Prospective Memory Decision Control in simulated maritime surveillance

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Background

Event-Based Prospective Memory (PM): Remembering to perform an intended action in the future when encountering some event/stimulus.

For example, you may intend to pass on a message to a friend.

Basic PM paradigm (Einstein & McDaniel, 1990).
Event-Based Prospective Memory in the Laboratory

Control Block
*Lexical decision instructions:* indicate whether letter strings are words or non-words.

PM Block
*Lexical decision instructions:* indicate whether letter strings are words or non-words. 
In addition, please press an alternative key if an item is green.

Yields “PM accuracy” measure and also a “PM cost” effect (Smith, 2003).
Evidence Accumulation Modelling

What we typically have in choice tasks:

An array of observed RT (mean, variance, skew) and accuracy data for each participant for each design cell.

Things we want in our theories:

The latent psychological processes that produced the data:

- Thresholds. Caution, bias
- Evidence accumulation rates. Speed of processing
- Encoding and motor response time.
Prospective Memory Decision Control Model (Strickland, Loft, Remington, & Heathcote, in press): uses three linear ballistic accumulators (Brown & Heathcote, 2008) to fit to entire PM data set.

\[ RT = \text{Accumulation time} + \text{non-decision time} \]
Prospective Memory Decision Control Theory
(Strickland et al., in press)

PMDC can measure effects of:

- **Capacity sharing** between monitoring for PM and the ongoing task on non-PM items.

- **Proactive control** *(Braver, 2012)* over decision processes, active throughout entire PM blocks, to enhance PM.

- **Reactive control** *(Braver, 2012)* over decision processes, active specifically on PM trials, to enhance PM.
Capacity sharing between PM monitoring and the ongoing task (blocked control trials- all non-PM items, e.g., a ‘word’ item)
Capacity sharing between PM monitoring and the ongoing task (non-PM items, e.g., a non-PM word, PM blocks)
Proactive control (control block)
Proactive control (PM block)

PM threshold control

Ongoing Task Delay

Word

Non-word
Reactive control (PM *items* vs non-PM *items*)

Example PM trial:

PM stimulus inputs

**PM**

**Word**

**Non-word**

Inhibition

Excitation
Results from basic paradigm (Strickland et al., under review)

No capacity sharing evident in decisions to non-PM items (i.e., non-PM accumulation the same in PM and control). Inconsistent with verbal PM theories (e.g., Smith, 2003; Einstein & McDaniel, 2005).

PM cost explained by proactive control over ongoing task thresholds. There was also proactive control over the PM threshold.

Reactive inhibitory control to PM items. This was most critical to the effects of PM manipulations (importance/PM target focality), and also key in explaining individual differences in PM.

Whereas PMDC was developed modelling responses to static, simple PM and ongoing task stimuli, applied settings tend to involve complex, multi-stimulus environments.

Here I attempt to fit PMDC to a complex applied task of interest: Maritime Surveillance. Our simulated environment, which involves making decisions about ships on a camera display, has previously been fitted by Palada, Neal, Vuckovic, Martin, Samuels and Heathcote (2016) with both the DDM and LBA.
Aims

Test adding an event-based PM to this Maritime Surveillance task (PM cost? PM errors?).

Test PMDC adequacy (fit).

Test model mechanisms (how it fits):

- Capacity sharing between PM monitoring and the ongoing task (non-PM ship accumulation in PM vs control blocks)
- Proactive control (ongoing task thresholds under PM load vs control)
- Reactive control (PM ship accumulation vs non-PM ship accumulation)
Ongoing task

4 or more features = Target
Less than 4 = Non-target
Ongoing task

Make 3 decisions (in 9 seconds) to ships travelling across the screen.

RTs scored relatively (i.e., time since last response). See Palada et al., 2016. Although there is a response deadline, non-responses are rare.
PM task

These are the life boat and flag features. When a ship has both of these, please **RIGHT CLICK** the **RED** response box instead of left clicking.

Please speak with the experimenter now.
Design ($N = 36$, ~1500 trials per person)

**Manipulated Factors**
- Control blocks (no PM task) vs PM blocks
- PM blocks: PM ships vs non-PM ships

**Extra Factors**
- Target Ships vs Non-target ships
- Response order within a trial (1,2,3)
- Session (First, Second)
Results
PM Cost to Ongoing Task RT

Ongoing Task Performance

RT (s)

cond

Control

PM
PM Cost to Ongoing Task Accuracy

Ongoing Task Performance

Correct Proportion (%)

Cond

Control

PM

S

nont
tar

S

nont
tar
PM Performance

PM Task Performance

![Graph showing PM Task Performance](image)

RT

![Graph showing RT](image)
Modelling


Fit graphs with posterior prediction (Meng, 1994).

Model Selection with DIC (Spiegelhalter, Best, Carlin, Van Der Linde, 2002), WAIC (Vehtari, Gelman, & Gabry, 2017), Bayes factors with bridge sampling (experimental) (Gronau, Wagenmakers, Heck, & Matzke, 2017).

Posterior difference distributions for inference ($p$, $Z$ score)
Model Mechanisms
Capacity Sharing – rates to non-PM ships (control vs PM)

Correct Accumulation rates

Error Accumulation rates
Proactive Control

Non-target decision

Target decision

Threshold

Control  PM

Block

Control  PM
Reactive Inhibitory Control (Accumulation to ongoing task decisions on non-PM ships vs PM ships)
Summary

Our EVPM intention produced typical PM data in terms of PM errors and PM costs.

The PMDC model can fit to this data.

**Replicating results from basic paradigm:** Some evidence of PM-induced proactive control over ongoing task thresholds (same as basic paradigms). Strong evidence of reactive inhibition of ongoing task decisions on PM trials.

**Different in this paradigm:** Capacity sharing between PM monitoring and the ongoing task.
Some future directions

Use task-specific inputs as a front-end to the decision model.

Covariates:

Trial-to-trial:

Eye-tracking to measure attention/arousal.

Number of ships since last PM cue

Participant level:

Proactive / reactive control abilities

Cognitive capacity
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