ATTENTION AND SITUATION AWARENESS MODEL

(A-SA)

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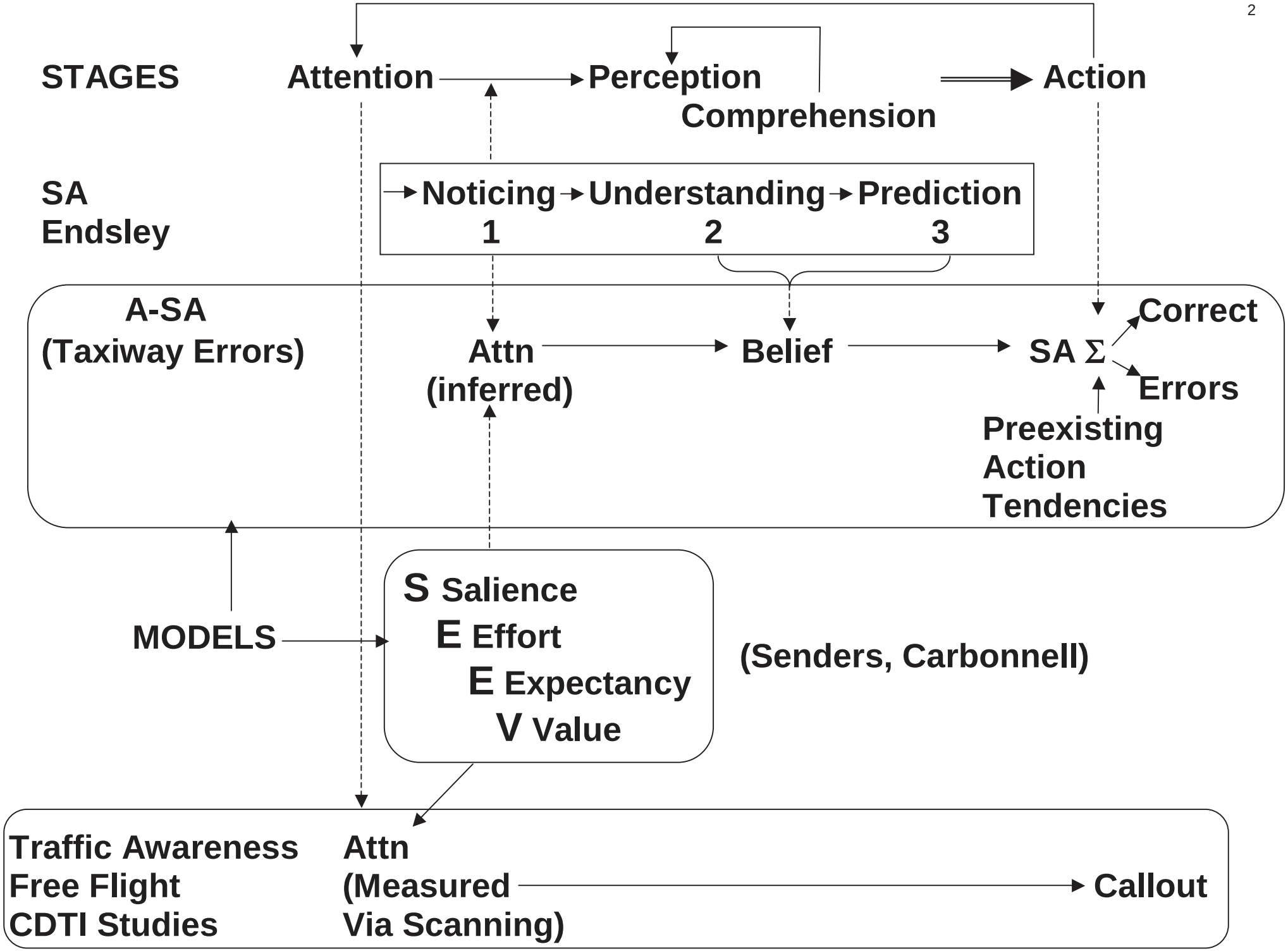
Two Applications


STAGES
Attention
Perception
Comprehension
Action
SA
Endsley
Noticing
1
Understanding
2
Prediction
3
A-SA
(Taxiway Errors)
Attn
(inferred)
Belief
SA Σ
Correct
Errors
Preexisting
Action
Tendencies
MODELS
S Salience
E Effort
E Expectancy
V Value
(Senders, Carbonnell)
Traffic Awareness
Free Flight
CDTI Studies
Attn
(Measured
Via Scanning)
Callout

Approach:

- **Goal Oriented**
  - **Taxiway errors**
  - **Scanning/mid air detection**
- **Computationally Feasible (bounded values of 0-1)**
- **Conceptually/Cognitively Plausible (Attention, cognitive workload, expectancy, memory decay, etc.)**

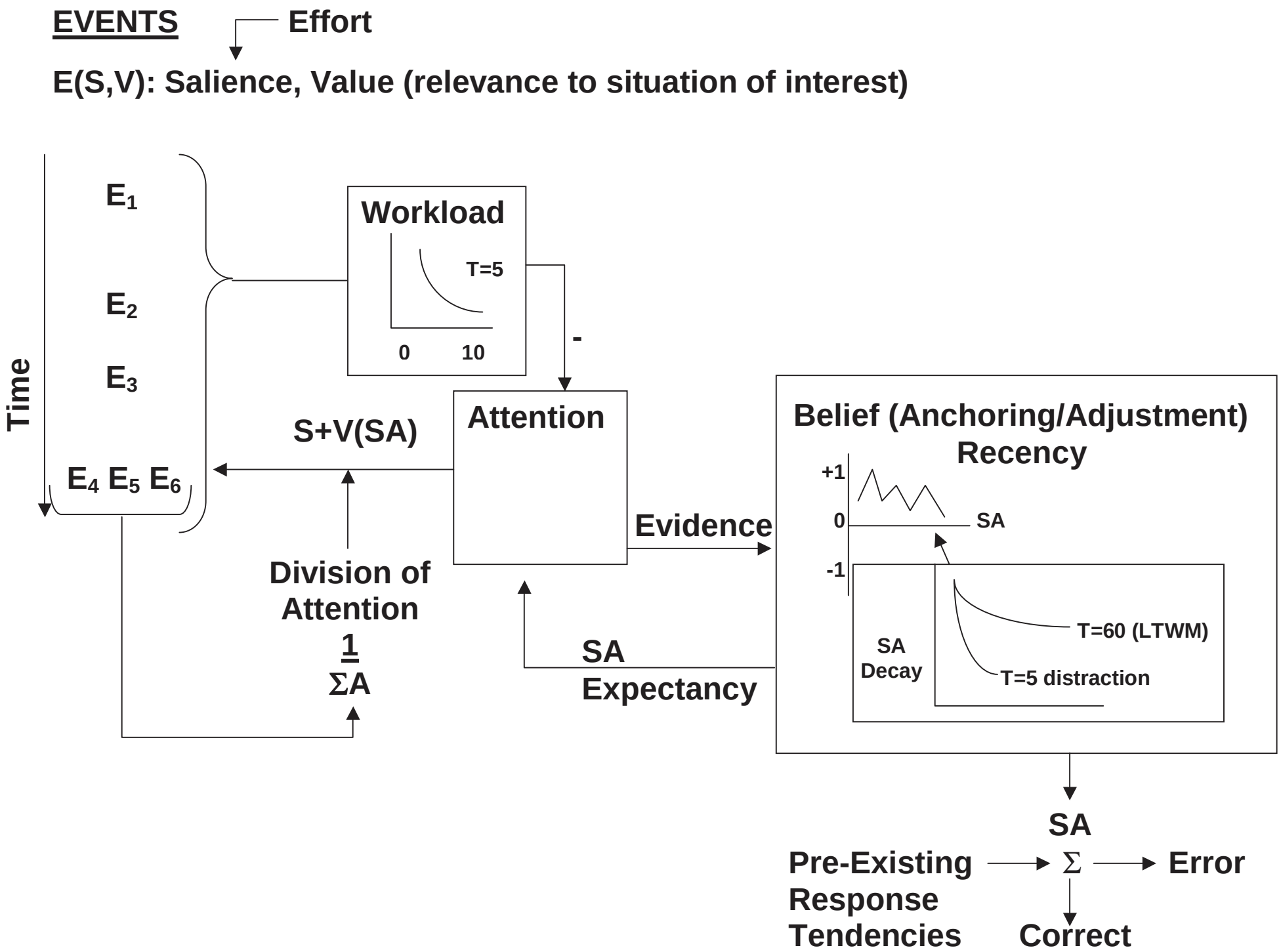
Taxiway Errors

- **Understand the scenarios (video, transcripts, error features)**

- **Construct real event file from video** | **Construct pseudo file for model exercise**

- **Develop, test and refine model**

- **Produce plausible data for variance in SA $\Rightarrow$ variance in turn errors, but <u>not</u> model <u>specific</u> errors**


EVENTS
Effort
E(S,V): Salience, Value (relevance to situation of interest)
Time
E1
E2
E3
E4 E5 E6
Workload
T=5
0
10
-
Attention
S+V(SA)
Division of Attention
1
ΣA
Evidence
SA Expectancy
Belief (Anchoring/Adjustment)
Recency
+1
0
-1
SA
SA Decay
T=60 (LTWM)
T=5 distraction
SA
Pre-Existing Response Tendencies
Σ
Error
Correct

FREE MODEL PARAMETERS

SA decay (McCarley number) T=60

Active decay/interference T=5

Assume equal weighting for salience and value

EVENT PARAMETERS

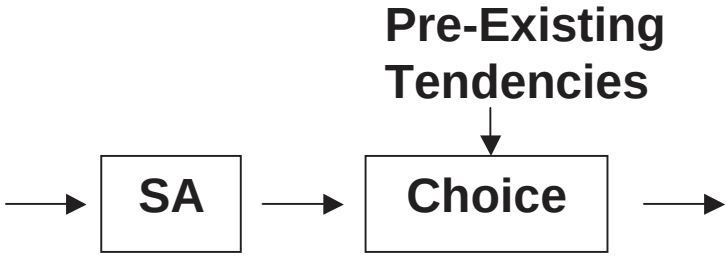
Salience/conspicuity (0-1)

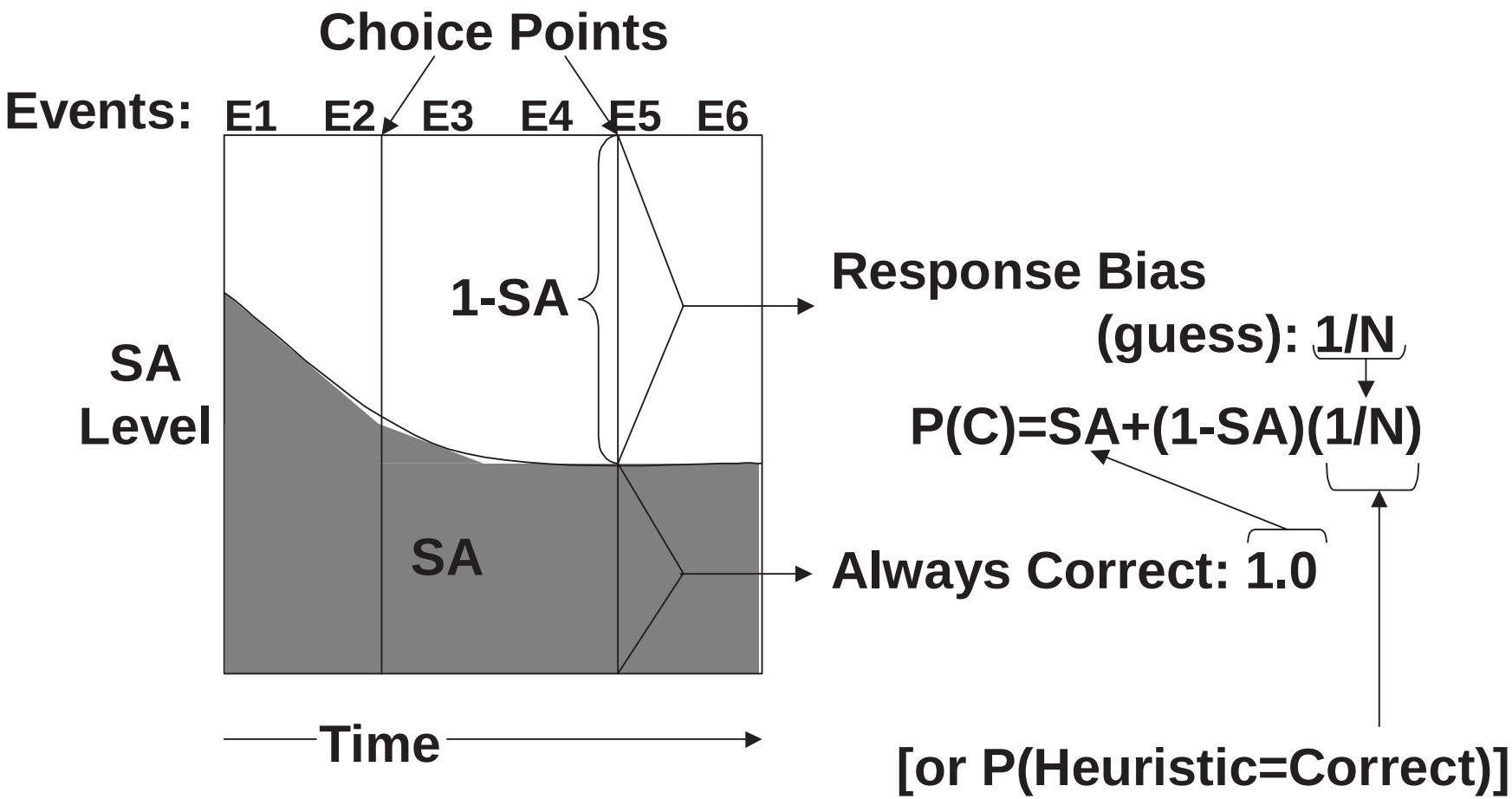
Value (0 $\rightarrow$ +1) (over simulation)

(-1 $\rightarrow$ 0 $\rightarrow$ +1)

KEY MODEL ASSUMPTIONS

- **Attention proportional to salience/conspicuity**
- **Information access effort (E) accounted for by salience**
- **Unrehearsal material (in workload, in rehearsal-prevented SA) decays at t=5 sec**
- **Otherwise SA declines at t=60 (Ericsson & Kintsch, LTWM)**
- **Belief/SA guides attention (top down, confirmation bias). No metacognitive processes**
- **Unipolar belief: +SA vs. O SA, rather than bipolar belief (SA correct vs. SA error)**
- **Lower SA ⇒ Greater contribution of response tendencies to error.**




Choice Points
Events:
E1
E2
E3
E4
E5
E6
1-SA
SA
Level
SA
Time
Response Bias
(guess): 1/N
P(C)=SA+(1-SA)(1/N)
Always Correct: 1.0
[or P(Heuristic=Correct)]

Simulation Results

(a) Full event file of 11 minute video (72 events)

- Adjusted SA decay to approach

  2% error rate

- SA: E_1 E_2 E_3 E_4 E_5 . . . .

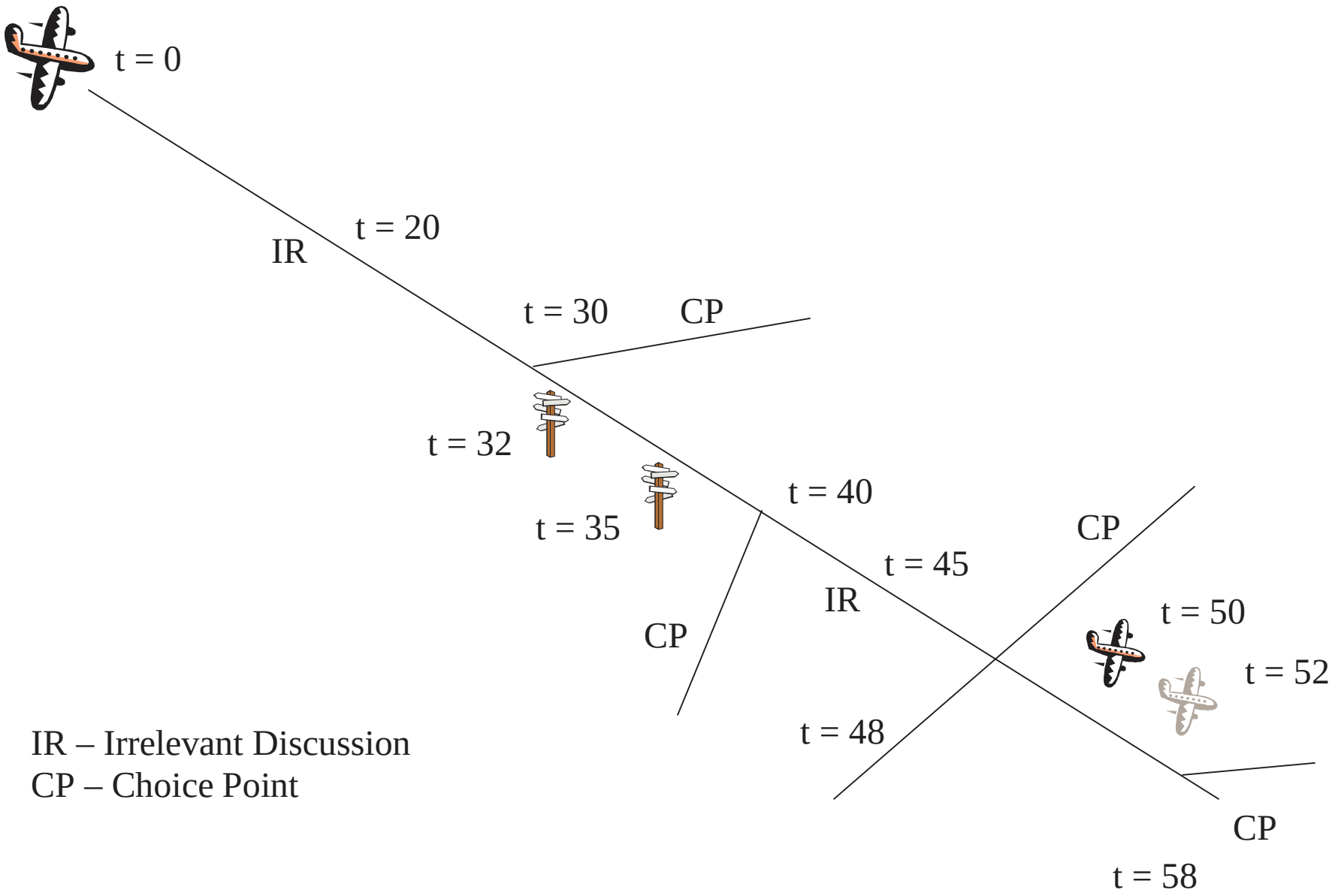
  $E_2 \rightarrow$ Choice P(C)

  $E_4 \rightarrow$ P(C)

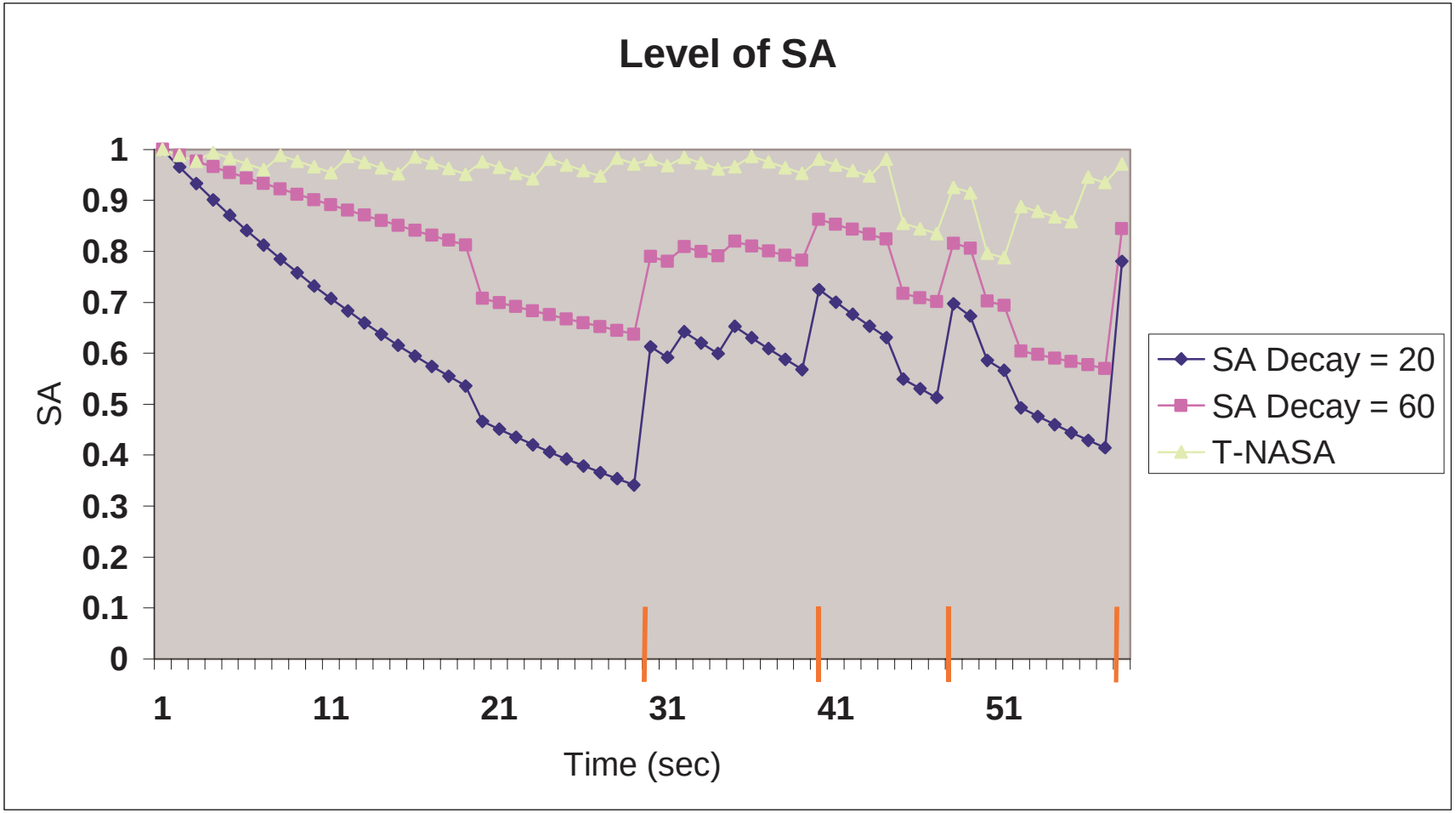
(b) Simulated 1 minute pseudo run (10-15 events)

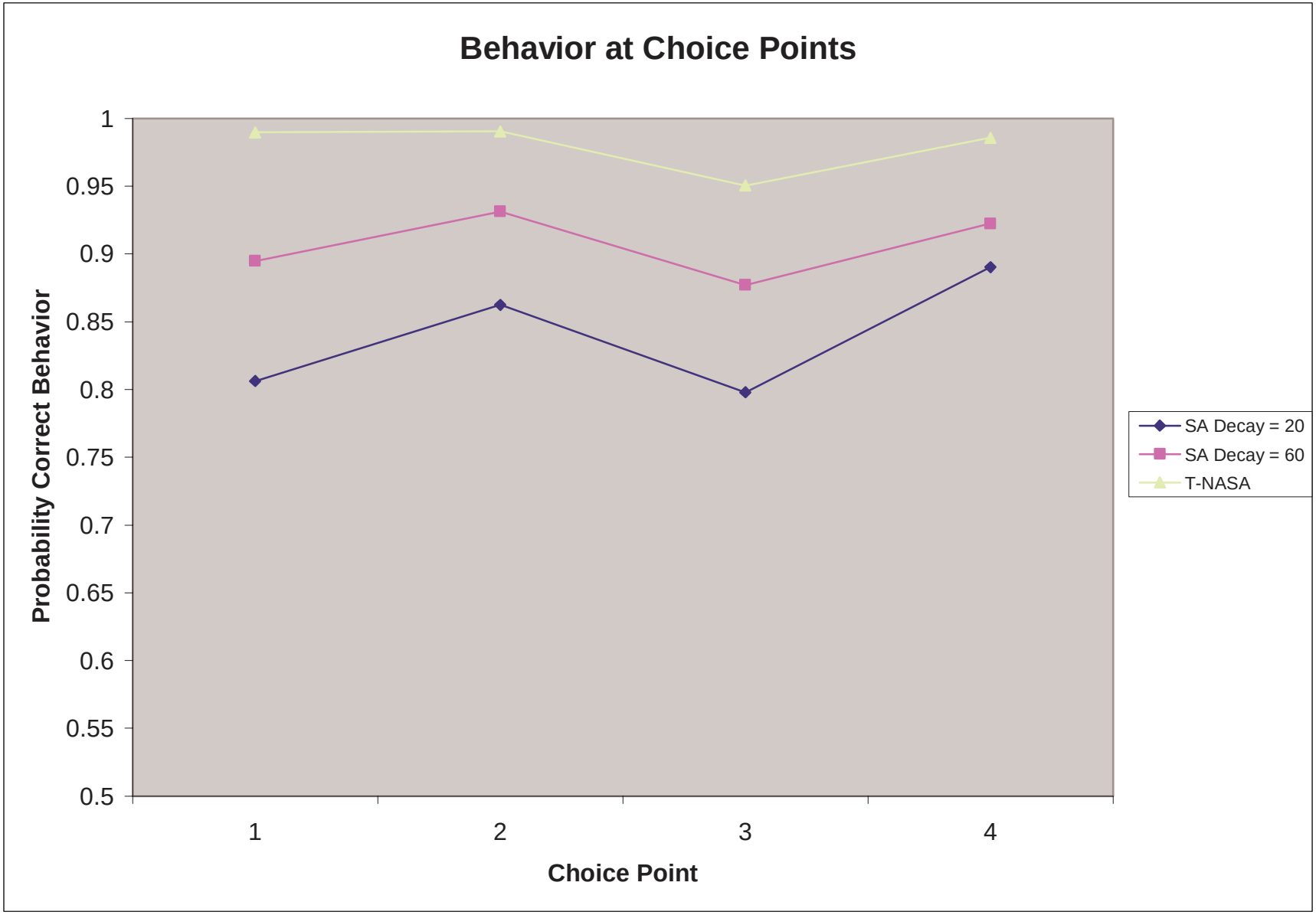
- Varied workload, salience, value, SA decay, choice point complexity. Simulated T-NASA display glance (4 sec).

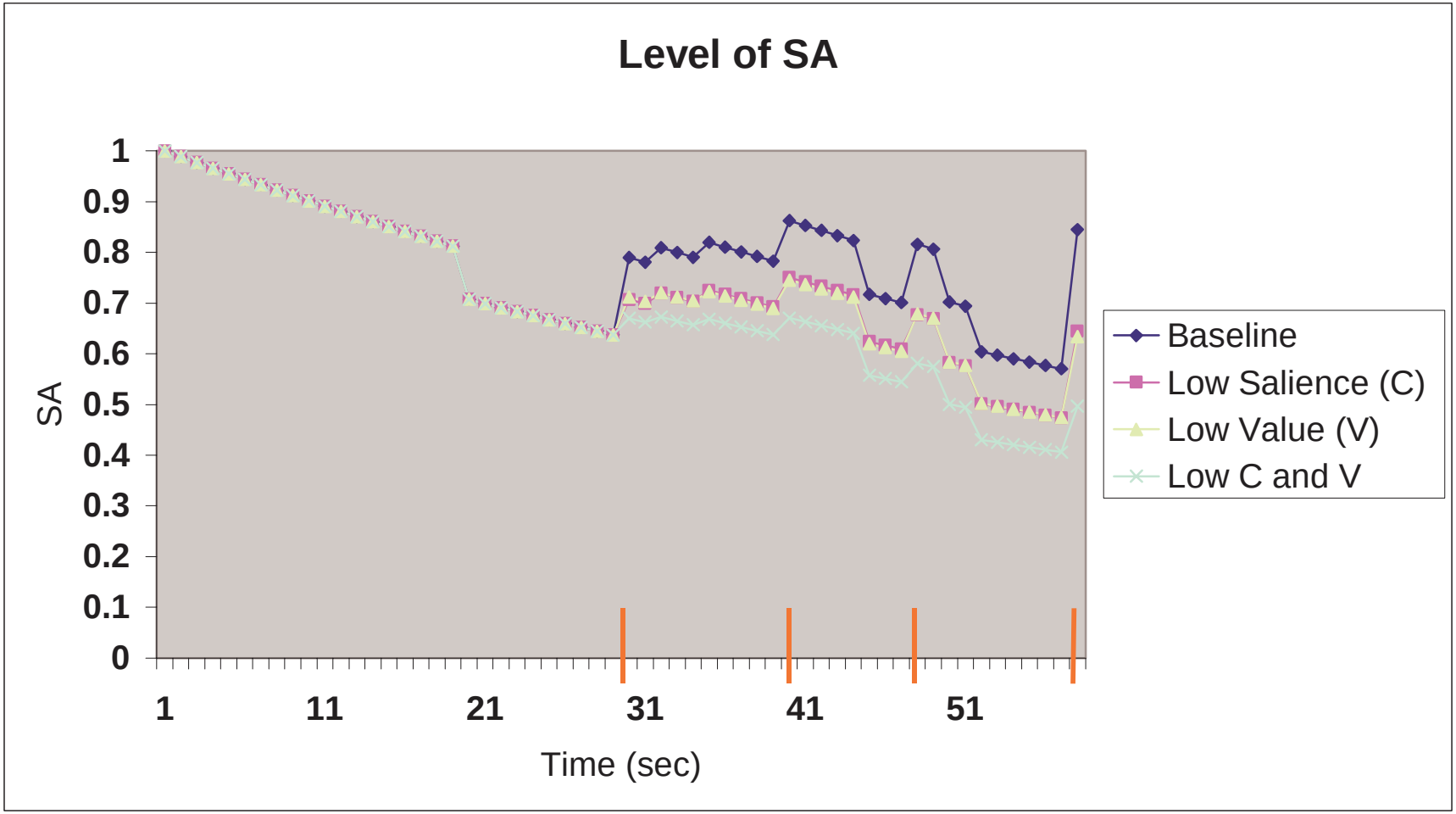
- Additional adjustments in model architecture

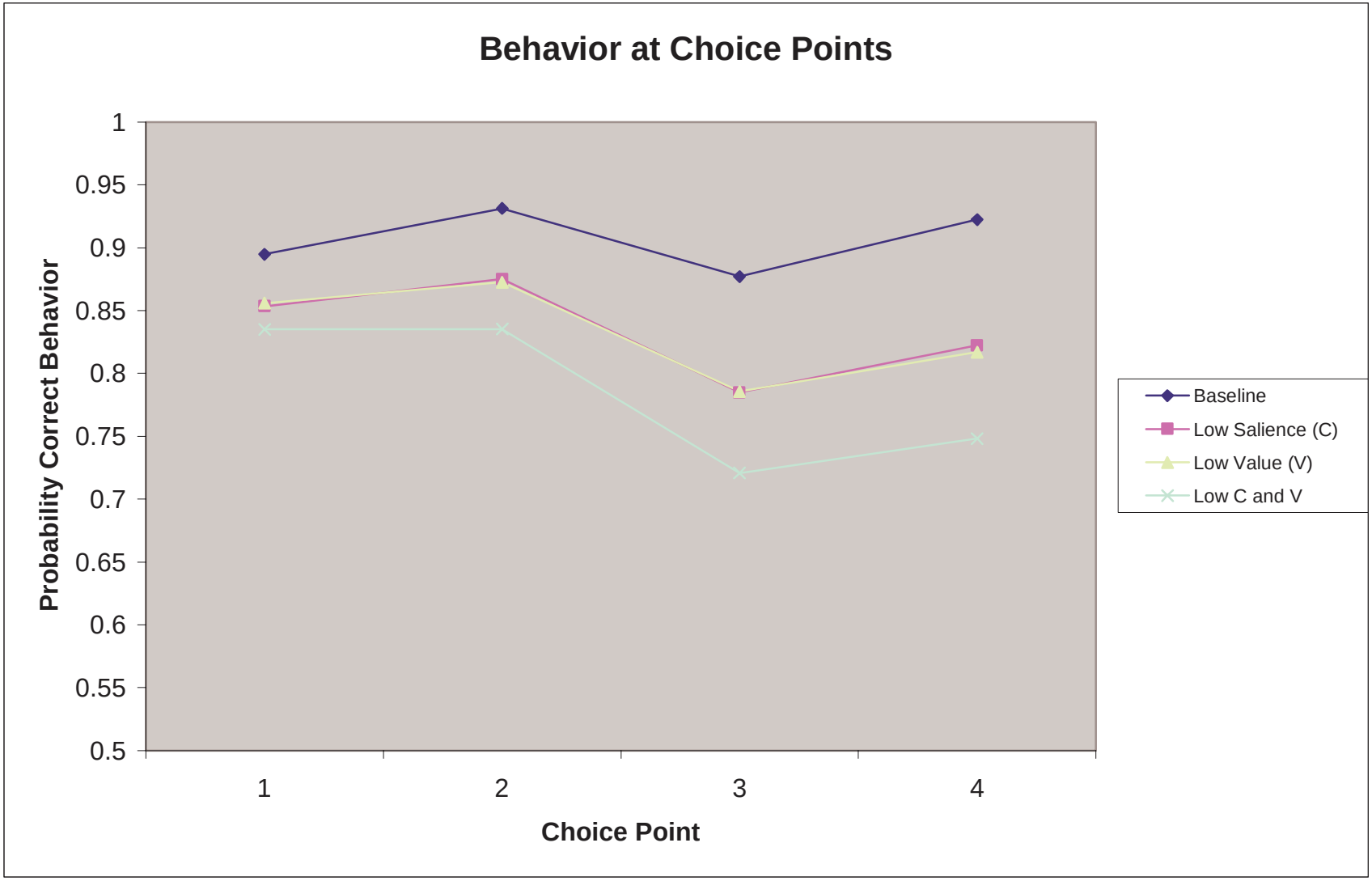


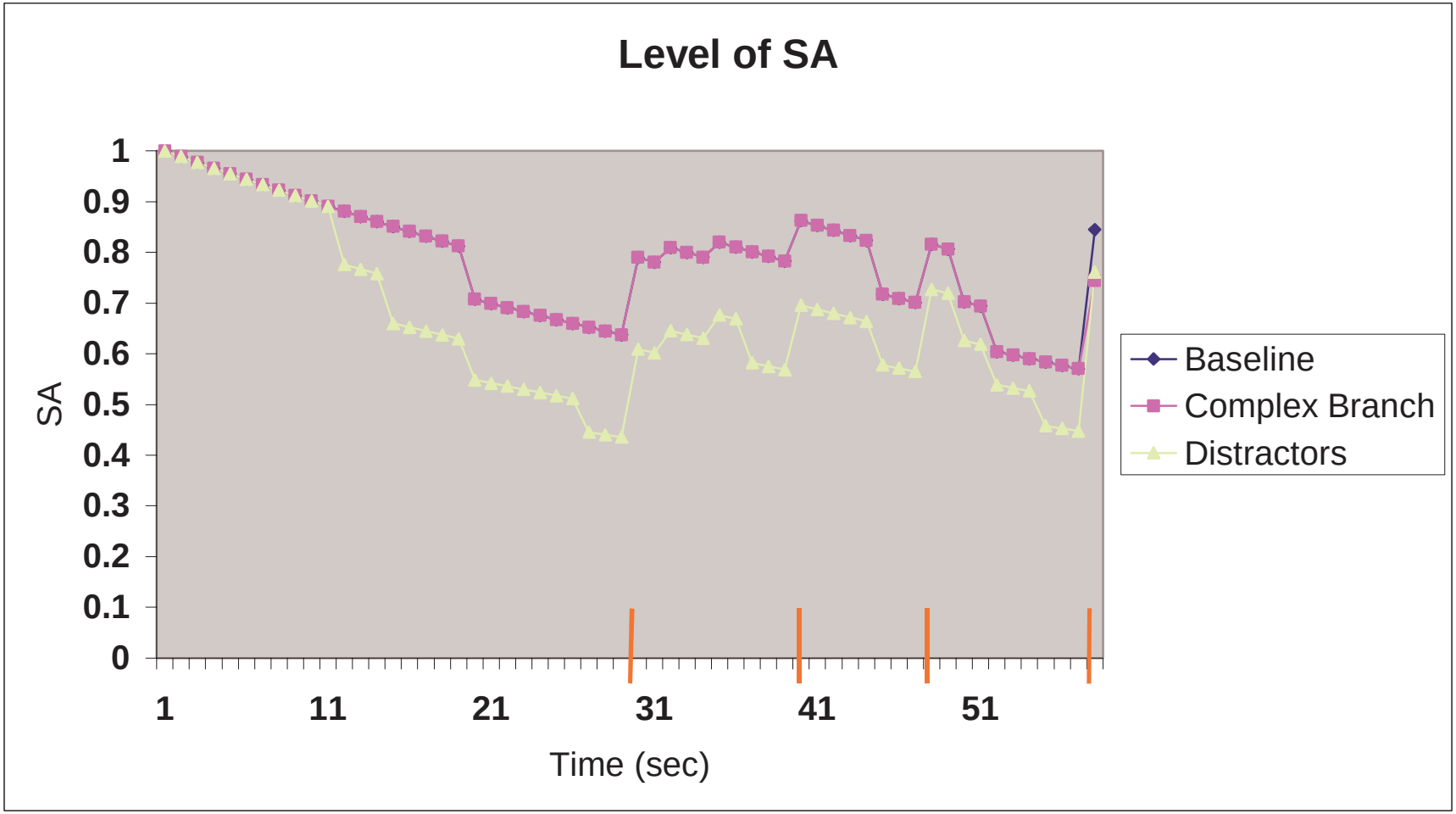
IR – Irrelevant Discussion
CP – Choice Point

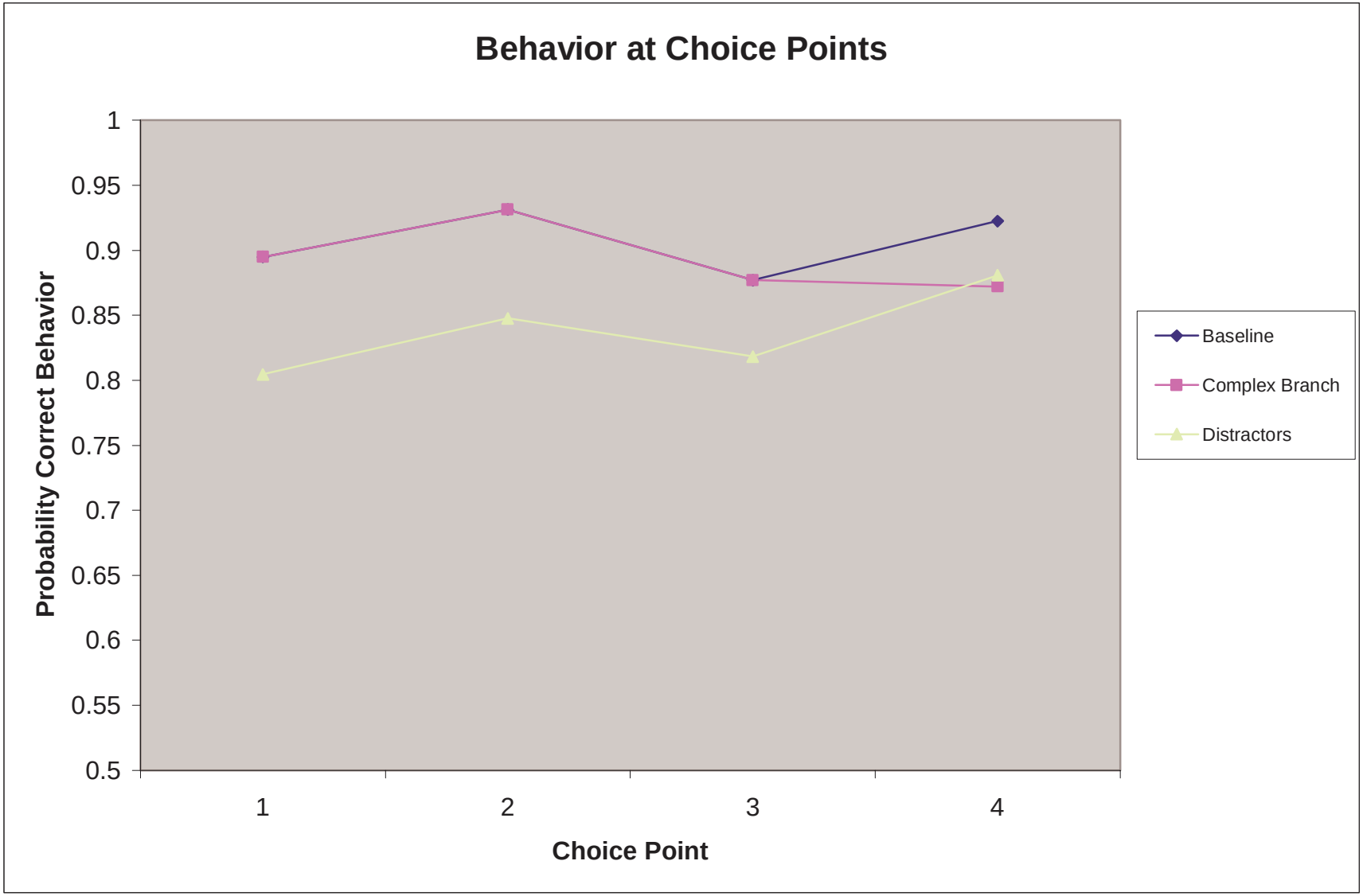

Level of SA
SA
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
11
21
31
41
51
Time (sec)
SA Decay = 20
SA Decay = 60
T-NASA

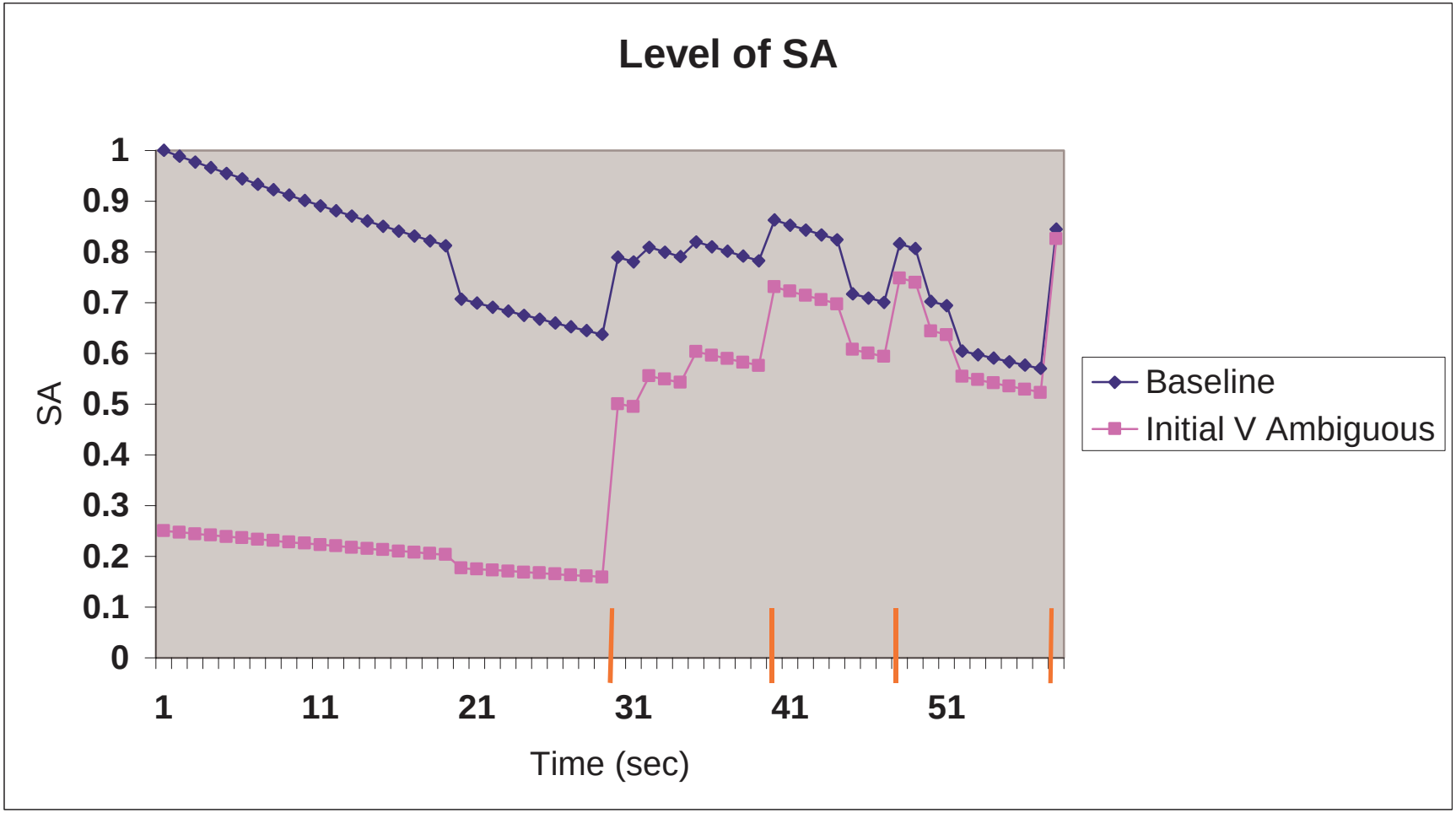

Behavior at Choice Points
Probability Correct Behavior
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
1
2
3
4
Choice Point
SA Decay = 20
SA Decay = 60
T-NASA

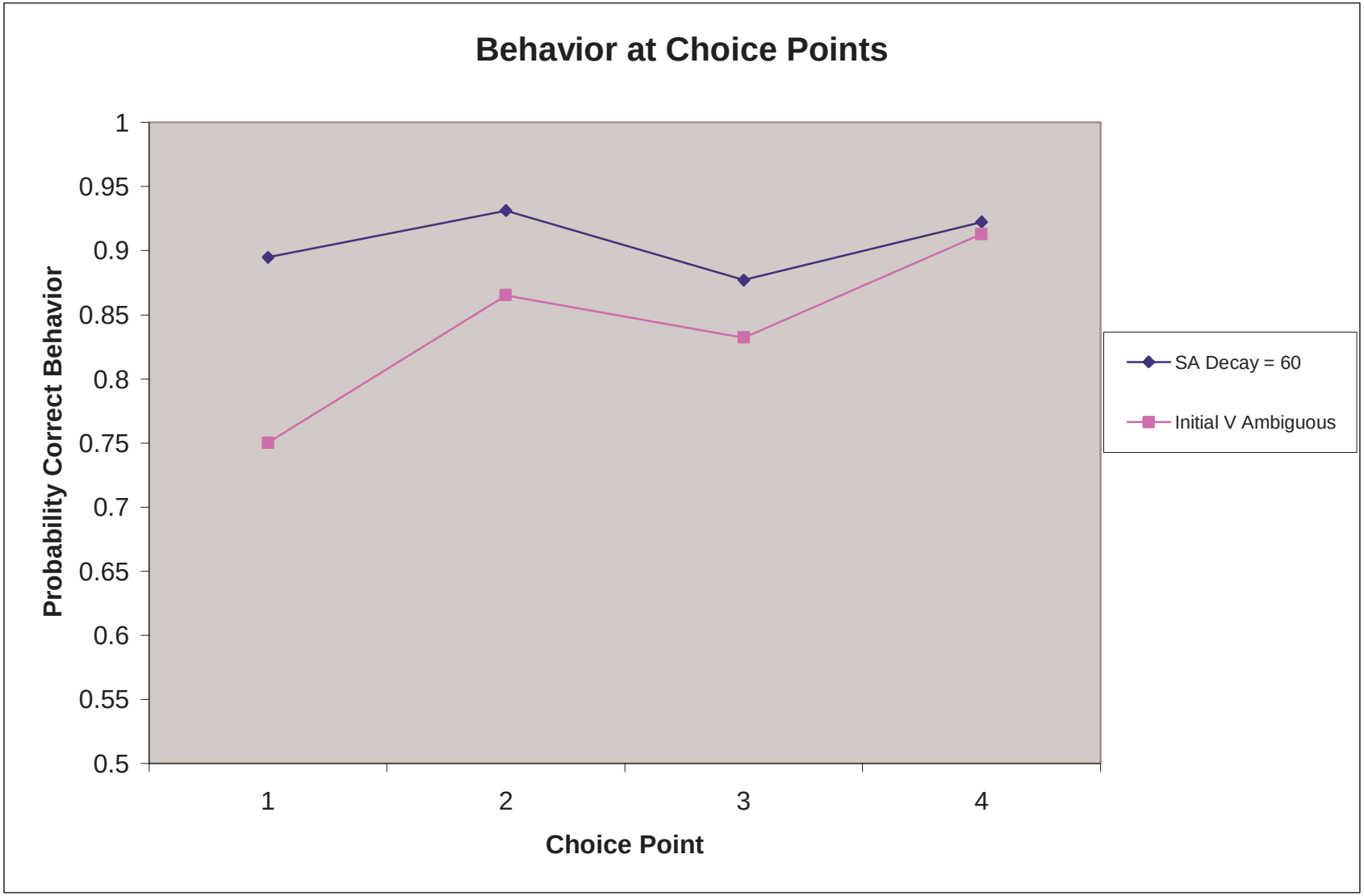

Level of SA
SA
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
11
21
31
41
51
Time (sec)
Baseline
Low Salience (C)
Low Value (V)
Low C and V


Behavior at Choice Points
Probability Correct Behavior
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
1
2
3
4
Choice Point
Baseline
Low Salience (C)
Low Value (V)
Low C and V


Level of SA
SA
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
11
21
31
41
51
Time (sec)
Baseline
Complex Branch
Distractors


Behavior at Choice Points
Probability Correct Behavior
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
1
2
3
4
Choice Point
Baseline
Complex Branch
Distractors


Level of SA
SA
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
11
21
31
41
51
Time (sec)
Baseline
Initial V Ambiguous


Behavior at Choice Points
Probability Correct Behavior
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
1
2
3
4
Choice Point
SA Decay = 60
Initial V Ambiguous

Coding of NASA Video. Time/Event/coded relevance

0 45 mark 2 0
0 50 check 0
1 03 discuss upcoming exit 1.0
1 50 configure airplane 0
1 55 repeat exit 1.0

2 20 500 feet 0
2 55 300 feet 0

3 05 TOUCHDOWN 0.5
3 11 reverse throttles 0
15 PASS EXIT T3 1.0
18 PASS EXIT T4 1.0
35 PASS EXIT T6 1.0
48 should be seven 1.0
53 PASS EXIT T7

4 04 should be nine 1.0
4 10 SIGN 1.0
4 15 EXIT T9 TURN, 1.0
4 25 SIGN 1.0
36 repeats clearance instruction 1.0

5 10 SIGN 1.0
5 11 CROSS (+) INTESECTION 1.0
5 13 SIGN 1.0
SIGN 1.0
SIGN 1.0

5 14 traffic ahead 0
5 17 BRANCH INTERSECTION 1.0
5 20 SIGN 1.0
5 34 left on mike 1.0
5 36 SIGN
5 45 TURN ON MIKE (CROSS) 1.0
5 55 to mike 6
5 57 SIGN 0.5

6 10 SIGN 1.0
6 15 BRANCH INTERSECTION 1.0
6 20 conversation 0
6 25 SIGN 1.0
6.30 BRANCH INTERSECTION 1.0
6 36 CROSS INTERSECTION 1.0
6 46 BRANCH INTERSECTION 1.0
6 54 CROSS INTERSECTION 1.0

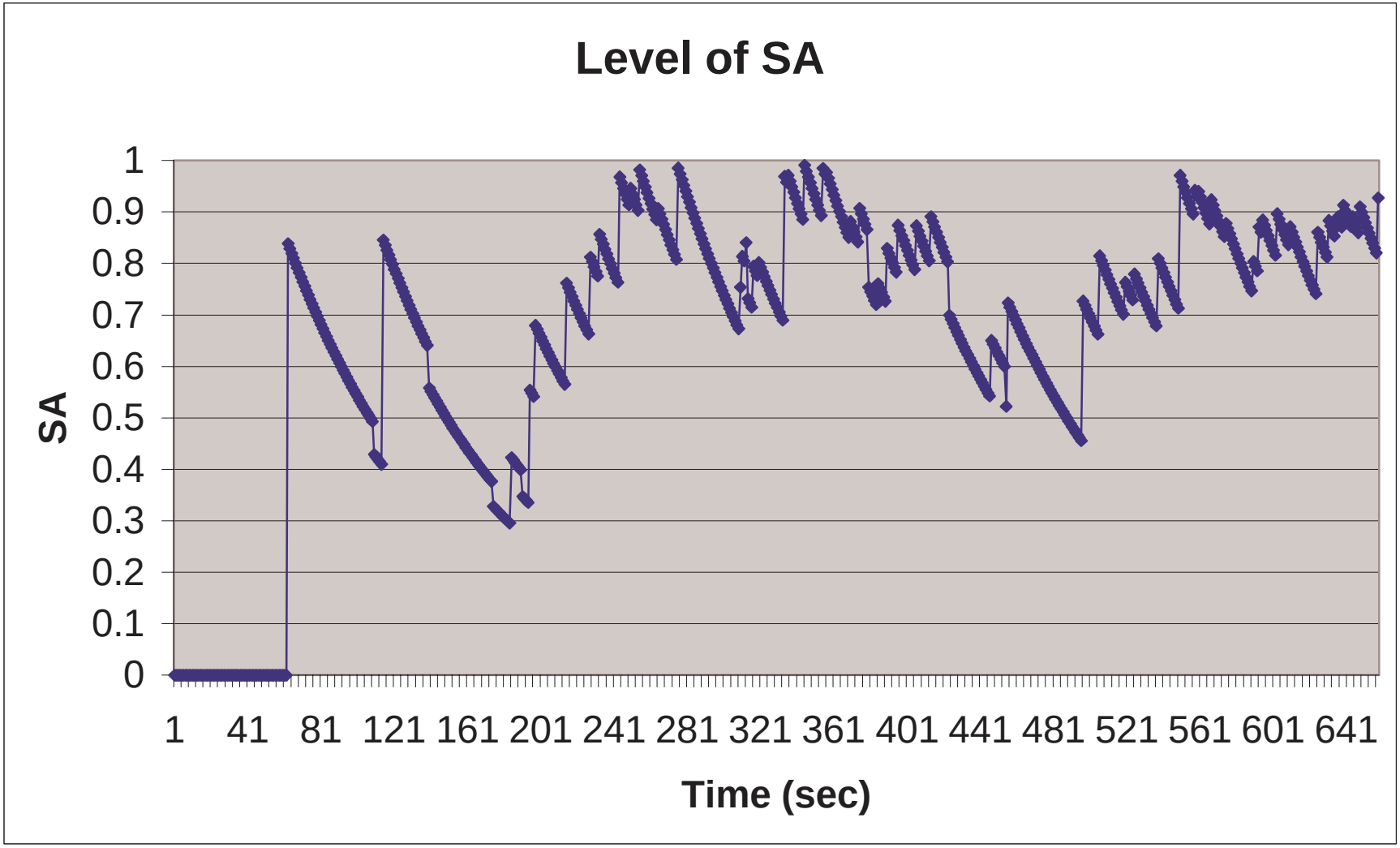
7 04 conversation 0
7 27 SIGN 1.0
7 35 RUNWAY INCURSION 0 (Salience = 1)
7 36 CROSS INTERSECTION 1.0

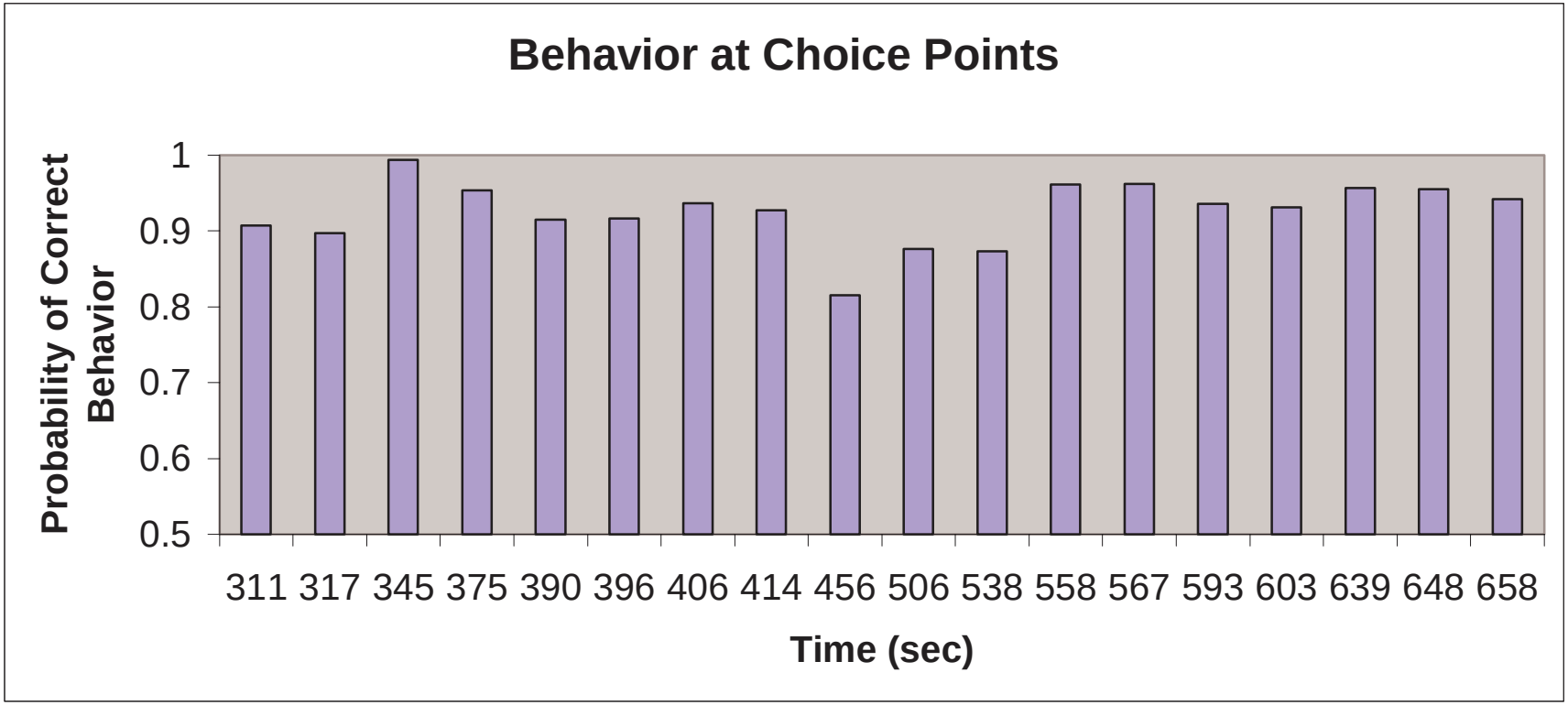
8 17 anticipating mike 6 1.0
8 26 CROSS INTERSECTION 1.0
8 40 SIGN 1.0
8 45 SIGN 1.0
8 58 TRAFFIC VISIBLE 0 Salience = 0.5
8 58 CROSS INTERSECTION 1.0 (*He pauses here*)

9 10 straight ahead 1.0
9 18 CROSS INTERSECTION 1.0 *Pilot hesitates and momentarily starts to turn in the wrong dir*ection.
9 20 SIGN 1.0
9 27 DELTA 1.0 (*I think this is crossing a branch. Check with map*).
9 35 SIGN 1.0
9 50 SIGN 1.0
9 53 BRANCH 1.0
9 55 SIGN 1.0
SIGN 1.0

10 03 CROSS INTERSECTION 1.0
10 10 SIGN 1.0
SIGN 1.0
SIGN 1.0
10 25 BRAVO 1.0 (*crossing a branch*?)
10 31 ALPHA 1.0 (*crossing a branch*?)
10 35 SIGN 1.0
10 36 SIGN 1.0
10 39 BRANCH INTERSECTION 1.0
10 44 SIGN 1.0
10 48 BRANCH INTERSECTION 1.0
10 58 VERY COMPLEX INTERSECTION 1.0 (*Check map for complexity level*)

11 00 “I don’t know which way to turn, but I’ll take this”. (*Explicit statement of loss of SA, Our model should predict*


Level of SA
SA
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1 41 81 121 161 201 241 281 321 361 401 441 481 521 561 601 641
Time (sec)


Behavior at Choice Points
Probability of Correct Behavior
1
0.9
0.8
0.7
0.6
0.5
311 317 345 375 390 396 406 414 456 506 538 558 567 593 603 639 648 658
Time (sec)

APPLICATION 2

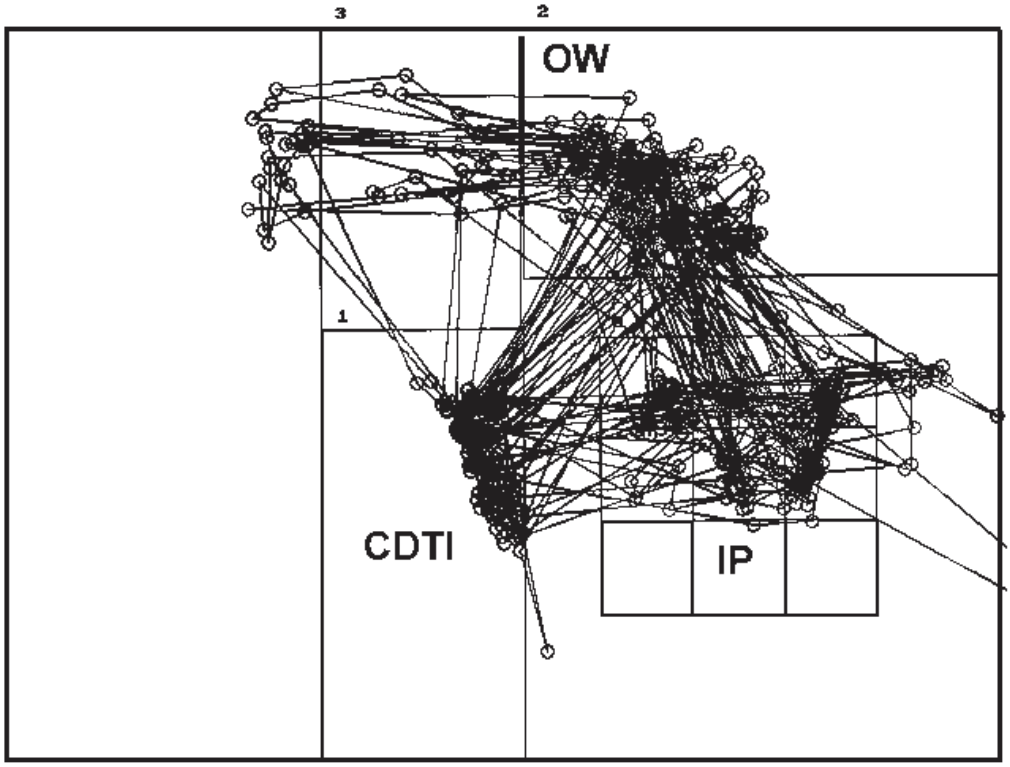
The SEEV Model

Aircraft Visual Scanning/ Traffic Detection

Three experiments:

- Baseline (ATC)
- CDTI (Free Flight)
- CDTI, Datalink, and Traffic Density (Expectancy)

Attention: Visual Scanning to Areas of Interest (AOI)


3
2
OW
1
CDTI
IP

Free Flight Simulation 2

- 12 pilots

- 3 display conditions
  - Auditory (IP, OW + Aud ATC)
  - Visual (IP, OW, CDTI)
  - Redundant (IP, OW, CDTI, + Aud ATC)

- Traffic density (1 vs. 4 traffic)/leg (expectancy)

- Scrutiny on call-out time:

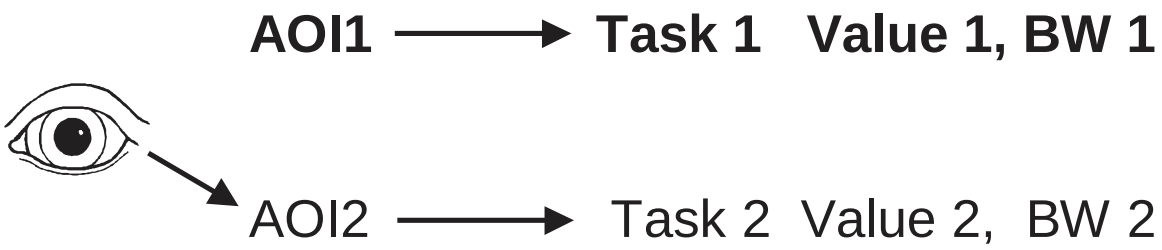
  (a) of CDTI aircraft (visual cueing)

  (b) of ATC aircraft (“traffic 10:00 low”)

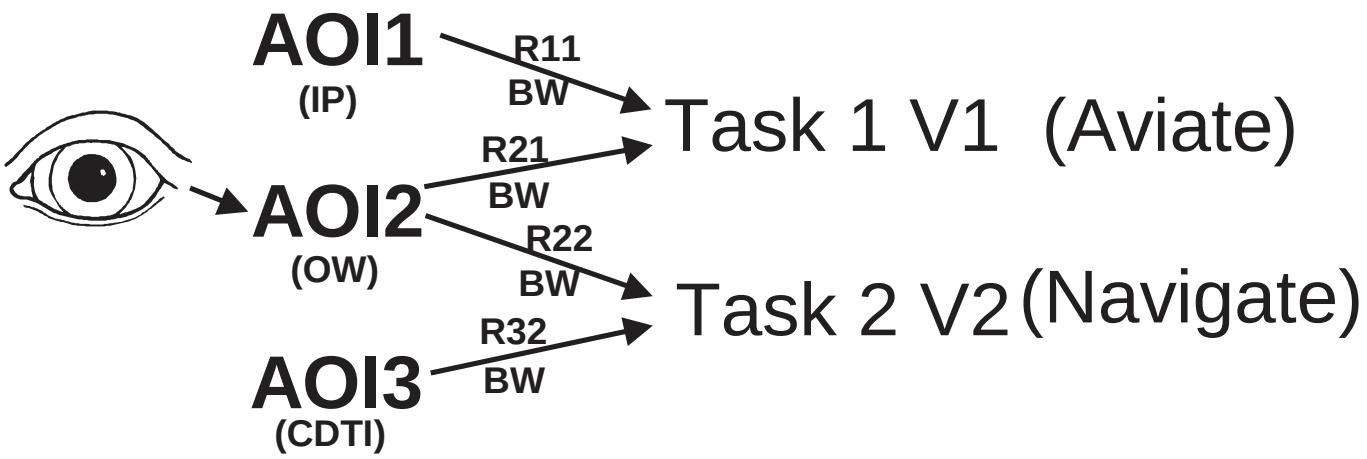
  (c) of “rogue aircraft” (CDTI transponder-off)

  (d) as a function of conspicuity

SIMPLE SCAN MODEL (Senders)



AVIATION SCAN MODEL



Visual Attention (Scan) to AOI =

$$\sum_{\text{TASKS}} [(\text{BW x relevance(value) of AOI to task x task priority}]$$

SEEV Model

Expectancy and Value in Pilot Visual Scanning Two Experiments

1. 17 pilots.
   - Free Flight (CDTI) vs. Baseline (ATC Vectors)
   - Conflict (Maneuver) vs. Non-Conflict (Straight & Level)

Area of Interest (AOI)

		IP	OW	CDTI
Free-Flight	Confl.			
	N.C.			
Base-line	Confl.			
	N.C.			

10 Conditions x AOI
(Predictive data points)
% Dwell time within an AOI

2. Free Flight Experiment

$$P(AOI_j) = \sum_{t=1}^{n} (bB_t)(rR_t)(V_t)$$

MODEL FITTING ASSUMPTIONS

- **Simplest digital coefficients**

- **<u>Task priority</u> (Av > Nav),**
  (Nav in freeflight > Nav in baseline)

- **<u>Relevance</u>: IP most relevant for Aviate**
  OW for AV: true horizon
  OW and CDTI equal for Nav.

- **Bandwidth: IP (6 instruments) > OW > CDTI**

Horizon
Attitude

Bandwidth Multipliers

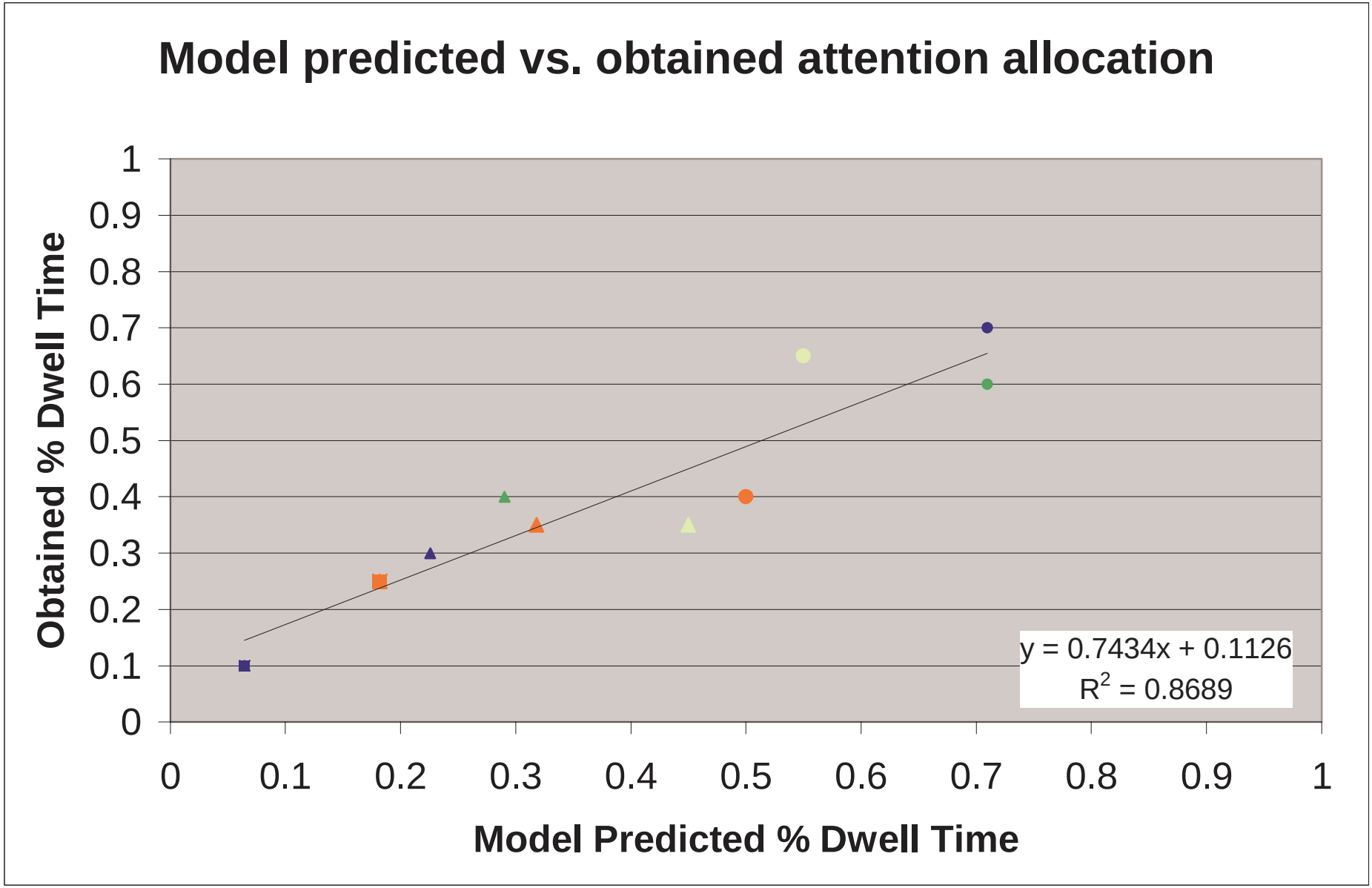
	Leg	IP	OW	CDTI
Free	Confl.	3	2	1
Flight	N.C.	2	1	0.50
	Confl.	3	2	
Baseline	N.C.	2	1	

Relevance Multipliers

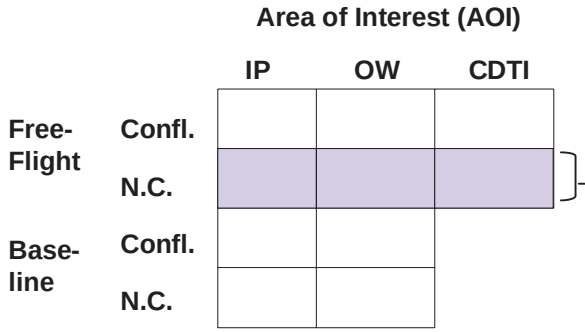
	Task	IP	OW	CDTI
Free	Aviate	3	1	0
Flight	Navigate	1	2	2
	Aviate	3	1	
Baseline	Navigate	1	2	

Priority Multipliers

	Aviate	Navigate
Free Flight	3	2
Baseline	3	1

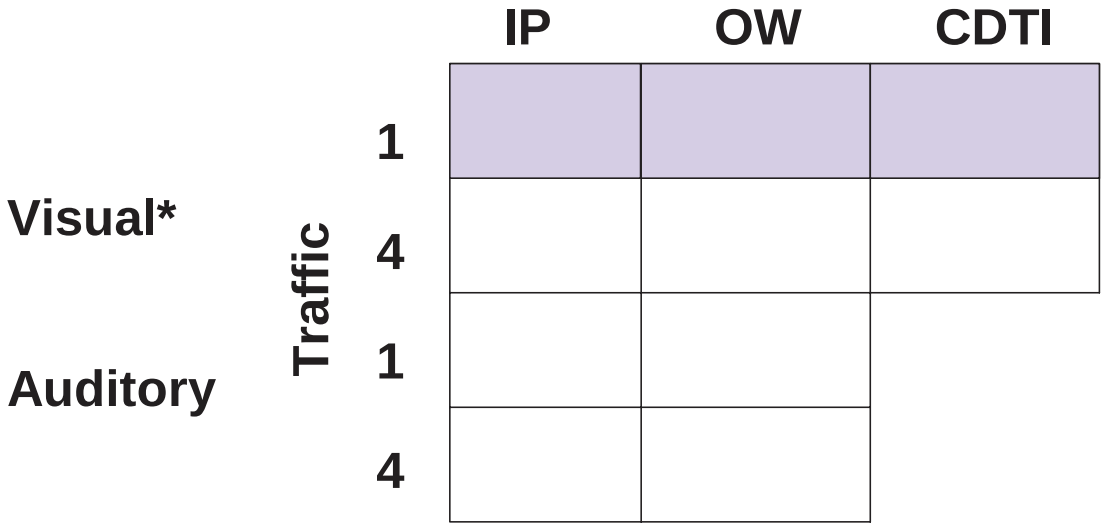

Model predicted vs. obtained attention allocation
Obtained % Dwell Time
Model Predicted % Dwell Time
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
y = 0.7434x + 0.1126
R2 = 0.8689

Experiment 1



Experiment 2: Free flight, non-conflict trials

- **Visual (CDTI)* Traffic Identification vs. Auditory (ATC-Callout) Identification**
- **Traffic Density: 1 vs. 4 per leg**

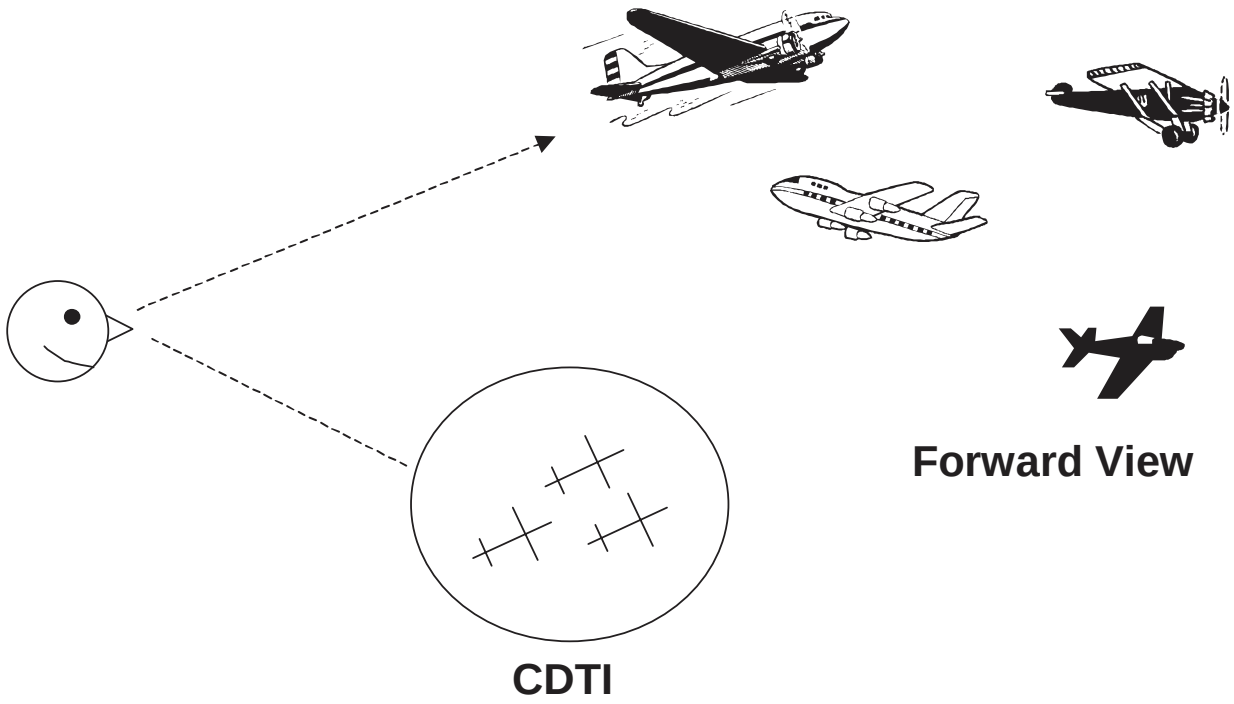


***Includes both visual only, and Redundant CDTI + Aud**

Free Flight 2

Vulnerability of pilot's traffic scan (selective attention), to

Automation's imperfect knowledge of traffic



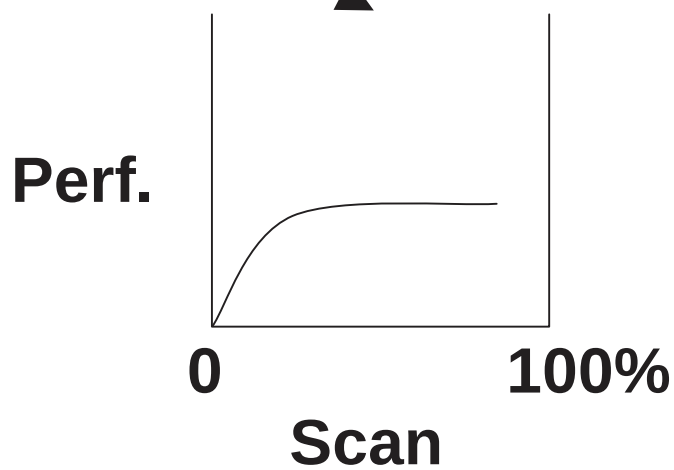
Further Directions

1. Model Parameters → Scan → Performance (Traffic Callout)

Tight Coupling

Loose Coupling

RT, Errors



2. Individual Differences

3. Role of Effort (in the neighborhood)