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Age and Disease Effects on Estimates of Vehicle Time-to-Arrival

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ABSTRACT

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Vehicle-pedestrian collisions are often caused by an inability of the pedestrians (and drivers) to correctly estimate the time-to-arrival (TTA) of an approaching objects. Little is known about life span changes in the ability to correctly estimate TTA. This research examines age and disease effects on the perception of TTA as a function of vehicle approach velocity and headway distance when image is occluded.

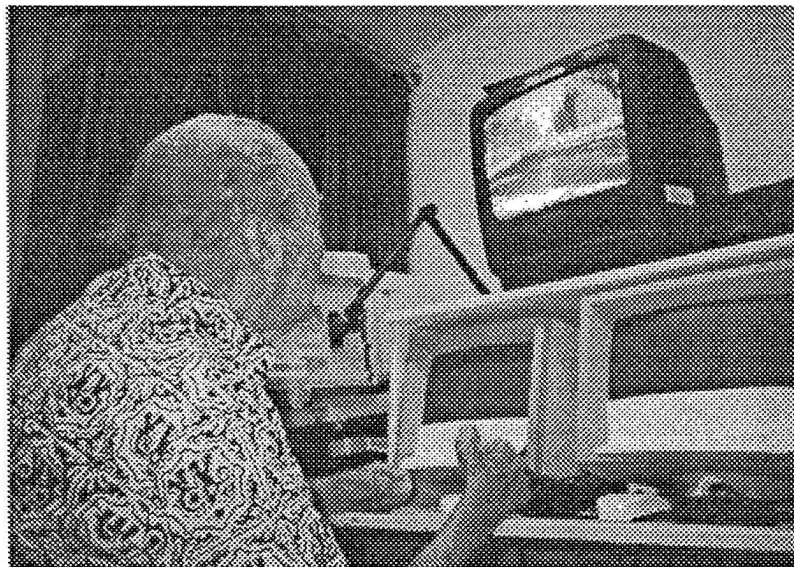
188 (93 female & 95 male) have been tested to date: 172 healthy community volunteer controls (ages: 5-7, 9-11, 15-19, 20-30, 31-50, 51-70, 71-90 years) and 16 patients diagnosed with mild Parkinson's Disease (PD). Participants viewed video clips of vehicles approaching from three distances (occlusion headway at 20, 60, 100m) and at four velocities (~ 7, 10, 12, & 15 m/s) and were asked to press a button when they estimated the vehicle would pass before them (TTA in msec).

Results revealed that nearly all participants underestimated actual durations of TTA, females were slightly worse than males, and that estimates were most accurate for the 20-50 year olds and got worse for the younger and older groups. Accuracy of TTA improves into the teen years and deteriorates in later adulthood. PD cases performed as well or better than their controls, suggesting no sensory or perceptual impairments, despite obvious motor system disabilities.

These findings aid development of effective screening tools to determine an individual's fitness to execute critical timing maneuvers, especially in ascertaining fitness-to-drive, and in modeling life span changes in time perception and information processing capabilities. They also help in extension of the number of years of effective mobility and safe driving by teenagers, the elderly, and the disabled.



Children using their perception of Time-To-Arrival
(estimate of the rate of gap closure) to initiate an unsignalized road crossing.



An older participant estimating TTA in our laboratory from a video of vehicles approaching from three distances, at four velocities, displayed from the perspective of a pedestrian.

INTRODUCTION

- Most behaviors slow with increasing age and severity of neurodegenerative disease.
- Older adults are more likely to be involved in or cause a motor vehicle accident, and are less likely to survive it, than other age groups. They also have higher fatality rates as pedestrians, occupants, and drivers (due to frailty and co-morbidity).
- The most common type of vehicular accidents for teen and older drivers involves collisions.
- Human collision avoidance ability involves intuitive stages of information processing: detection of the object, calculation of the rate of gap closure (time-to-arrival), assessment of response options, selection of response, and execution of the evasive maneuver (Figure 1).

- Parkinson's Disease (PD) patients have bradykinesia and rigidity that often interferes with movement control, but it is not known if PD affects sensation, perception, and event timing (Figure 1).
- One method of measuring perception of the rate of gap closure and life span changes in event timing is estimation of Time-to-Arrival (TTA).

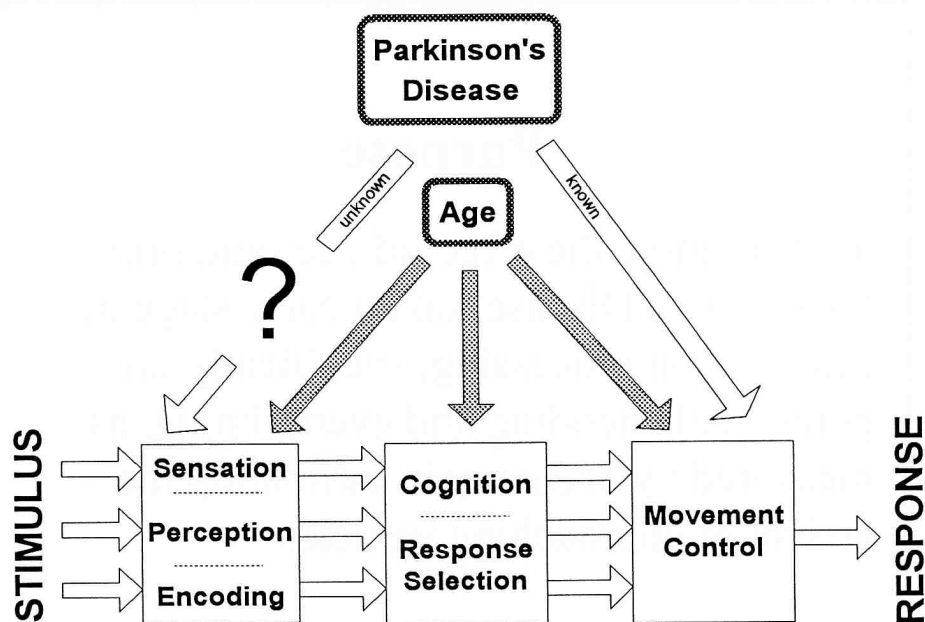


Figure 1. Effects of age and disease on a model of information processing.

Time-to-Arrival (TTA)

- One's estimation of the time it will take an approaching object to reach them, or for them to collide with a stationary object towards which they are moving
- TTA involves the sensation of silhouette expansion on the retina and the perception of the rate of gap closure
- **Hypothesis:** TTA estimation improves in childhood, deteriorates in later life, and is impaired by most neuropathologies, except PD

Purpose

To determine the effect of age (and mild Parkinson's Disease) on an early stage of information processing, specifically on perceptual encoding and event timing, as measured by accuracy in estimating the arrival of approaching vehicles

METHOD

Sample Population

- 188 community based ambulatory from a large study of participants ages 5-95 years in Honolulu (Table 1)
- 16 PD cases and 23 healthy elderly matched controls
- PD diagnosis confirmed by phone inquiry to primary care physician
- Participants were recruited from a wide variety of sources: flyers, presentations to groups, exhibits at conferences, newspapers, etc.

Table 1. Participant Demographics

<i>Age Group</i>	<i>Female</i>	<i>Male</i>	<i>Total</i>
5-7 years	10	11	21
9-11 years	9	12	21
15-19 years	13	11	24
20-30 years	18	16	34
31-50 years	12	9	21
51-70 years	14	11	25
71-90 years	13	13	26
Parkinson's 51-70 years	3	7	10
Parkinson's 71-90 years	3	3	6
TOTAL	95	93	188

Task

- Participants viewed multiple sequences of real-world video situations from the point of view of a pedestrian standing on a curb watching vehicles approach at four speeds and from three distances
- When the vehicle reached a defined distance (headway), the video display went blank and the participant was asked to press a handheld button when s/he estimated the vehicle would pass before her/him
- Display features were controlled by using both a
 - * *constant viewing time* of 4.2 s (12 trials) and a
 - * *constant viewing distance* of 20 m (12 trials)

Independent Variables

Age & Sex: (Table 1)

(Mild Parkinson's Disease: Cases vs. Controls)

Vehicle Headway (Display Occlusion Distance): 20, 60, or 100 m

Vehicle Approach Velocity:

constant viewing time (7.4, 10.2, 12.4, 15.3 m/s)

constant viewing distance (7.8, 10.2, 12.7, 15.4 m/s)

Dependent Measures

- **TIME-TO-ARRIVAL** (TTA in msec)
 - Mean Constant Error = actual - estimated TTA
 - Mean Absolute Error Ratio = (act - est)/act TTA
 - Mean Within-Subject Standard Deviation

RESULTS

- For both methods, everyone underestimated TTA: Children were worst, followed by the oldest group, with young adults making the best estimates (Figure 2).
- Underestimations of TTA increased in the all age groups as headway distance (the pedestrian's distance from the vehicle when the screen became blank) increased and velocity decreased (Figure 3).
- Age differences were greater for headways of 60 and 100m than for 20m (Figure 4).
- Patients with mild PD did as well or better than their age-matched peers (Figure 5).

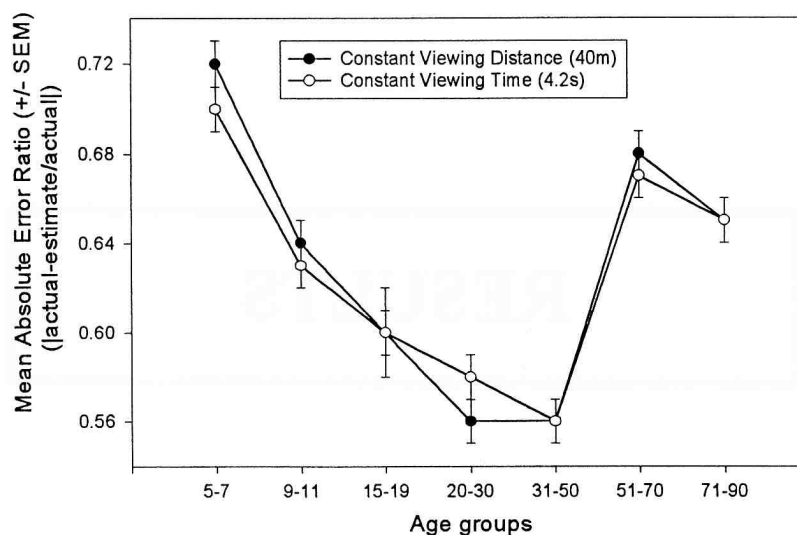


Figure 2. Two methods of examining mean constant error of estimated time-to-arrival by age groups.

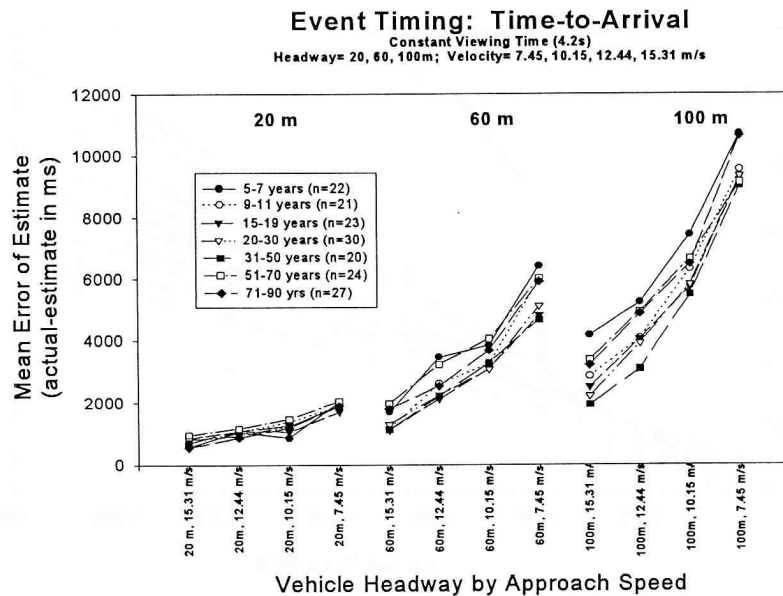


Figure 3. Mean constant error for estimation of time-to-arrival by age, headway, and speed for constant viewing distance.

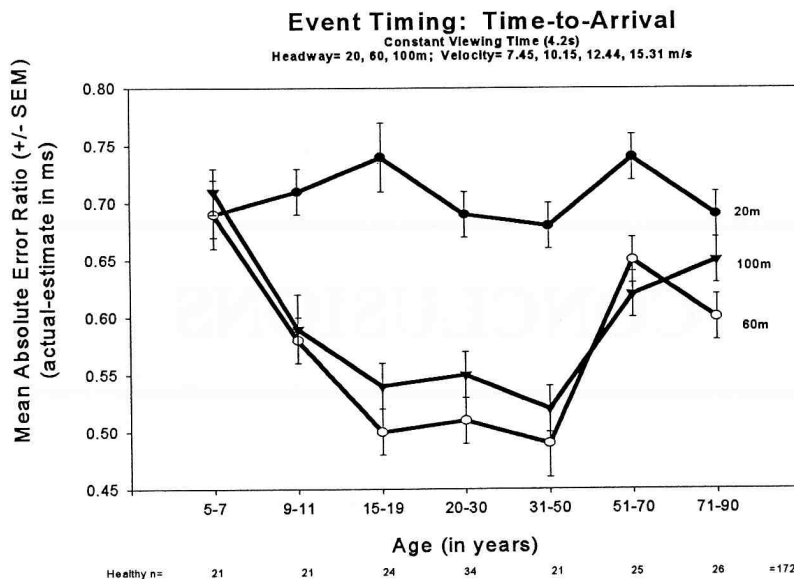


Figure 4. Mean absolute error ratio of estimated time-to-arrival by headway distance and age groups.

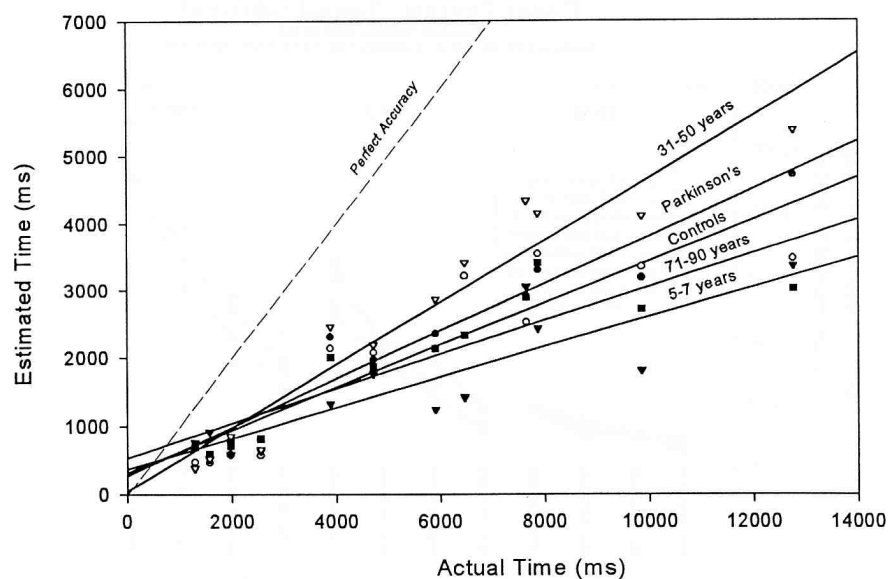


Figure 5. Scattergram of actual and mean estimated time-to-arrival for all age groups, including Parkinson's patients and controls, with group regression lines.

CONCLUSIONS

- **TTA Perception:** As vehicle headway and vehicle velocity increases, TTA is increasingly underestimated by all ages
- **Age:** Children and older adults are less accurate in predicting TTA than young adults
 - Children and older adults may need special assistance to reduce their risk of accidents
- **Disease:** Estimates of TTA are not likely to be impaired by mild PD
 - If mild PD impairs driving, it is unlikely to be in the early perceptual encoding stages of information processing

AGE AND DISEASE EFFECTS ON ESTIMATES OF VEHICLE TIME-TO-ARRIVAL

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