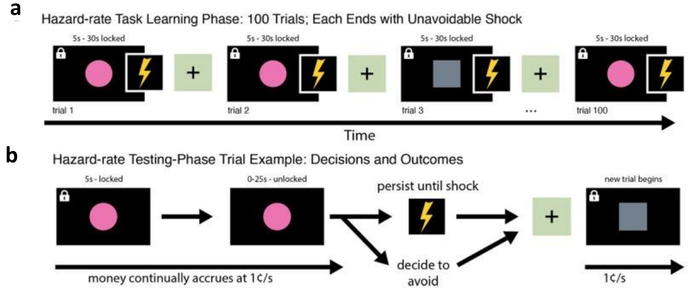


Figure 3: The two phases of the hazard rate behavioral paradigm- the learning phase (a) and testing phase (b).

Task variations

In a follow-up experiment, we repeated the above paradigm but replaced the shocks with the presentation of a star on the screen (not an inherently aversive stimulus).

Intolerance of Uncertainty Predicts Early-Late Difference in Anxiety

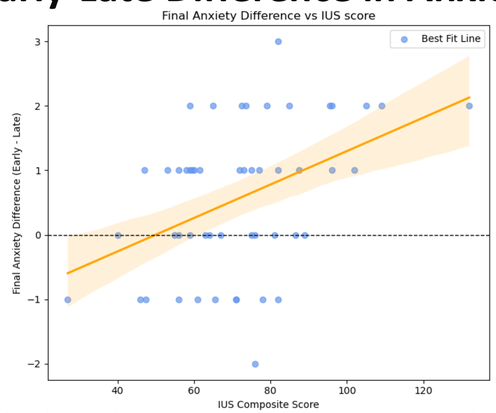


Figure 4: Correlation between anxiety difference scores in a final 30 second trial for the early and late environments vs Intolerance of Uncertainty Questionnaire score, showing significant correlation (OLS regression, n= 51, p< 0.01). This indicates that hazard rate may differentially affect people's experience of anxiety depending on their intolerance of uncertainty.

Hazard Rate Leads To Avoidance And Anxiety

Shock Results

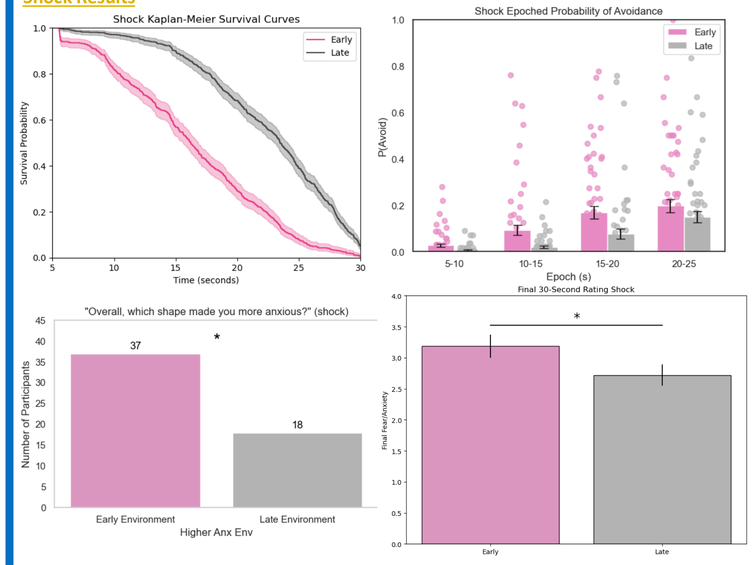


Figure 5: Shock Results. Participants escaped earlier on average in the early condition (a, n = 46, x^2=284.7, p<0.001). In epochs with matched shock probability, participants were more likely to avoid the early condition (b, independent samples t-tests, n= 61, [5-10s: t= 2.75 , p< 0.01], [10-15s: t= 3.16, p< 0.01], [15-20s: t= 2.71, p< 0.01], [20-25s: t= 1.28, p = 0.20]). In a forced choice question, participants were significantly more likely to rate the early threat condition as more anxiogenic (c, n= 55, x^2= 6.56, p= 0.01). In a final, unavoidable final shock trial for each condition, participants reported significantly more fear/ anxiety in the early condition (d, paired t test, n= 43, p< 0.05)l

Star Results

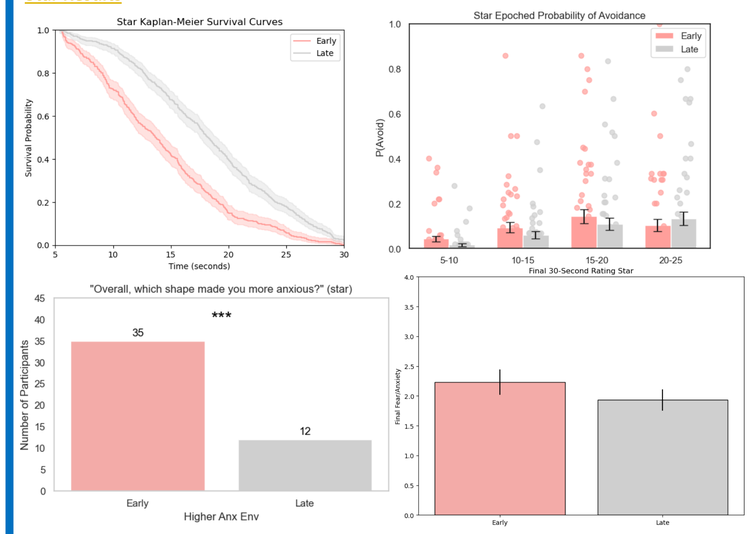


Figure 6: Star Results. Participants escaped earlier on average in the early condition (a, n = 30, x^2=90.03, p<0.001). In epochs with matched probability of seeing a star, participants were about equally likely to avoid the each condition (b, independent samples t-tests, n= 61, [5-10s: t= 1.85 , p= 0.07], [10-15s: t= 1.24, p= 0.22], [15-20s: t= 0.857, p= 0.39], [20-25s: t= -0.77, p = 0.44]). In a forced choice question, participants were significantly more likely to rate the early threat condition as more anxiogenic (c, n= 55, x^2= 11.26, p< 0.001). In a final, unavoidable final shock trial for each condition, participants did not report significantly different anxiety between condition (d, paired t test, n= 43, p= 0.15).

Conclusions

High hazard rate caused increased anxiety related behavior in both task variations. Further, trait anxiety (as measured by the IUS) predicted how anxiogenic participants rated each condition. This gives us confidence that hazard rate is involved in the experience of anxiety, and we will continue to do further experiments to better understand how.

Please contact me with questions / comments!

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