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Reaction Time as a Marker of Neurocognitive Decline. Measurement of Simple, Choice and Discrimination Reaction Time in Geriatric Subjects

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Abstract

Background: Reaction time (RT) is a critical indicator of cognitive-motor function and represents the time interval between stimulus presentation and voluntary response initiation. While RT decline with aging is well-documented, most assessments focus solely on simple reaction time (SRT), neglecting the more complex cognitive processes required in daily life. This study addresses the need for comprehensive, accessible RT assessment tools in geriatric populations.

Objective: To measure and compare simple reaction time (SRT), choice reaction time (CRT), and discrimination reaction time (DRT) across different age groups in healthy geriatric subjects, and to validate the clinical utility of a low-cost, field-appropriate assessment method.

Methods: A cross-sectional study was conducted with 80 community-dwelling adults aged 55–75 years, stratified into four age groups (55–60, 61–65, 66–70, and 71–75 years) with equal gender distribution. Three variations of the Ruler Drop Test were employed and reaction time was measured. Statistical analysis included one-way ANOVA with Tukey's post hoc comparisons.

Results: All three RT measures demonstrated significant age-related increases ($p < 0.001$). SRT increased from 30.4 ± 3.82 cm in the youngest group to 46.6 ± 2.76 cm in the oldest group. CRT showed a similar pattern, rising from 34.8 ± 3.58 cm to 50.2 ± 3.24 cm. DRT increased from 33.4 ± 3.32 cm to 48.1 ± 4.18 cm. The most pronounced deterioration occurred in the 71–75 age group. Complex RT tasks (CRT and DRT) showed greater age-related decline than SRT, suggesting preferential impairment of higher-order cognitive processes.

Conclusion: Reaction time increases significantly with advancing age, particularly after 70 years. The Ruler Drop Test offers a valid, reliable, and economically feasible tool for assessing cognitive-motor function in older adults. Also enables early detection of functional decline and fall risk assessment in both clinical and community settings, making it particularly valuable for resource-limited environments. The findings support the incorporation of comprehensive RT assessment into routine geriatric screening protocols to facilitate timely intervention and preserve functional independence.

Keywords: Reaction Time; Geriatric; Ruler Drop Test; Neurological Aging; Age-related decline; Fall Risk

1. Introduction

Reaction Time (RT) can be described as the time taken between a stimulus presentation and an individual's initiation of a rapid voluntary response. RT indicates the time required for a sequence of mental processes, namely processing

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the stimulus, making a decision, and programming the response. [1] Accordingly, RT measures the pace of human information processing and motor response directly and quantitatively. Since it indicates both sensory- perceptual and cognitive-motor processes, it is among the most extensively utilized variables for human performance studies throughout life. Three most generally acknowledged RT types are Simple Reaction Time (SRT), Choice Reaction Time (CRT), and Discrimination Reaction Time (DRT) [2]. In SRT, the subject must make a response to one stimulus as rapidly as possible. The measure is very reliant on intact basic sensory and motor pathway function and is commonly used due to its ease and low cognitive demand. In contrast, CRT is the capacity to select the appropriate response from among a variety of choices upon receiving a variety of stimuli. This form of RT is crucial for adaptive behaviour, wherein various cues demand various responses. For instance, a green light may demand the movement of the right hand, whereas a red light demands the movement of the left. Surwillo (1973) reported a notable slowing in CRT among older adults, demonstrating that with advancing age, the brain's ability to discriminate between stimuli and select the appropriate response becomes significantly impaired [7]. The third category, DRT, shows the test taker two or more stimuli, one of which is correct. The test taker must respond to the correct stimulus while discarding other, incorrect stimuli [4]. This performance not only involves speed of decision but also selective attention and the ability to inhibit irrelevant stimuli. Physiological aging impacts the central nervous system, compromising its ability to handle large amounts of sensory input coming in from a variety of sources at the same time [9]. As a person ages, especially after the age of 60 years, RT was found to decline significantly [5]. This slowness is not just a retardation in neural processing but also an impairment in sensory and motor function integration. These changes are more than scientific speculation; they have tangible and important implications for everyday functioning. Slower RT in older adults has been linked to a higher risk of falls, compromised mobility, and slower response to potentially threatening stimuli in the environment. These effects undermine independence, safety, and quality of life. Notably, RT has proved to be an extremely robust, objective, and painless indicator of functional status in elderly groups, a useful parameter for both research and clinical assessment [6],[7],[10].

As significant as this identification is, RT measurement still remains inadequately incorporated into routine geriatric clinical practice. A key reason is that most of the RT tests employed in practice only assess SRT. Although helpful, SRT tasks fail to capture the cognitive complexity of daily life. In real life, little do older persons encounter scenarios where a single stimulus elicits a single response. Daily life demands more complex cognitive processes, exactly the sort activated on CRT and DRT. Such tasks as crossing a busy road, reacting to a falling object while on the telephone, or making a movement choice based on several environmental stimuli involve attention, discrimination, task-switching, and decision-making capacities. Facts reveal that older adults score significantly lower on CRT and DRT tests compared to SRT tests [4]. Such a performance difference highlights the ecological validity of measures of complex RT over those of simple RT. From a cognitive gerontological point of view, RT has both clinical and theoretical importance. Most of the research on RT conducted to date has been in a laboratory setting, with an overrepresentation of SRT. Although informative normative data and theoretical formulations have come from these studies, they frequently do not take into consideration the multi-tasking and decision-making requirements of actual functioning in older adults. Moreover, there is a shortage of literature on RT, specifically CRT and DRT tested in field-based or community-based trials. This is significant because feasible, scalable methods of assessment are necessary to translate the findings from research into clinically important interventions.

Multiple RT types must be assessed not only to discern decline in cognitive-motor functioning with age but to inform strategies for preserving quality of life and falls prevention. There are a number of recognized RT measurement methods currently available. Some include the Ruler Drop Test (RDT-S, standard version), the Deary-Liewald Reaction Time Task (DLRT), number reaction time boxes, the MOART Reaction Time and Movement Time Panel (Lafayette Instruments), the Jensen box, the Vienna Test System (VTS), and the Cambridge Neuropsychological Test Automated Battery (CANTAB). Although these systems are efficient, numerous ones have serious disadvantages to them. Most need specialized, expensive equipment, as well as technical staff to deliver and interpret. This restricts their usefulness in large-scale community screening, home testing, or application in the resource- poor clinical setting. The Ruler Drop Test provides a significant alternative. It is easy, cheap, portable, and easy to perform without needing specialized equipment or training. The SRT version of the RDT has been established as a valid, reliable tool for the collection of RT data from older adults with and without cognitive impairment, who reside in the community and in institutions. Since it does not rely on costly technology, it has the potential for wide application in various settings. Significantly, versions of the RDT can be constructed to measure not just SRT, but CRT and DRT as well, thereby expanding its value for more difficult, ecologically valid RT assessment.

Reaction-time measures have found widespread use in research because of two main reasons. First, they are closely tied to tasks in everyday life, particularly in situations where quick responding is highly important, like sports performance and driving safety. Second, RT measures yield a sensitive and objective measure of the latency for cognitive and neural processes, such as detection of the stimulus, processing, and initiation of motor response.[1] Such characteristics render RT a distinctive and useful parameter for identifying minute changes in cognition that may prelude overt functional impairment. Based on the above, there is significant rationale for research that compares and measures several types of RT—SRT, CRT, and DRT among older adults in an easy, inexpensive, and massifiable approach. Such an approach would fill several gaps in existing research and clinical practice: it would establish baseline normative data for healthy older adults; it would validate the real-world utility of a portable RT assessment procedure; and it would give clinicians and researchers an effective vehicle for early identification of decline and fall risk prediction.

2. Materials and methods

The present cross-sectional study was conducted over a period of six months to assess Simple Reaction Time (SRT), Choice Reaction Time (CRT), and Discrimination Reaction Time (DRT) in community-dwelling geriatric subjects. A total of 80 individuals *(Male n=40, Females n=40)* aged between 55 to 75 years were recruited through convenience sampling. Participants were stratified into four age groups (55–60, 61–65, 66–70, and 71–75 years), with 20 subjects in each group.

Three variations of the Ruler Drop Test (RDT) were employed to measure reaction times:

- **Simple Ruler Drop Test (RDT-S):** The subject was asked to catch a falling ruler as quickly as possible when dropped without warning. (Fig.1)

Figure 1 Simple Ruler Drop Test (RDT-S)

- **Choice Ruler Drop Test (RDT-C):** Two rulers were held, and participants were required to catch the one randomly released, avoiding movement of the opposite hand. (Fig.2)

Figure 2 Choice Ruler Drop Test (RDT-C)

- **Discrimination Ruler Drop Test (RDT-D):** Participants were instructed to catch the ruler only when a specific auditory cue (letter “B”) was given, while ignoring other cues (“A” or “C”). (Fig.3)

Figure 3 Discrimination Ruler Drop Test (RDT-D)

Each participant was provided with practice trials followed by testing trials to ensure familiarization and reliability of response. Reaction distance (cm) was recorded and converted into reaction time using standardized formulae.

2.1. Inclusion Criteria

- Community-dwelling individuals aged 55–75 years.
- Ability to understand and follow verbal instructions.
- Willingness to provide informed consent.

2.2. Exclusion Criteria

- History of neurological, orthopedic, or systemic conditions affecting mobility and hampering participation.
- Upper limb and Trunk - Musculoskeletal injury within the last 6 months.
- Medically diagnosed Visual or auditory impairments hampering particpation.
- Current usage of medically prescribed psychoactive medications.
- Cognitive impairment - (Addenbrooke's Cognitive Examination–III score <71/100).
- Psychological depression - (Geriatric Depression Scale score <5).

2.3. Sample Size Calculation

A sample size calculation was performed using G*Power 3.1.9.4 for a one-sample t-test. A significance of $\alpha = 0.10$, and statistical power $(1-\beta) = 0.90$ was desired. The analysis indicated that a minimum total sample size of 96 participants would be required to detect the expected effect.

2.4. Statistical Analysis

Data analysis was performed using SPSS version 30. Normality was assessed using Q-Q plots. One-way ANOVA was used for between-group comparisons, with Tukey's HSD for post hoc analysis. Significance was set at $p \leq 0.05$.

3. Results

Table 1 Population Demographics will be inserted here

		GENDER		Total
		Female	**Male**	
AGE	55 – 60	10	10	20
	61 - 65	10	10	20
	66 - 70	10	10	20
	71 - 75	10	10	20
Total		40	40	80

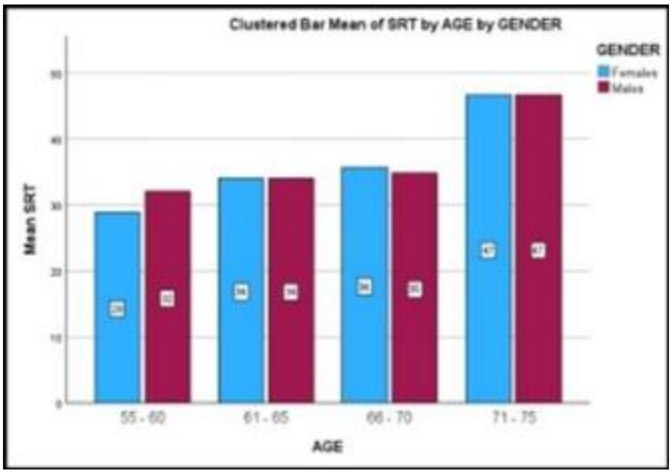

Figure 4 Simple Reaction Time Graph placeholder

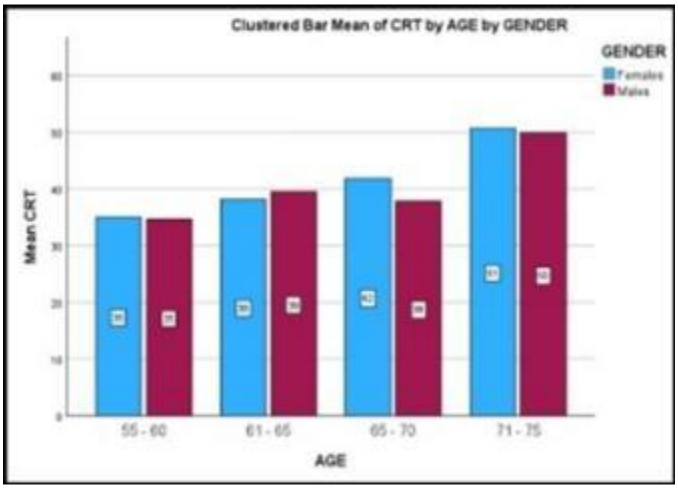

Figure 5 Choice Reaction Time Graph placeholder

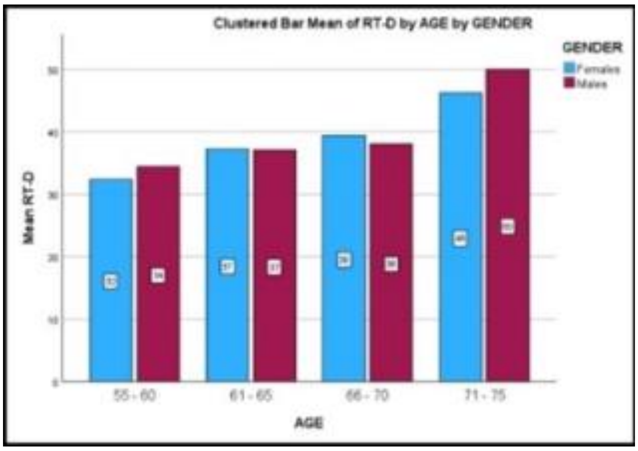

Figure 6 Discrimination Reaction Time Graph placeholder

Table 2 Reaction Time Summary will be inserted here

Group	SRT			CRT			D-RT		
	Mean SRT	N	Std. Deviation	Mean CRT	N	Std. Deviation	Mean RT-D	N	Std. Deviation
55 – 60	30.4	20	3.817	34.8	20	3.578	33.4	20	3.315
61 - 65	34	20	2.902	38.8	20	2.191	37.1	20	2.469
66 - 70	35.2	20	1.508	39.8	20	3.238	38.7	20	2.536
71 - 75	46.6	20	2.761	50.2	20	3.238	48.1	20	4.179
Female	36.25	40	6.946	41.4	40	6.472	38.8	40	5.707
Male	36.85	40	6.562	40.4	40	6.535	39.85	40	6.86
Total	36.55	80	6.72	40.9	80	6.482	39.32	80	6.292

Table 3 Post Hoc Comparison will be inserted here

(I) AGE		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
55-60	61 - 65	-3.60*	0.890	0.001	-6.01	-1.19
	66 - 70	-4.80*	0.890	0.000	-7.21	-2.39
	71 - 75	-16.20*	0.890	0.000	-18.61	-13.79
61 - 65	55 - 60	3.60*	0.890	0.001	1.19	6.01
	66 - 70	-1.20	0.890	1.000	-3.61	1.21
	71 - 75	-12.60*	0.890	0.000	-15.01	-10.19
66 - 70	55 - 60	4.80*	0.890	0.000	2.39	7.21
	61 - 65	1.20	0.890	1.000	-1.21	3.61
	71 - 75	-11.40*	0.890	0.000	-13.81	-8.99

71 - 75	55 - 60	16.20*	0.890	0.000	13.79	18.61
	61 - 65	12.60*	0.890	0.000	10.19	15.01
	66 - 70	11.40*	0.890	0.000	8.99	13.81
Based on observed means. The error term is Mean Square(Error) = 7.922.						
*. The mean difference is significant at the 0.05 level.						

4. Discussion

The present study aimed to measure Simple Reaction Time (SRT), Choice Reaction Time (CRT), and Discrimination Reaction Time (DRT) in a healthy geriatric population using low- cost, field-appropriate tools adapted from the Ruler Drop Test. A (n=80) community-dwelling

older adults between 55 to 75 years were recruited and grouped into four strata by age. The results demonstrated statistically significant increase in reaction time across all three tests as age advanced, especially in the 71–75 age group. The assessment was conducted through three variations of the RDT. SRT measured the participant's response to a single falling ruler. CRT added complexity by requiring the participant to identify which of two rulers would fall. DRT involved cognitive discrimination, instructing the participant to catch the ruler only when prompted with a specific auditory cue. Each test incorporated multiple trials to ensure response validity and eliminate anticipatory bias. Quantitative analysis showed that mean SRT increased from 30.4 sec (±3.82) in the 55–60 age group to 46.6 sec (±2.76) in the 71–75 group. Similarly, CRT rose from 34.8 sec to 50.2 sec, and DRT from 33.4 sec to 48.1 sec across the same age bands. Post hoc comparisons ($p < 0.001$) confirmed significant differences between the eldest (71-75) group and all (55-60) younger cohorts, especially for SRT and CRT. These results highlight that reaction time is not only affected by age but accelerates significantly in the decade after 70. This trend aligns with findings from Deary and Der (2005) [12], who observed consistent RT slowing from ages 16 to 63 and even more prominently beyond 65 [12] Similar presentation was seen in the past literature where reaction times steadily increase, with a noticeable acceleration at the age of 60. The brain degeneration accelerates exponentially rather than linear pattern of loss as also seen in our data. [17],[18],[19] The current data validates this deterioration in neural processing as both age-dependent and task-specific where tasks requiring greater discrimination and decision-making (CRT, DRT) are more heavily impacted.

4.1. Theoretical perspectives on Neuro-cognitive aging.

The increase in RT with age has strong anatomical and physiological predispositions. Normal aging is associated with widespread neurodegenerative changes including neuronal loss, white matter lesions, reduced dendritic branching, and synaptic pruning, particularly in prefrontal and parietal cortices responsible for executive and motor function. Slower cortical conduction velocities and decreased neurotransmitter efficiency (especially dopamine and acetylcholine) lead to delayed signal transmission and processing. These physiological changes disproportionately affect higher-order cognitive functions like decision-making, attention, and inhibition—explaining why CRT and DRT degrade more sharply than SRT with age. [20] As people age, their sensorimotor integration processes which translate sensory information into muscular output also decrease, which increases reaction times. In order to sustain function, the aging nervous system must rely more on cognitive compensatory techniques, which frequently imply a greater mobilization of prefrontal cortex resources. Slower reaction times across all tested modalities are the result of this compensatory mechanism's increased processing time and decreased efficiency. [21],[22],[23]

In addition, sensorimotor integration, the ability to convert sensory input into motor output becomes less efficient and hence slower. Reduced proprioception, visual acuity, and vestibular processing, combined with diminished central processing speed, further contribute to increased RT in elderly individuals.[24] Reaction Time has direct functional implications in daily life tasks. Tasks like avoiding obstacles or catching a falling object. Delay in RT, particularly in CRT and DRT, compromises safety and independence. As such, RT has been shown to strongly correlate with fall risk, gait instability, and frailty. [25],[26] The significant slowing observed in the 71– 75 group suggests a critical window for early screening and intervention. Cognitive and motor training programs targeting reaction speed could be beneficial if initiated during the early geriatric period (60–70 years), potentially delaying decline. This study reinforces that RT is a sensitive, objective, and non-invasive indicator of functional decline.

The ability to capture changes in RT using a simple, low-cost method makes this tool highly practical for use in community screenings and physiotherapy, neurological, geriatric, community clinics especially where digital systems may be inaccessible.

5. Conclusion

The study successfully demonstrated that reaction time increases significantly with age, with the sharpest rise occurring after 70 years. CRT and DRT, requiring higher-order cognitive processing, showed more significant delays than SRT, indicating greater vulnerability of executive functions to aging. These findings prove that neural processing speed, decision- making ability, and sensorimotor coordination all progressively deteriorate with aging. The study confirms that a simple, low-cost adaptation of the Ruler Drop Test can serve as a reliable, field-friendly method to screen for cognitive-motor decline in community-dwelling elderly individuals. This makes it a valuable tool in both clinical and community settings for early detection of fall risk, functional impairment, and the need for targeted interventions.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

Approved by Institutional Ethical Committee.

Statement of informed consent

Informed consent was obtained from all participants included in the study.

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