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Action-outcome delays modulate the temporal expansion of intended outcomes

Rohan R. Donapati, Anuj Shukla & Raju S. Bapi

Presented By: Dileepkumar Adari

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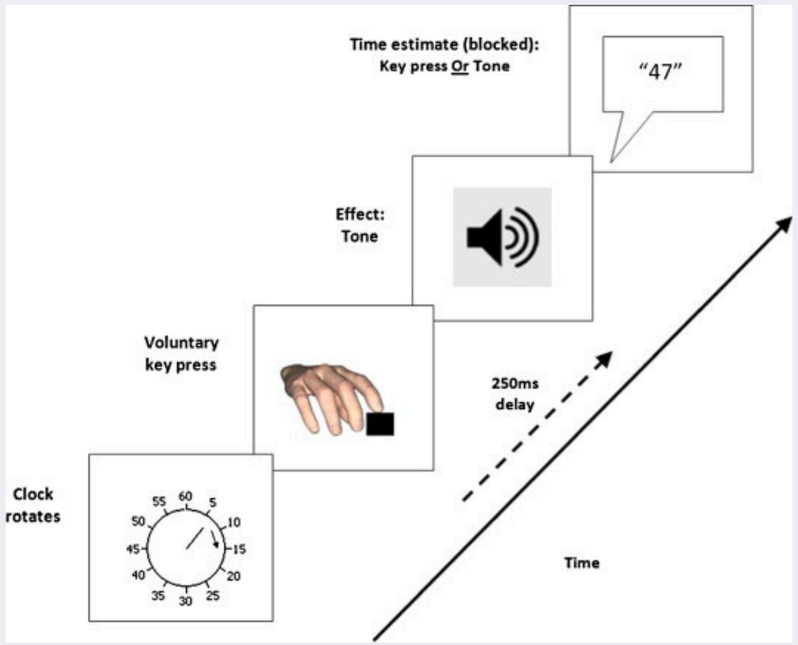
Introduction

What is Intentional Binding?

- The subjective perception that voluntary actions and their outcomes are closer in time than they are physically.
- Demonstrates how intention shapes time perception.

Does intention influence the perceived duration of an outcome?

Hypothesis: Intentional outcomes may appear longer in duration due to pre-activation of expectations.



Background & Motivation

Previous Research/ Past Studies

- Intentional binding is affected by external cues and expectation mechanisms.
- Shorter delays (250ms) show a stronger expansion of intended outcomes.
- External cues (e.g., visual indicators) may have influenced intention.
- Lack of control over outcome expectation

How This Paper Differs

- Removing external bias in experimental setup.
- Investigating whether pre-activation or attention allocation causes temporal expansion.

Research Question

- **How does the delay between an action and an outcome influence the perceived duration of an intended outcome?**
- **Is the effect driven by pre-activation or attentional allocation?**
- **Do different experimental designs (within-subjects vs. between-subjects) influence results?**

Experimental Design (Overview)

Modified Temporal Bisection Task

- Participants choose an outcome (shape) before an action.
- Action-outcome delay (250ms or 1000ms).
- Participants judge whether the outcome duration is "SHORT" or "LONG."

Two Experiments:

Experiment 1: Within-subjects (both short and long delays)

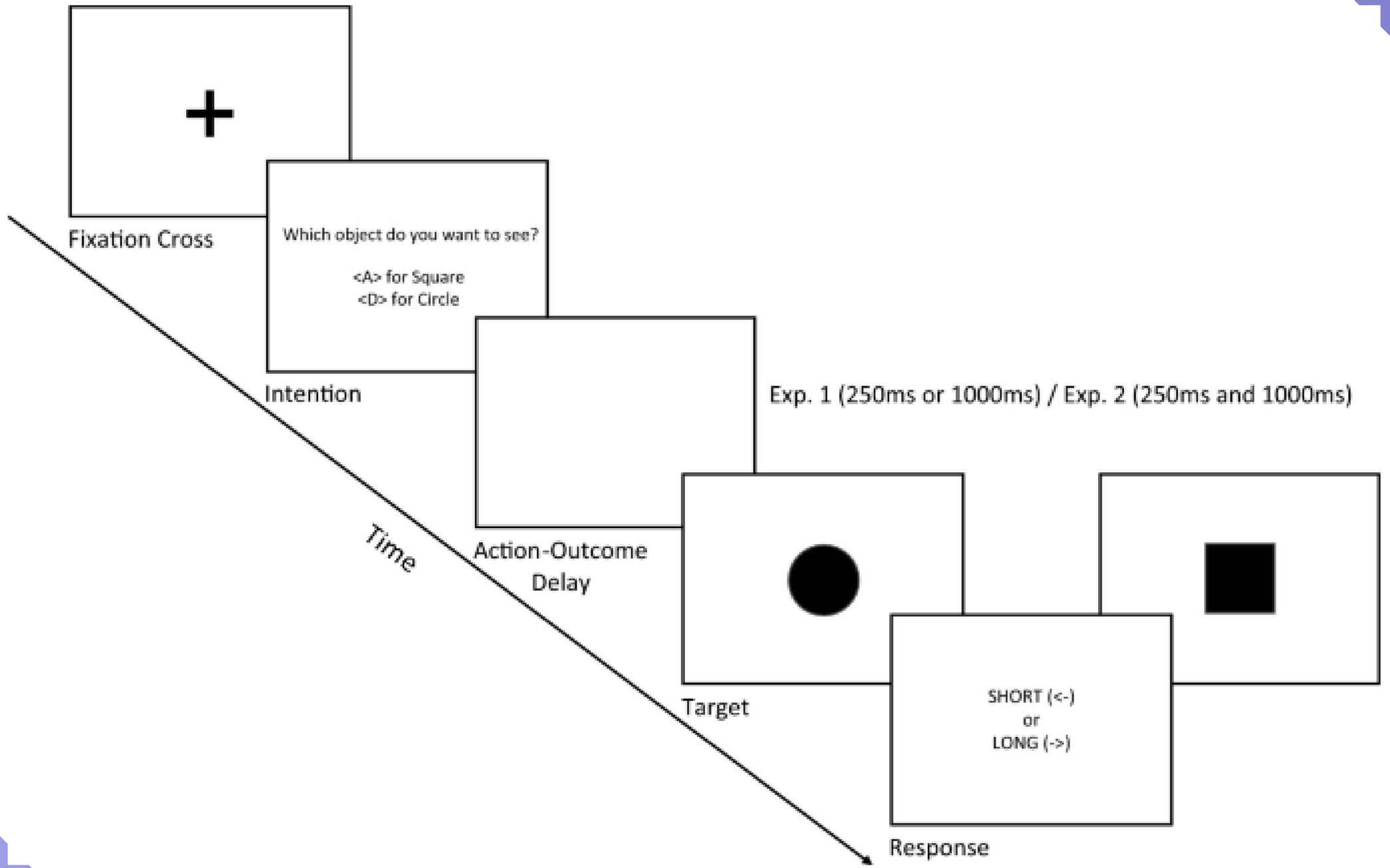
Experiment 2: Between-subjects (either short or long delay)

Key Manipulation: Intentional vs. unintentional outcome presentation.

Experimental Design (Overview)

Key Data Variables:

- **Subject ID:** Unique identifier for each participant.
- **Subject Age:** Age of the participant.
- **Gender:** Gender of the participant.
- **Group:** Indicates whether the participant belongs to the 250ms or 1000ms delay group.
- **TrialNumber:** Trial number for each participant.
- **Intended or Unintended Outcome:** Specifies whether the outcome was intended or unintended.
- **Reaction Time on Outcome Response:** Reaction time after the stimulus was presented.
- **Response - Short or Long:** Participant's judgment of whether the stimulus duration was closer to "short" or "long"
- **Stimulus Delay:** The delay between the participant's action and the stimulus presentation (250ms or 1000ms).
- **Objective Duration of Stimulus:** The actual duration of the stimulus (250ms to 850ms).


Fixation Cross
Which object do you want to see?
<A> for Square
<D> for Circle
Intention
Exp. 1 (250ms or 1000ms) / Exp. 2 (250ms and 1000ms)
Time
Action-Outcome
Delay
Target
SHORT (<-)
or
LONG (->)
Response

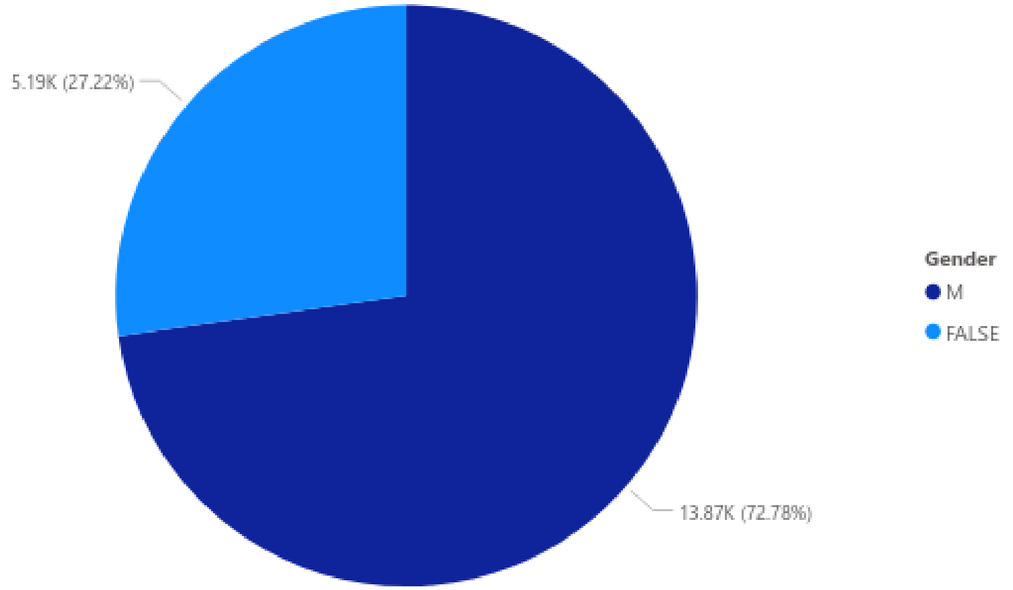
Experiment 1 (Within-Subjects)

- **Age range:** 18 to 30 years (Mean = 21.26, SD = 3.55)
- **Reaction Time (RT):** Highly variable, Mean = 965.22ms, SD = 1257.43ms
- **Stimulus Delay:** Mean = 625ms, SD = 375ms
- **Outcome type (Intended/Unintended):** Balanced (50% each)

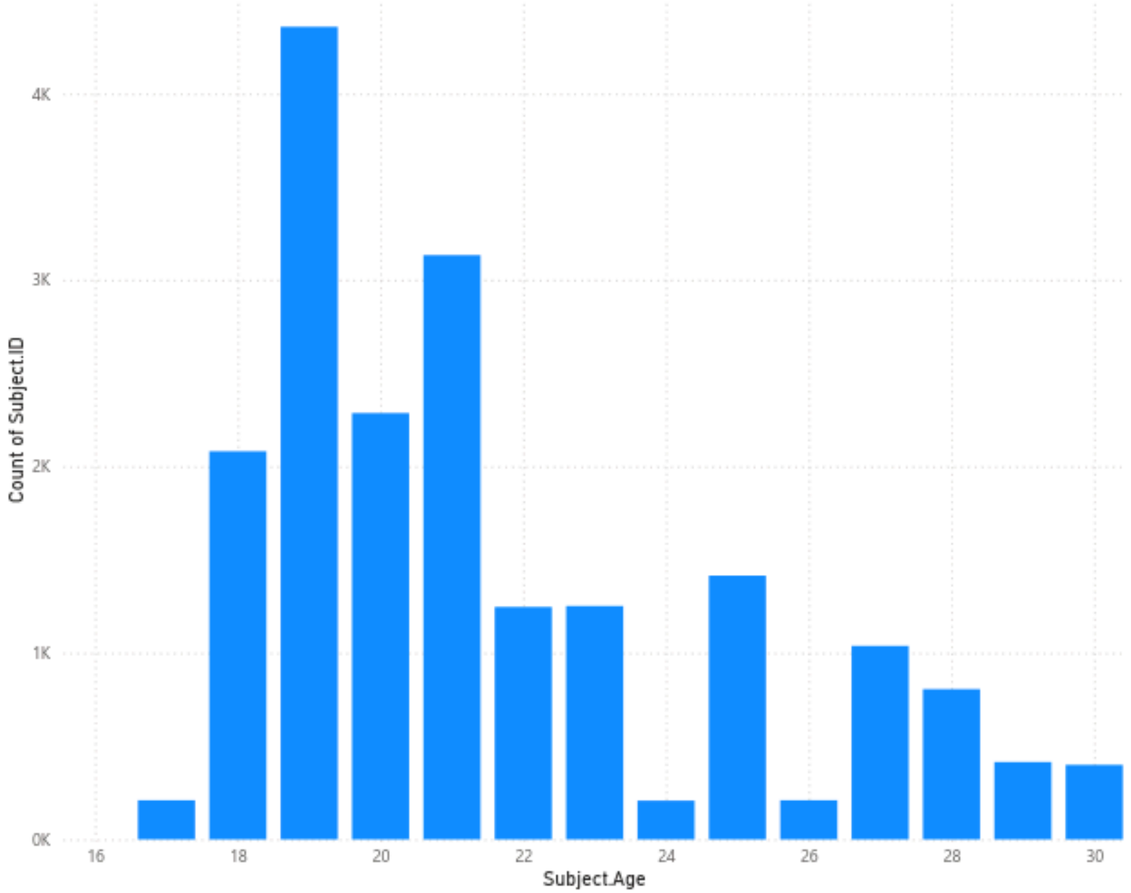
Experiment 2 (Within-Subjects)

- **Age range:** 17 to 28 years (Mean = 22.02, SD = 2.99)
- **Reaction Time (RT):** Mean = 934.31ms, SD = 1069.53ms
- **Stimulus Delay:** Mean = 608.69ms, SD = 374.66ms
- **Outcome type:** Balanced (50% each)

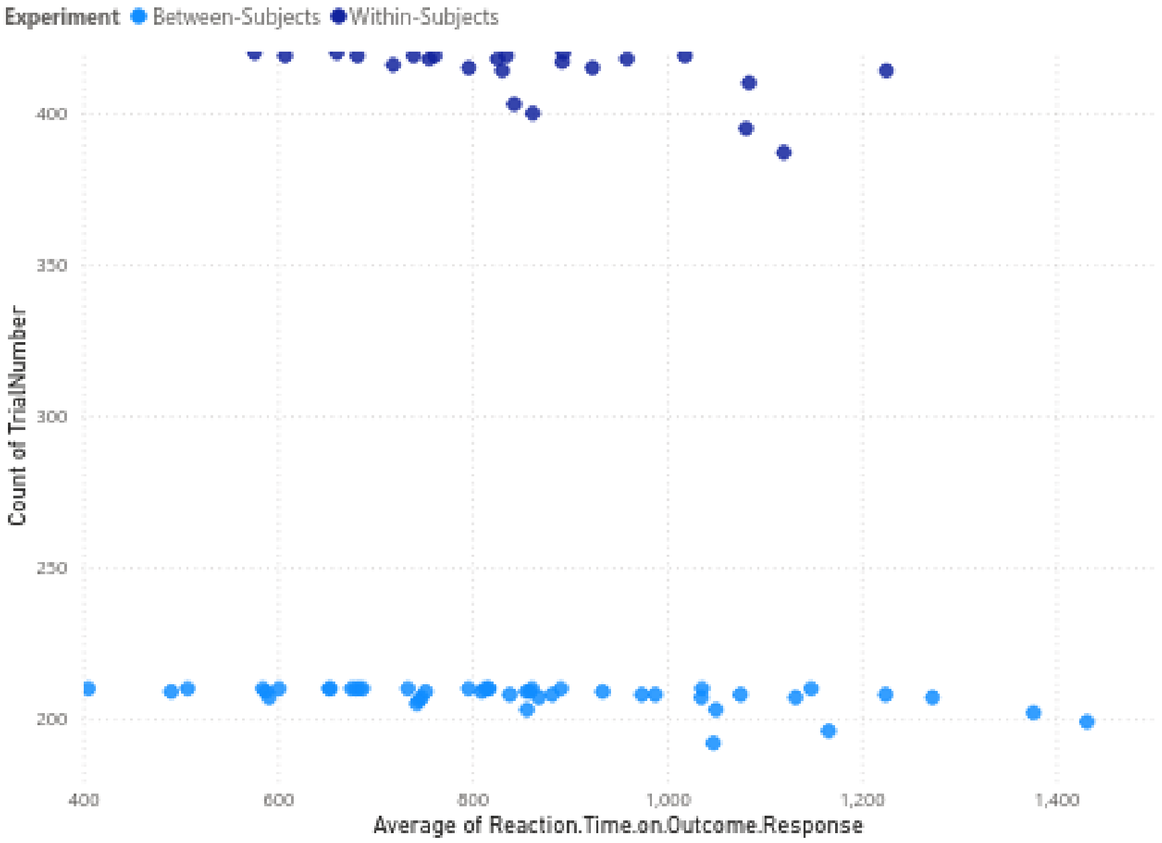
Count of Subject.ID by Gender



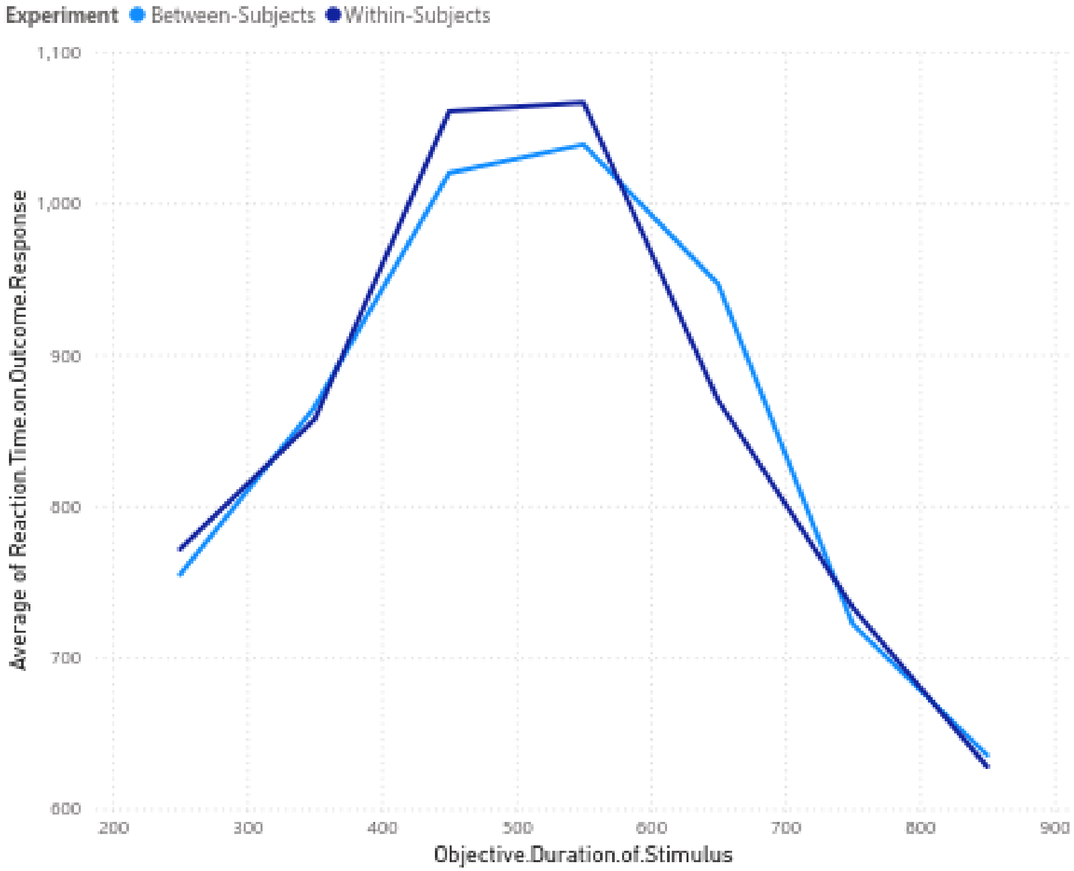
Count of Subject.ID by Subject.Age



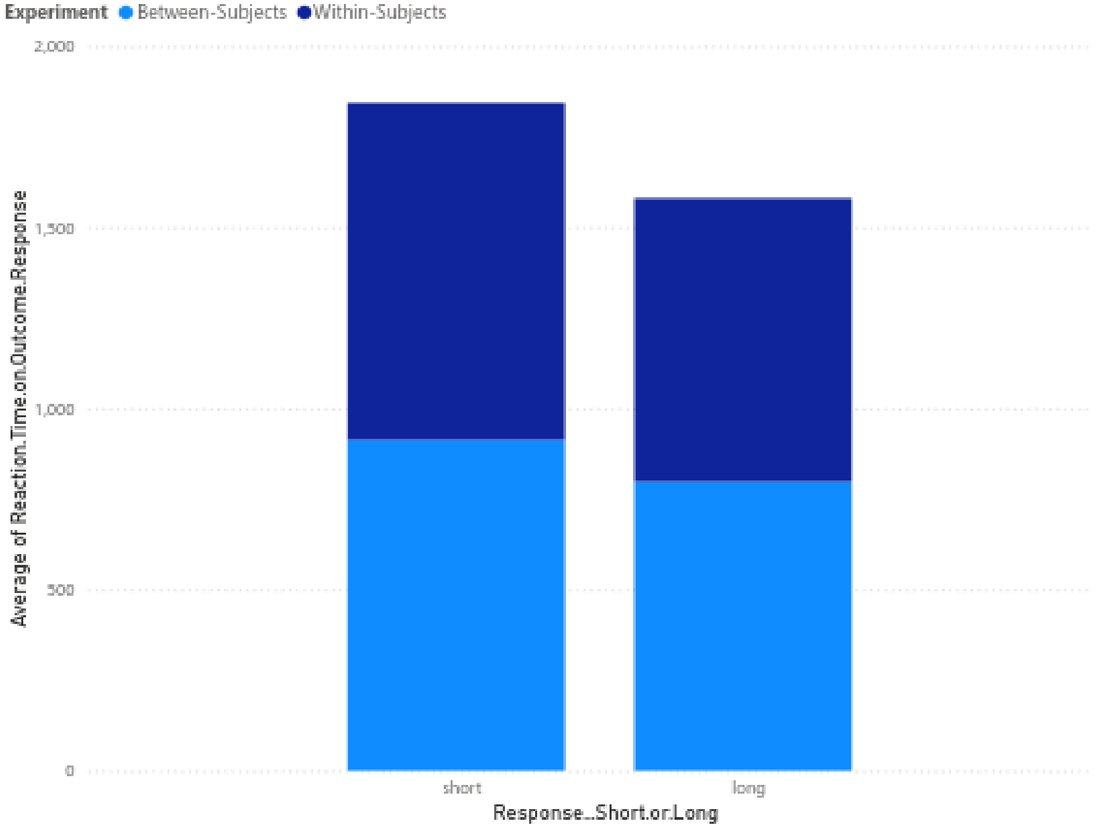
Average of Reaction.Time.on.Outcome.Response and Count of TrialNumber by Subject.ID and Experiment



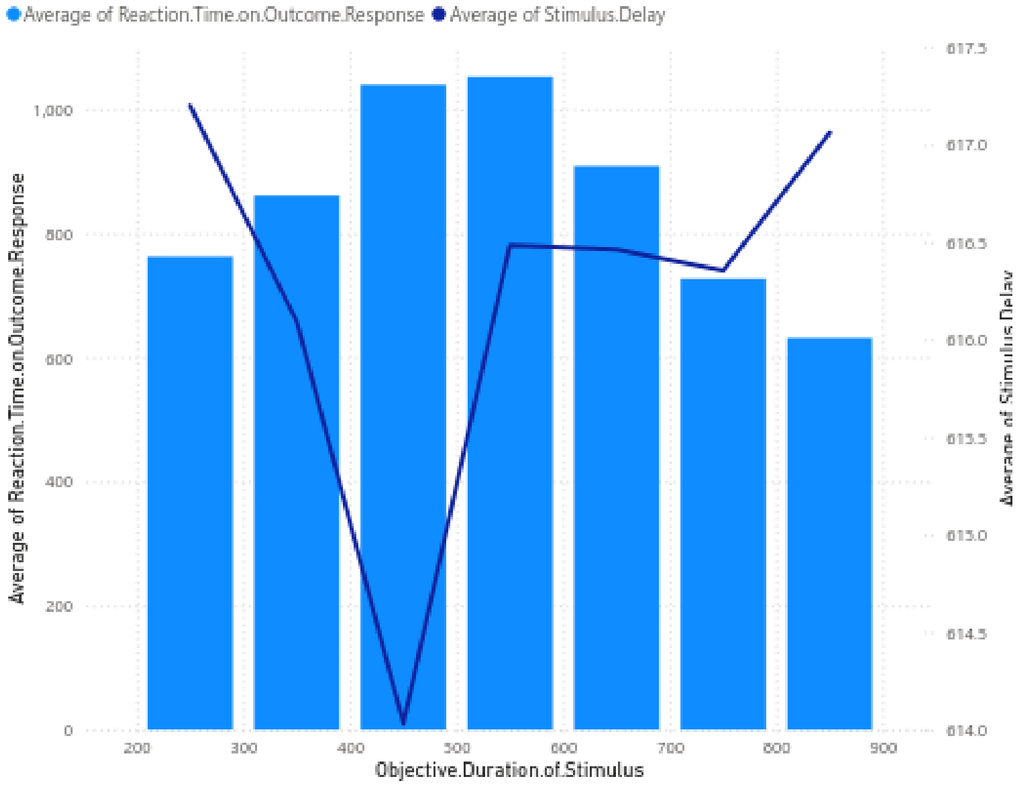
Average of Reaction.Time.on.Outcome.Response by Objective.Duration.of.Stimulus and Experiment

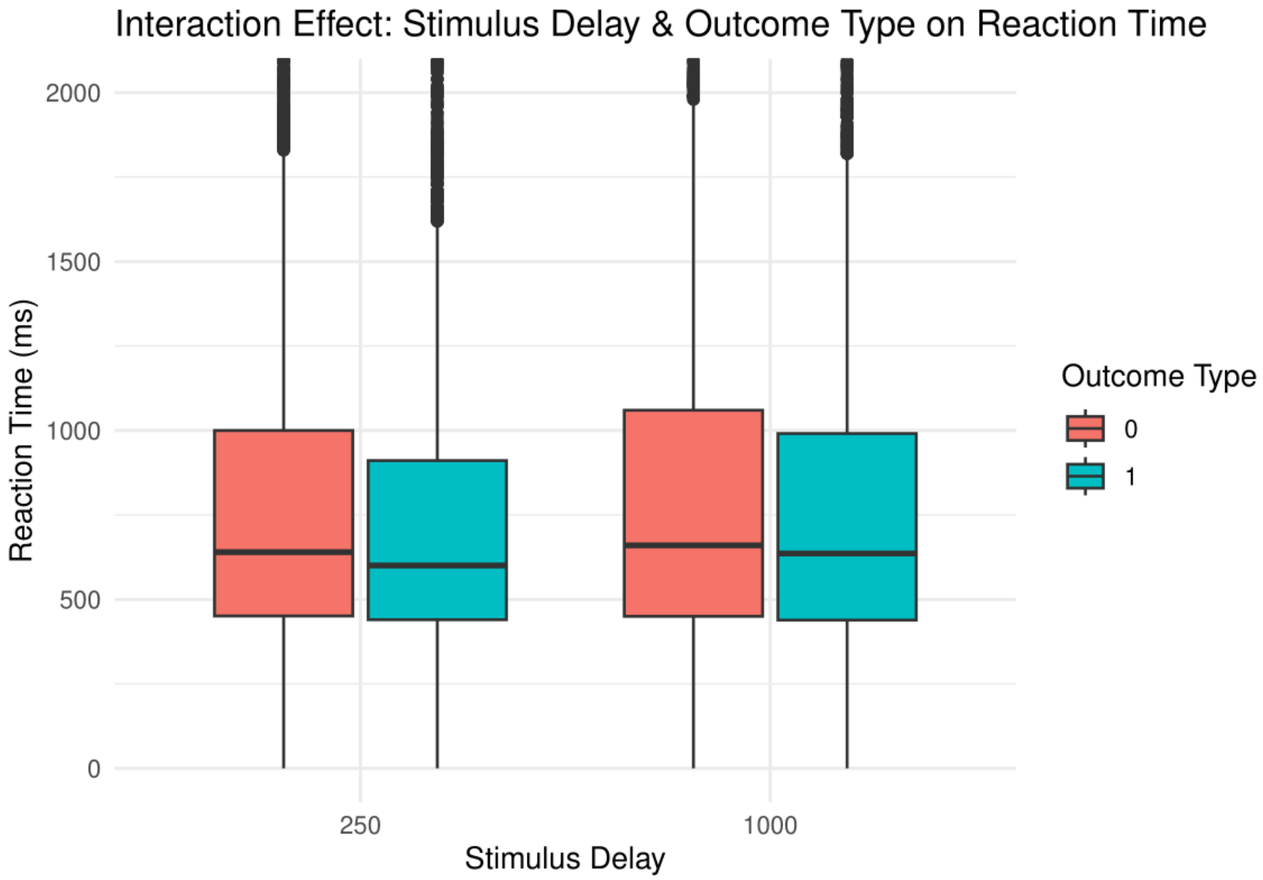


Average of Reaction.Time.on.Outcome.Response and Sum of Reaction.Time.on.Outcome.Response by Response...Short.or.Long and Experiment



Average of Reaction.Time.on.Outcome.Response and Average of Stimulus.Delay by Objective.Duration.of.Stimulus





- The interaction plot shows how intended and unintended outcomes affect reaction times across stimulus delays.
- Reaction times are slightly shorter for intended outcomes across both 250ms and 1000ms conditions, aligning with intentional binding theory.
- Variability is higher in unintended outcomes, suggesting that participants may struggle more when outcomes are not self-initiated.

Experiment 1 Results

- No significant effect of intention on temporal expansion.
- Longer delays (1000ms) caused general overestimation of outcome duration.

- Suggests that pre-activation may not be the main cause.
- Delay itself influences temporal perception.

Experiment 2 Results

- Significant expansion of intended outcomes, but only in the 1000ms condition.
- No significant expansion effect in the 250ms condition.

- Suggests that attentional allocation (not pre-activation) influences outcome perception.
- Temporal relevance affects time perception.

Future Directions

- Examining causality in temporal binding and whether different experimental conditions alter the perception of time.
- Investigating gender and age-related differences in intentional binding effects.
- Exploring the relationship between reaction time and subjective duration estimates to refine predictive models.
- Comparing within-subjects and between-subjects designs to assess their impact on perception and decision-making.

Conclusion

- **Main Findings:**
  - Intentional outcomes expand in time only at longer delays (1000ms).
  - Expansion is due to attention and memory, not pre-activation.
- **Implications for Time Perception:**
  - Intention-based time perception is dynamic and context-dependent.

References & Acknowledgements

Donapati, R.R., Shukla, A. & Bapi, R.S. Action-outcome delays modulate the temporal expansion of intended outcomes. Sci Rep 14, 2379 (2024). http://dx.doi.org/10.1038/s41598-024-52287-x

Thank You

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