Influence of Dispositional and Situational Factors on Human Perceptions of Fire Risk

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Some of the data in this presentation has not been through the NIST review process and should be considered experimental and/or draft results.

engineering laboratory

Pre–Evacuation Behavior During Egress

Introduction
- **Background**
- PADM
- Purpose of Study

Methods
- Judgment Task
- Participant Information

Results and Discussion
- Task Responses
- Dispositional Traits

Conclusions and Future Work

- A growing number of fire and life safety codes provide performance–based design options[1]
  - Egress calculations are increasingly a part of performance–based analyses[2]
- Pre–action processes play an important role in egress planning
  - Can lead to delays in taking action in response to an emergency[21]
  - May be a more important element of required escape time than the time needed to move to a safe place [7,8]
    - Significant impact on required safe egress time (RSET)

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Pre–Evacuation Behavior During Egress

- Comprehensive egress models exist that account for individual differences in occupant decision making processes [4–6]
  - Fidelity of human behavior in response to fire cues incorporated within models is still limited[16]
  - Including behavioral theories of human decision making can improve the timing of pre–evacuation actions in egress models regarding [17]
    - Humans can fail to perceive signs of a hazardous event as indicative of risk [19]
    - Normalcy bias: tendency of individuals to fail to recognize aberrant signals (e.g., smoke) as abnormal
    - Can lead to delays in responding to an emergency [17]
  - Further research is needed to identify individual differences that influence decision making [12]

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Framework for Occupant Response During Emergency

- The Protective Action Decision Model (PADM) describes processes that individuals may engage in when encountering hazard cues[18]

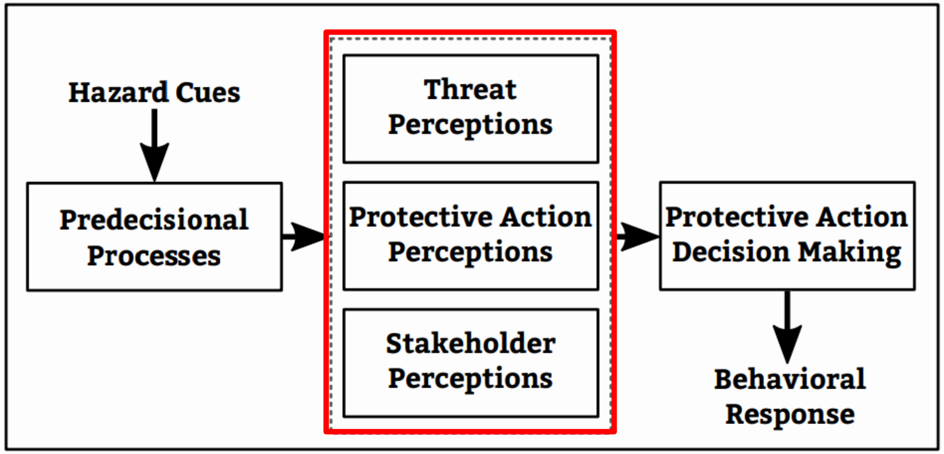

Figure 1. Portions of PADM (adapted from Lindell & Perry, 2012).

Framework for Occupant Response During Emergency

- Dispositional traits and situational factors can affect:
  - Perception of cues as indicative of risk[20]
  - Decision making regarding whether such cues warrant taking protective action[21]

- Supporting evidence for the order of PADM processes consists of post–hoc interviews and observational data[17]
  - Open questions remain regarding the extent to which perceptions and judgments when viewing fire cues are influenced by dispositional traits and situational factors

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Focus of this Study

- Psychophysical models used to assess the point during fire growth at which individuals viewing developing fires reliably perceived:
  - Deviation from normalcy
  - Risk was present
  - Protective action required

- Correlational analyses examined whether individual differences in judgments were connected to variations in dispositional traits (e.g., temperament, risk–taking)

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Impact of this Study

- Develop a framework to *quantify* occupant perceptions of fire scenarios

- Use results to inform models of risk perception in emergency scenarios
  - May enable *prediction* of evacuee behavior, accounting for individual differences in dispositional traits

- Hypothesis: As intensity of fire cues increase in room fires, the point at which changes in judgments occur will align with the PADM

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Judgment Task

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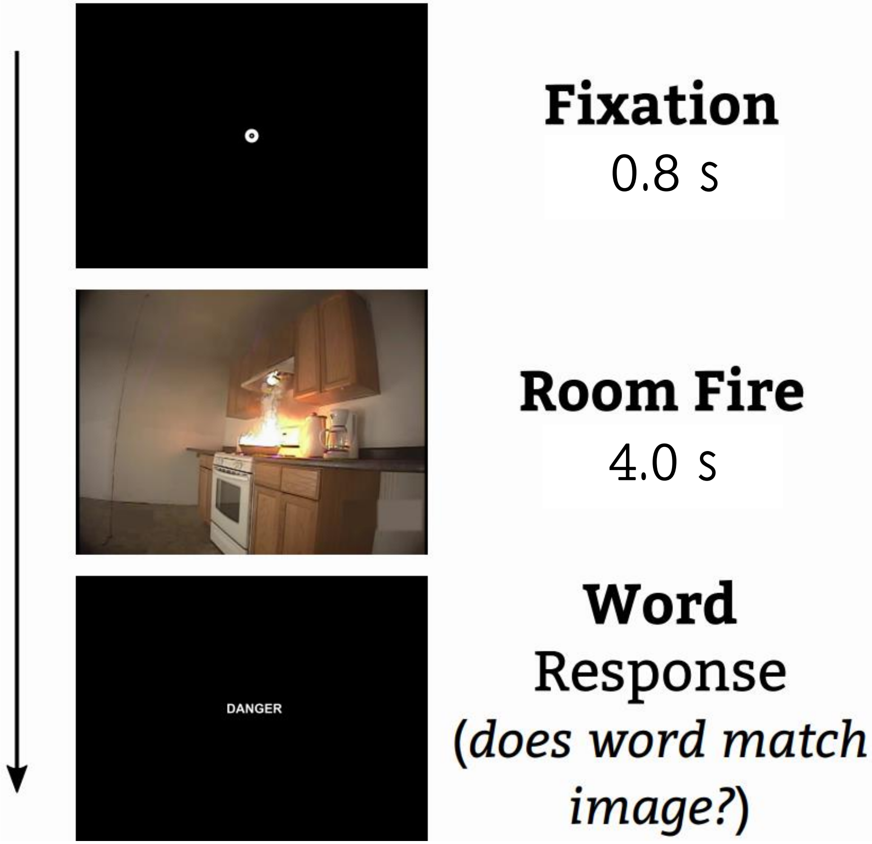
Conclusions and Future Work



Participants presented with room fire images and asked whether a presented word did or did not match the image

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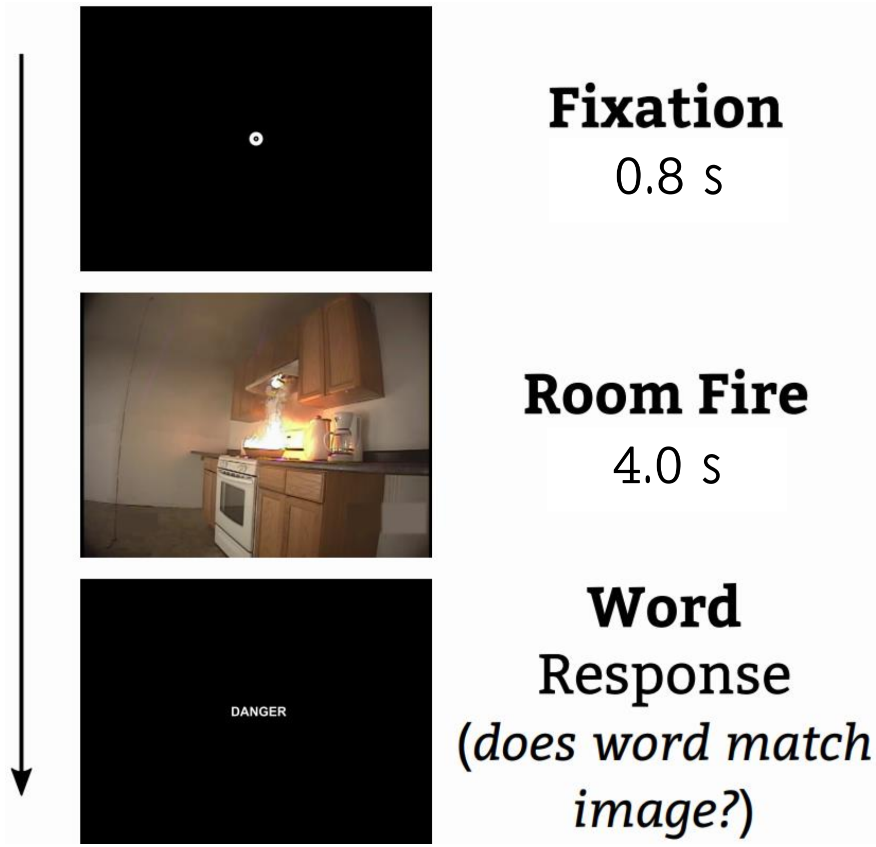

Each participant completed task on all 216 combinations of 36 images (4 scenes, 9 images per scene) and 6 stimuli (prompt words)

Judgment Task

- Images were taken during different stages of fire development in realistically furnished rooms
  - Two bedroom scenes and two kitchen scenes

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Conclusions and Future Work

- Images were taken during different stages of fire development in realistically furnished rooms
  - Nine images per scene
  - Apparent fire size/intensity varied

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Conclusions and Future Work

- A_{flame} calculated for two scenes
  - Proportion of image area occupied by visible flames (Min = 0.00; Max = 0.80)
  - Metric for quantifying apparent flame size

Judgment Task

- Tobii X3-120 eye tracker and software used to present task
  - Eye fixation data was collected, beyond scope of talk
- Words presented following each image, were selected to reflect earlier versus later processes associated with human responses to emergencies

Category	Stimuli	
Normalcy	Normal	Ordinary
Risk	Danger	Emergency
Protective Action	Evacuate	Flee

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Participant Information

- Forty participants
  - Undergraduate students from mid-sized university in the Baltimore-Washington metropolitan area (USA)
  - Received course credit for completing study
- Demographics
  - Age = 20.6 ± 2.3 years
  - Sex: Female, *N* = 35; Male, *N* = 5
  - Race:
    - Black (*N* = 37 including 4 Hispanic)
    - White (*N* = 2 including 0 Hispanic)
    - Mixed race (*N* = 1 including 0 Hispanic).
- Research protocol was approved by an institutional review board (IRB)

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Dispositional Measures

- Adult Temperament Questionnaire
  - 77–item questionnaire used to assess aspects of adult temperament [26]
  - For each item, individuals judged the extent to which a statement described themselves
  - Focused on four factors [27]:
    - Fear
    - Discomfort
    - Attentional control
    - Neutral perceptual sensitivity

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Dispositional Measures

- Risk–Taking Questionnaire
  - 18 item questionnaire, observed to reliably assess[25] the extent to which young adults engage in risky behaviors
  - For each item, participants indicated whether they agreed or disagreed that a statement applied to themselves
  - Scores were summed into two subscales
    - Behavior
    - Assessment

Eye Fixations

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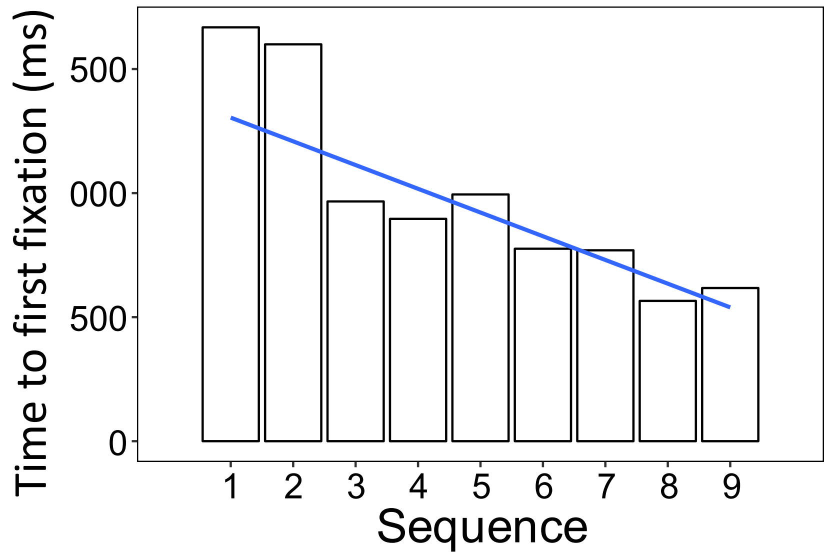
Eye Fixations

- Time to first fixation
  - Elapsed time to initial eye fixation to visible flame in image



- Linear regression
  - Sequence: $t(4132.739) = -14.560$, $p < .001$

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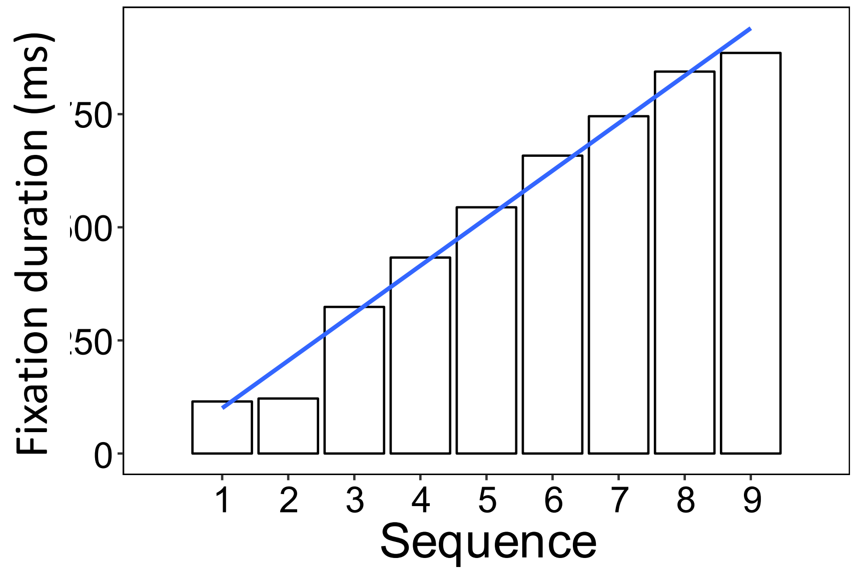
Eye Fixations

- Total Fixation Duration
  - Total duration of eye fixations to visible flame in image



- Linear regression
  - Sequence: $t(7630.540) = 33.022$, $p < .001$

Responses on Judgment Task

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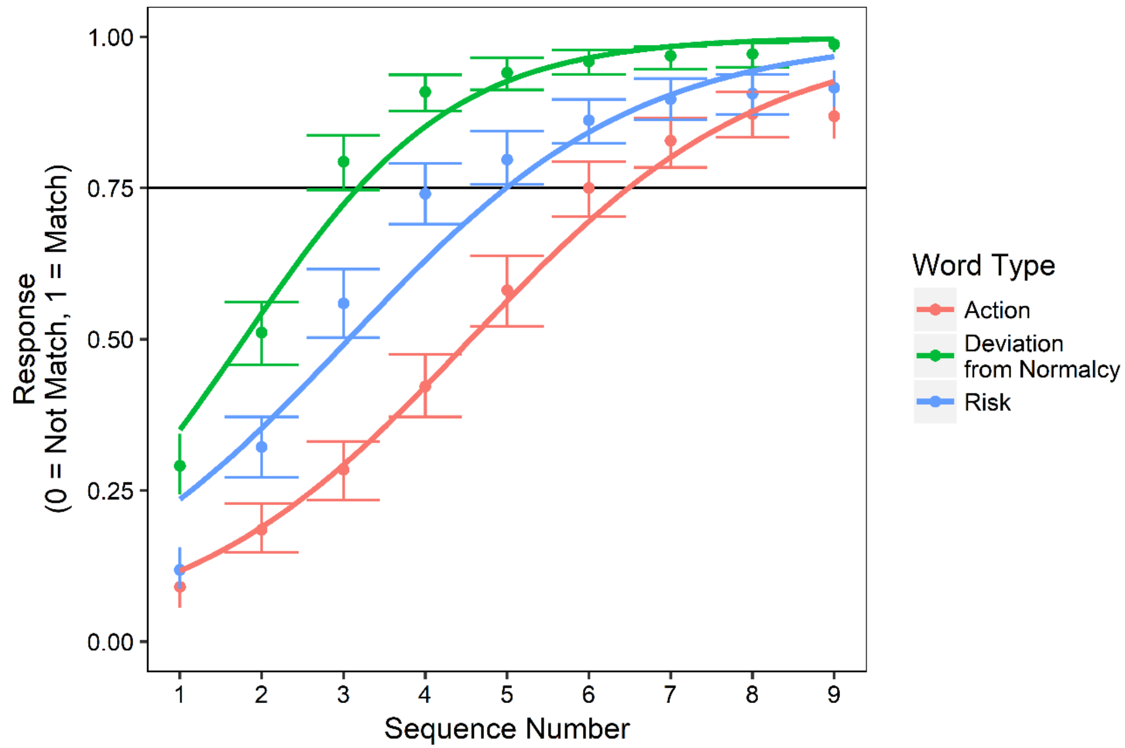

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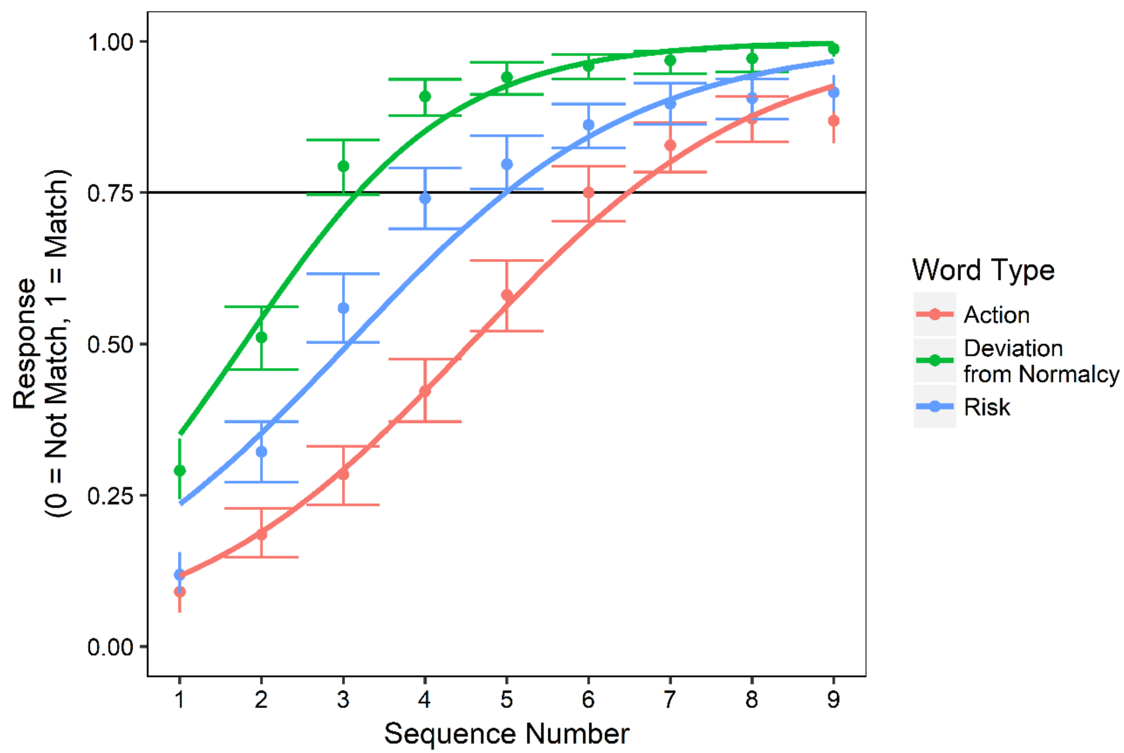
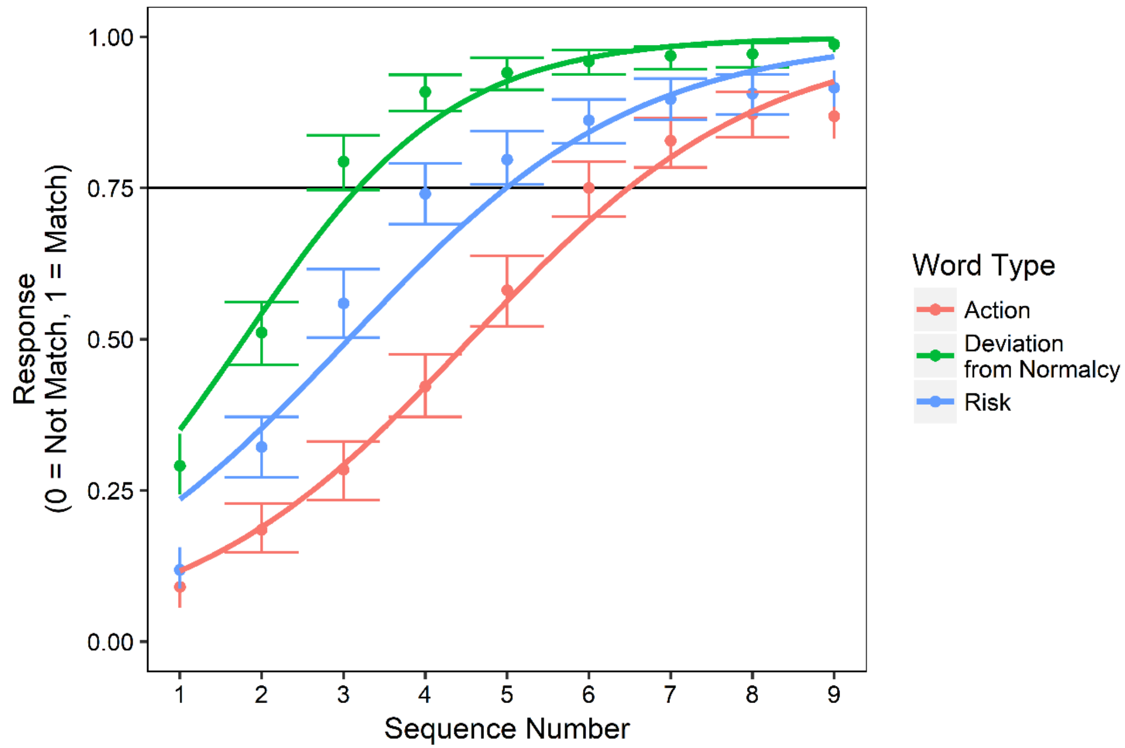
Responses on Judgment Task



- Response coding:
  - Normalcy, no risk, no protective action = 0
  - Deviation from normalcy, risk, protective action = 1

Responses on Judgment Task



- Binomial Regression
  - Sequence N: $\chi^2(1) = 70.936$, $p < 0.001$
  - Word type: $\chi^2(2) = 70.947$, $p < 0.001$
  - Sequence N × Word type: $\chi^2(2) = 29.871$, $p < 0.001$

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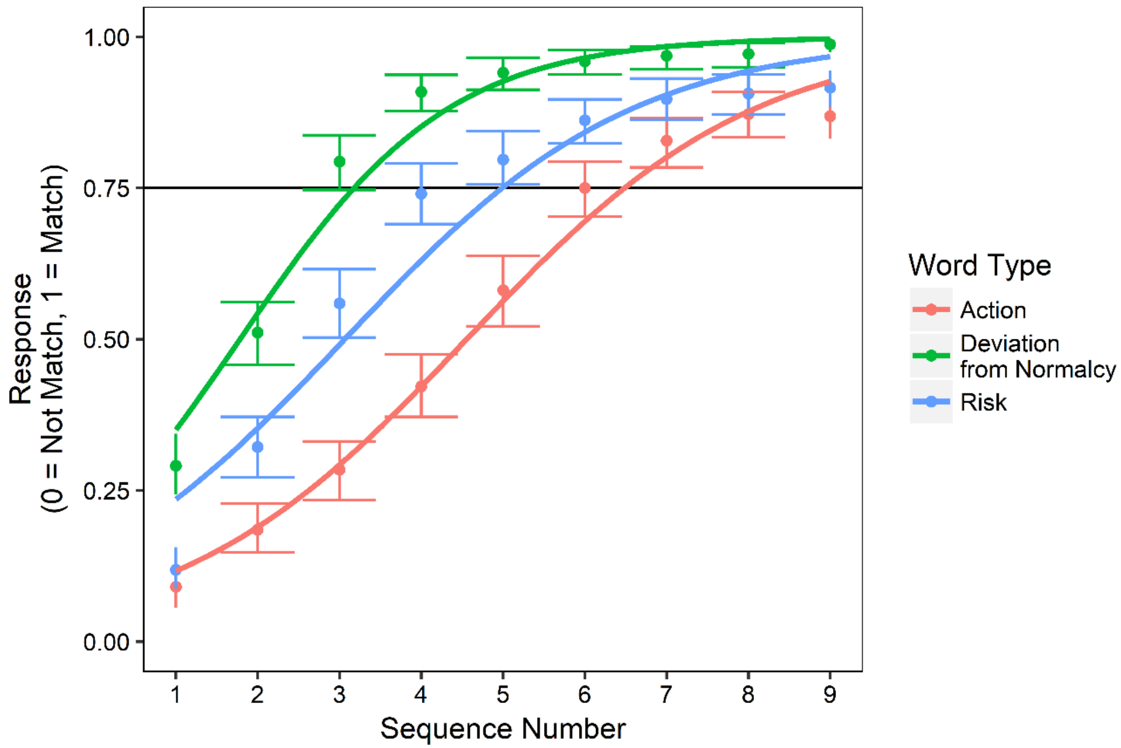
Responses on Judgment Task



- Planned Contrasts (p's < .001)
  - Word type (Intercept):
    - Deviation from Normalcy > Risk > Protective Action
  - Sequence N × Word type (Slope):
    - Deviation from Normalcy > Risk > Protective Action

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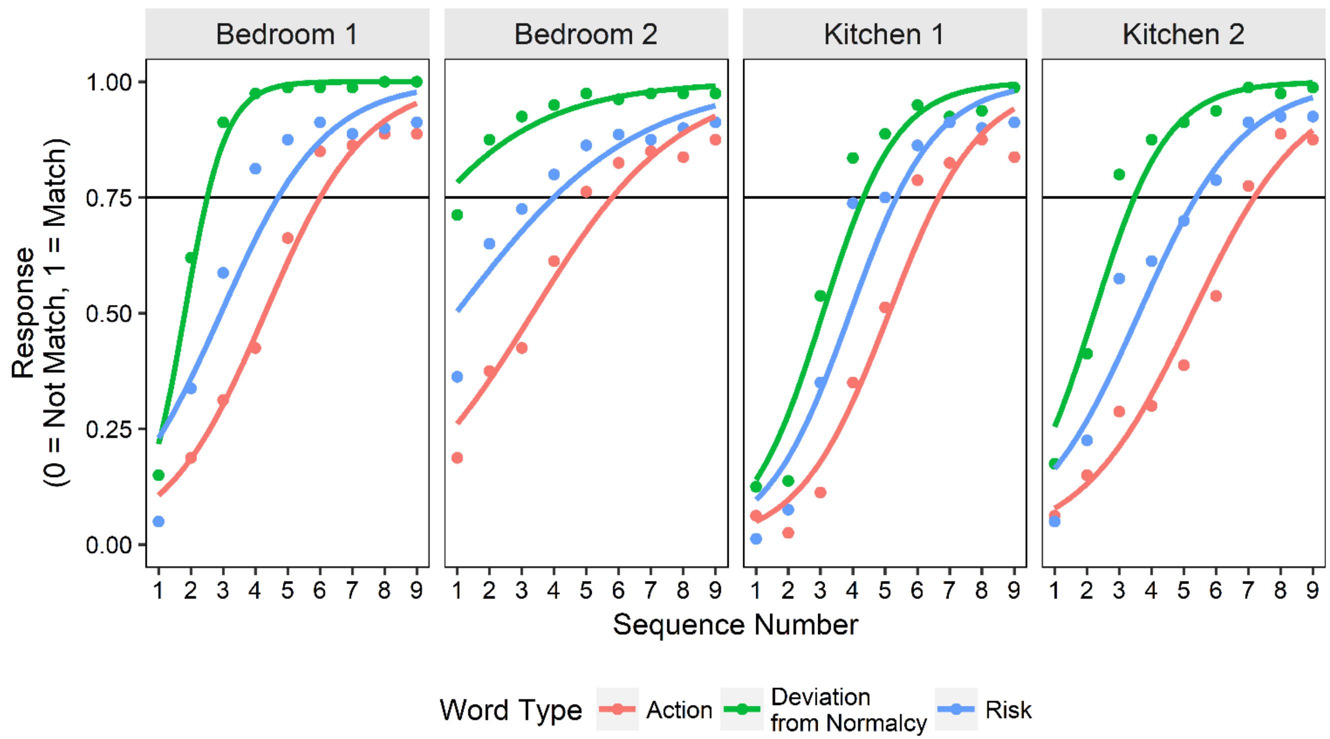

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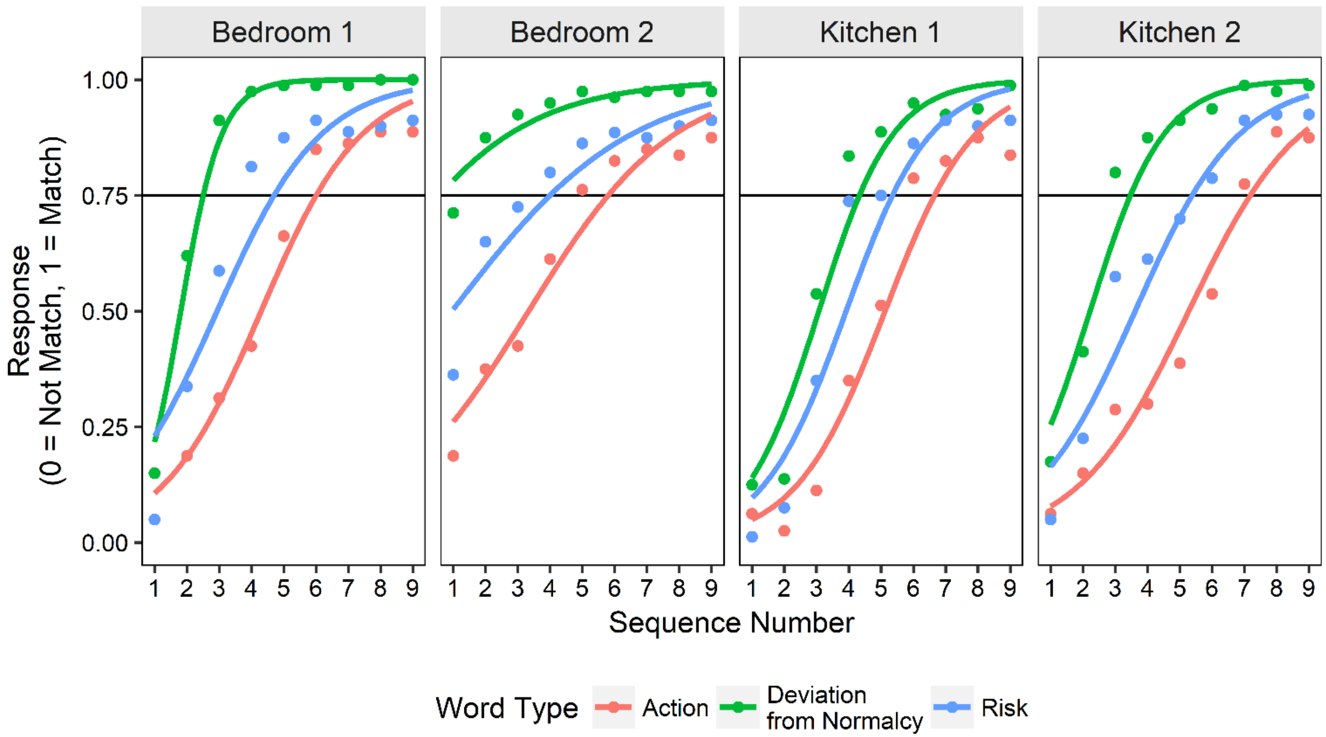
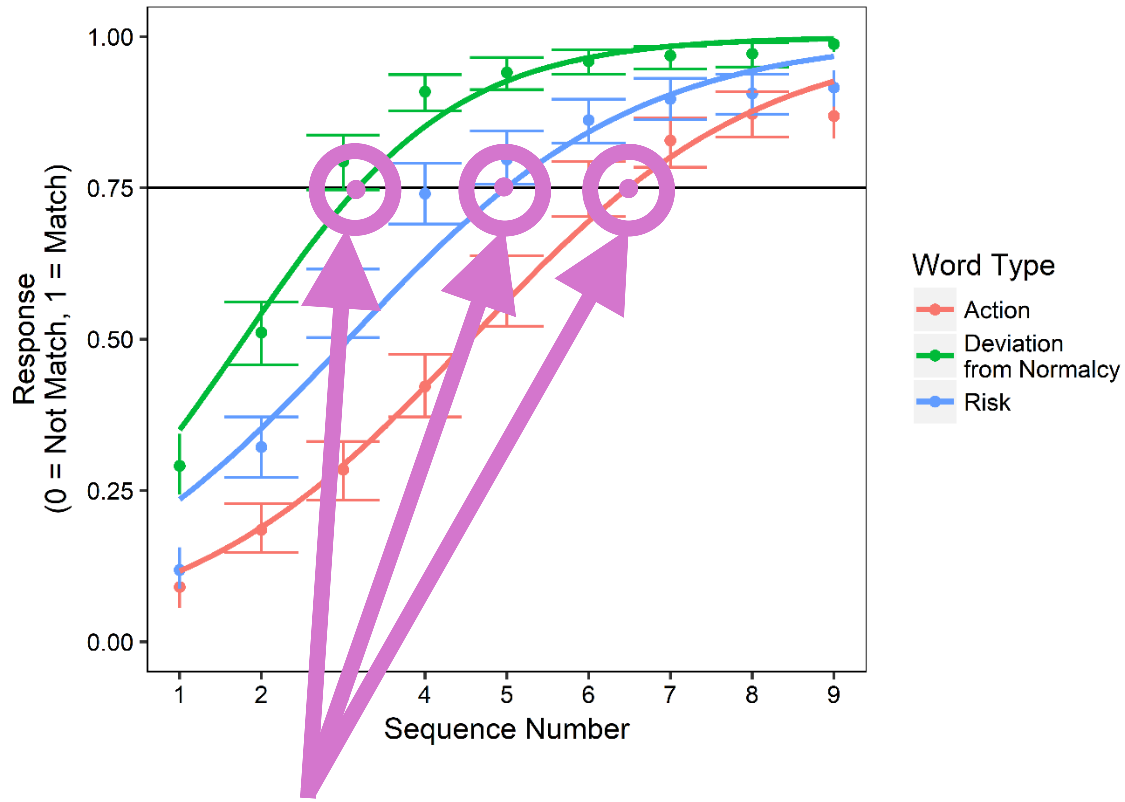
Responses on Judgment Task

- Evidence of situational effects
  - Slopes / intercepts varied by scene
  - Can analyze effects of word type on slope, intercept using the average across scenes



Threshold Analysis



- Threshold:
  - Point at which participants reliably (75%) judged a word applied to an image

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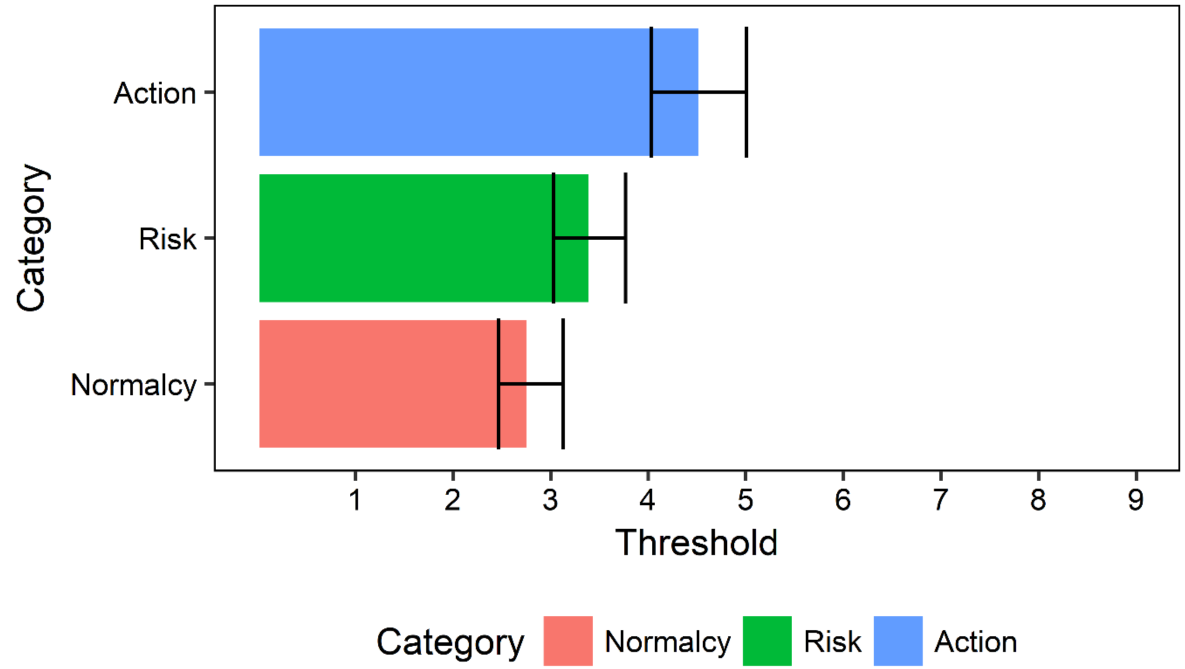
Threshold Analysis



- Planned Contrast (Sequence Number)
  - $t(58.948) = 7.400$, $p < 0.001$
  - Deviation from Normalcy < Risk < Protective Action

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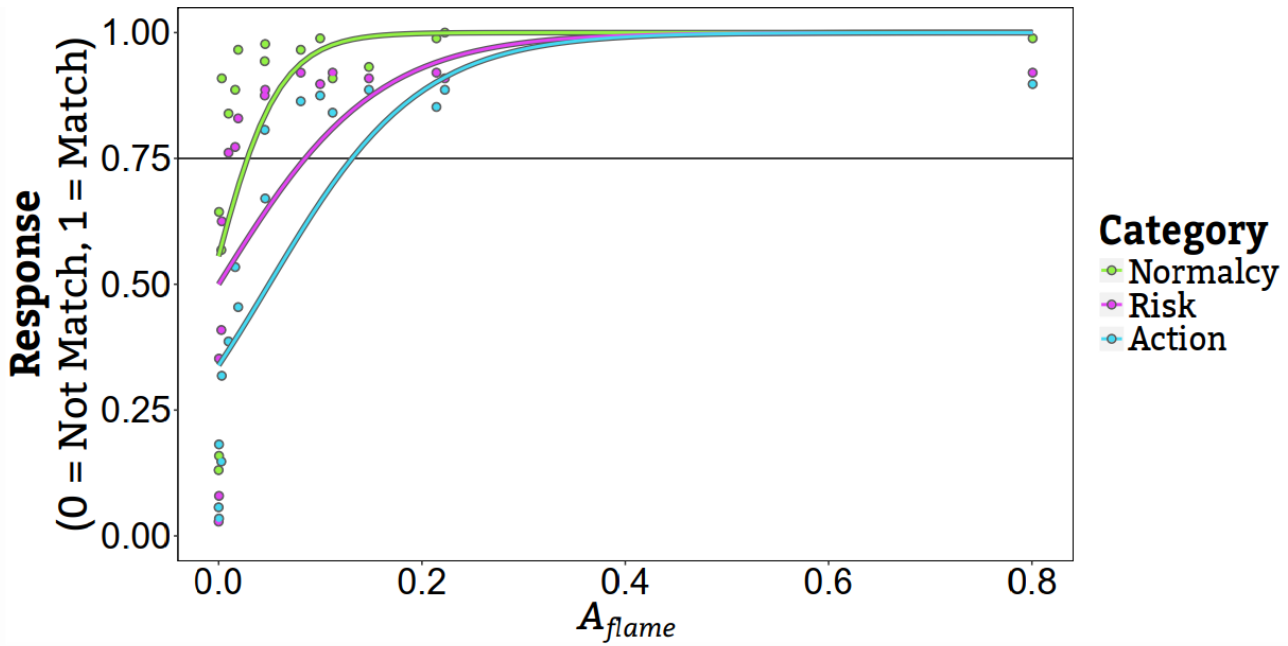
Responses on Judgment Task



- Binomial Regression
  - Sequence N: $\chi^2(1) = 70.936$, $p < 0.001$
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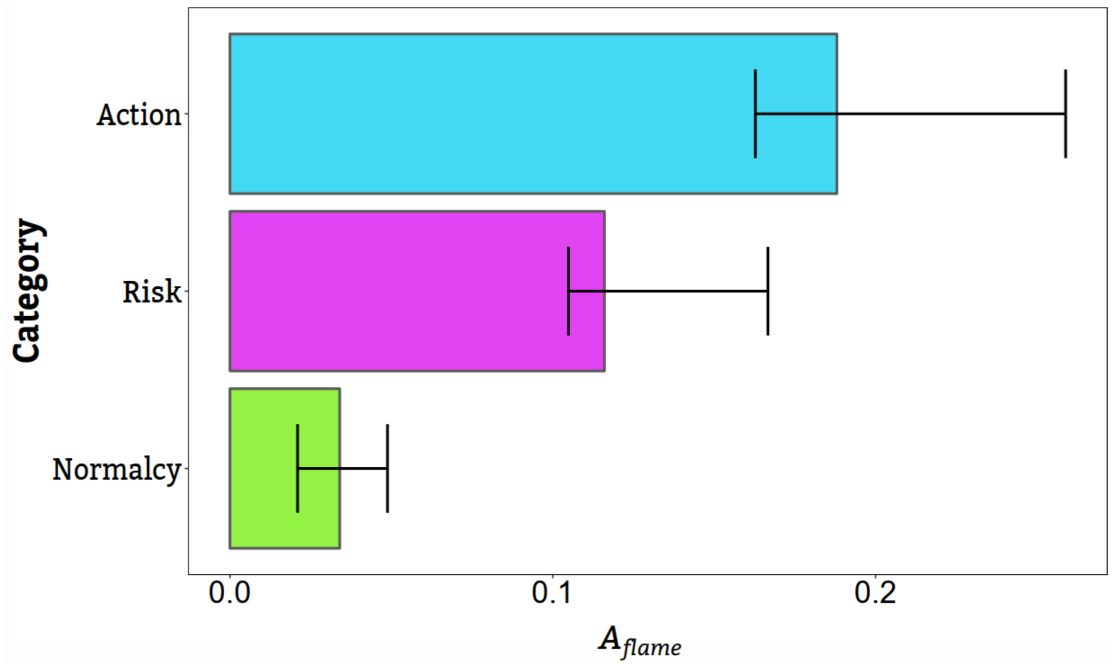

- Bootstrap analysis (A_{flame})
  - Bedroom 1 and Kitchen 1
  - 973 iterations

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Correlational Analyses

- Significant correlations:
  - Deviation from normalcy and risk thresholds
  - Risk and protective action thresholds

Factor	1	2
1-Deviation from normalcy Threshold	---	---
2-Risk Threshold	0.502	---
3-Action Threshold	0.289	0.545

Correlational analyses (Pearson *r* statistic) examined the strength of linear relations between individual variations in word type thresholds and scores on temperament and risk taking questionnaires

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Correlational Analyses

- Significant correlations:
  - Risk threshold and Discomfort

Factor	1-Normalcy	2-Risk	3-Action
4-ATQ Fear	0.075	0.199	0.05
5- ATQ Discomfort	0.248	**0.381**	0.178
6-ATQ Attentional Control	0.236	0.095	-0.055
7-ATQ Neutral Perceptual Sensitivity	0.238	0.036	0.042
8-RT-18 Assessment	0.036	0.112	-0.001
9-RT-18 Behavior	-0.048	0.012	0.075

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Conclusions

- Methodology developed to quantify decision making when presented with visual fire cues

- Results suggest judgments of visual cues can be used to examine how humans perceive a fire-related emergency
  - Performance aligns with earlier and later stages of the PADM[17] as well as previous observational and self-report evidence collected from fire-related emergencies[20]

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Conclusions

- Strong positive correlation between:
  - Deviation from normalcy and risk thresholds
    - Indicates that participants who judged images with less intense fire cues as indicative of risk also judged images as indicative of protective action with less intense cues
    - Demonstrates that normalcy biases can influence when individuals identify cues as indicative of an emergency [21]
  - Risk and protective action thresholds
    - Aligns with stages of the PADM: when individuals decide a situation poses an imminent risk, they are more likely to take protective action [17]
  - Risk threshold and discomfort temperament
    - Greater negativity towards sensory stimulation → more time needed to identify images as indicative of risk

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Future Work

- Decision making during emergencies can be influenced by perceived risk of the hazard[22]
  - Provide participants with scenarios that emphasize the potential risk to others
    - May better determine whether temperament of individuals influences judgment
  - Virtual reality can increase perceived presence in an environment [29]
    - 3D immersive videos available (e.g., wildfires, in–room kitchen fires)
  - Can an artificial environment simulate real videos?
    - Ability to control exact fire size, environment

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Future Work

- Determination of which stages of PADM judgment words most directly align with
  - Consider different words to elucidate more refined differentiations in stages of the process, beyond broad steps of normal/risk/take protective actions
- Compare vs. actual fire size (i.e., Heat Release Rate, HRR, not A_{flame})
- Use study to separately determine participants' perception/estimation of rate of fire growth
- Move Survey online
  - Larger numbers of participants, better statistical information regarding impact of dispositional factors

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Future Work

- Fire risk often perceived by non-visual cues (e.g., other sensory modalities, such as smell)[8]
  - Open questions remain as to whether patterns in performance observed in the present study would be observed when using fire cues of different, or multiple, sensory modalities
- Incorporate these results into actual egress models
  - Impact on response (i.e., predicted egress time, calculation of RSET)

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Results

- Plot of set of curves for one scenario
  - Intro each data point, what the solid lines are (logistic curves) what the horizontal line is (75% threshold), how normalcy is flipped to reflect deviation from normalcy
  - If all the same, say so, then so average
  - If notable differences, show all four as a split screen
- Task responses
  - Effect of sequence number
  - Interaction between sequence number and word category
  - Linear contrast codes (order of deviation, risk, action)
  - Bootstrap analysis
  - Discuss limitations + future analysis goals
- Threshold questionnaire scores (individual diffs)
  - Model vs. individual response, planned contrast
  - Proper description/overview of the math
  - Big old table highlighting all the factors
  - Highlight/bold key correlations of interest
  - Discuss limitations + future analysis goals

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Conclusions and Future W

- What is the what?

The Protective Action Decision Model 617

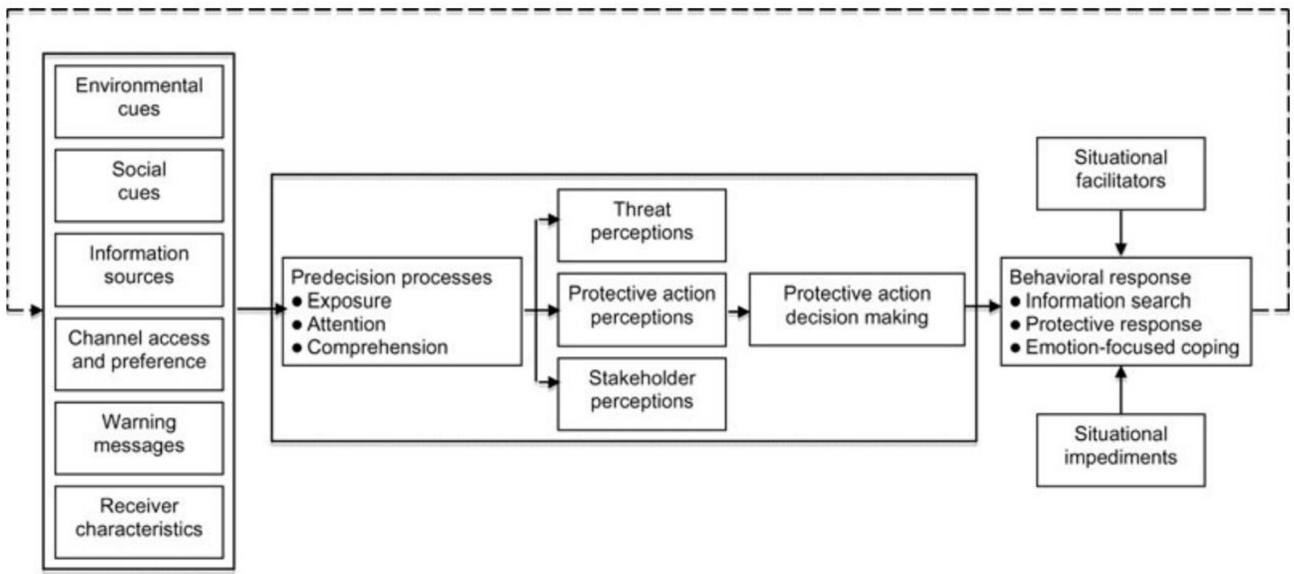

Fig. 1. Information flow in the PADM.
Source: Adapted from Lindell & Perry (2004).

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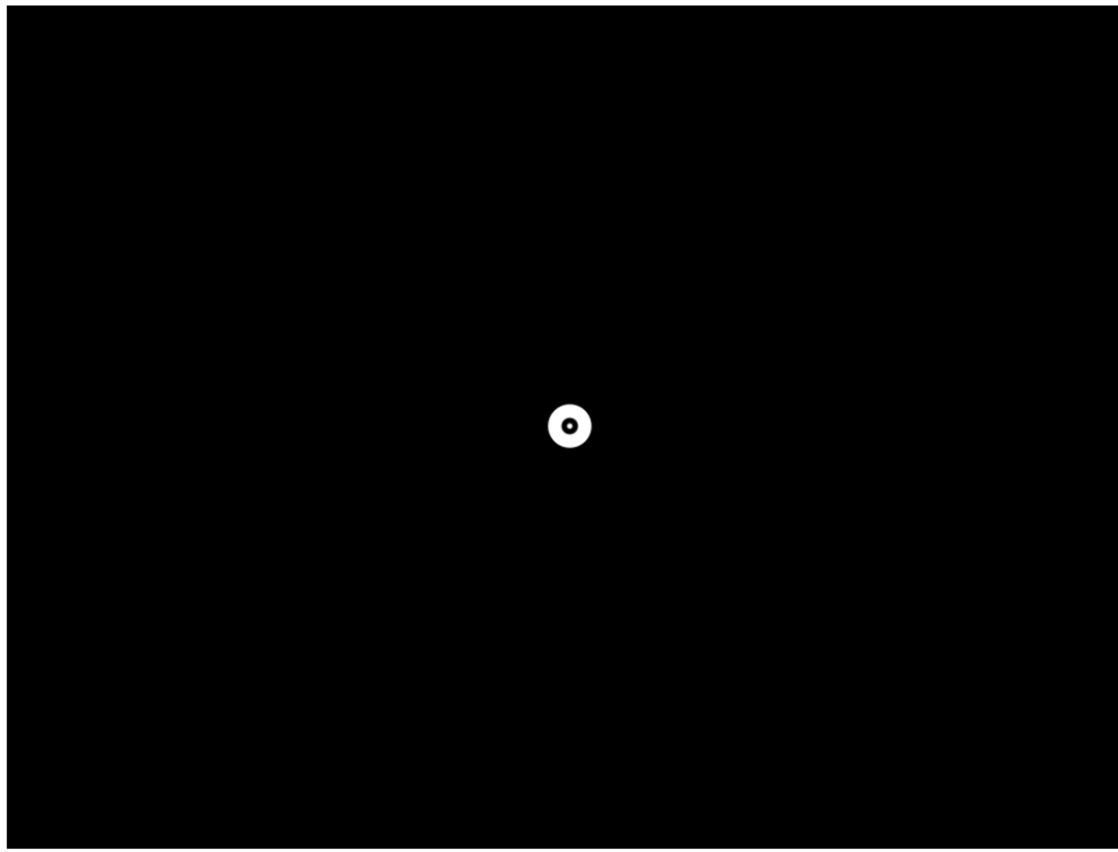
Judgment Task

- Fixation (800 ms)



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Judgment Task

- Room Fire Image (4000 ms)

National Institute of Standards and Technology
U.S. Department of Commerce

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Judgment Task

- Word Response

DANGER

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

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