Reaction Time

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I. Historical Background
II. Importance

Choice Reaction Time The time between the presentation of one of several stimuli and the occurrence of one of several responses. It is termed choice reaction time because a discrimination has to be made between two or more stimuli and a different response made depending on which stimulus was presented.
Cognition Mental or intellectual abilities, typically assessed with special psychometric or experimental tests.
Neurological Status The level of one's health with respect to the central nervous system.
Perceptual Speed A cognitive ability usually assessed with simple paper-and-pencil tasks requiring search or discrimination tasks.
Slowing The decrease in speed in many RT and perceptual speed tasks associated with increased age.
Speed The rate at which an individual can carry out many processes. Typically assessed with choice reaction time and perceptual speed tasks.

REACTION TIME is typically measured in terms of the time elapsing between the presentation of a stimulus, which is often a brief visual or auditory signal, and a discrete response such as the press or release of a response key, the initiation of a movement, or the emission of a vocal response.

I. HISTORICAL BACKGROUND

The first systematic assessment of the relations between adult age and reaction time (RT) was by Galton in the late 1800s, although analyses of his data were not published until much later. There were sporadic investigations of the relations between age and RT until about 1950, when interest in this topic increased because of an assumption that an individual's RT might be informative about the status of his or her neurological system. A number of studies then appeared in which RT per se was the focus of the research.

Beginning in the 1960s, there was an increase in the use of RT as a primary dependent variable because it was assumed to reflect the duration of interesting mental processes. RT measurement in the context of mental chronometry has been a valuable tool in the information-processing perspective on cognition, and a very large number of studies have been reported within this tradition. In recent years a major issue in RT research has been the extent to which RT measures reflect general or specific age-related influences.

II. IMPORTANCE

There are three major reasons why RT is an important topic in gerontology. First, the speed with which a simple response can be produced is a very elementary behavioral measure, and therefore may function as a relatively direct indicator of an individual's neurological status. Second, studies of RT have revealed moderately large age relations, and these relations are among the most consistent and robust in all of the behavioral sciences. And third, RT measures have been found to be related to measures of higher cognitive functioning. In fact, measures of speed are actually included in several intelligence test batteries. These three points are elaborated in the following paragraphs.

A. Indicator of Neurological Status

RT has been considered a reflection of neurological status because a rapid response to an external stimulus not only requires intact sensory and motor processes, but also an efficient system of communication between input and output processes. There are clearly many neurological conditions that could exist with little effect on RT, but at least at a very gross level, it seems reasonable to assume that factors related to intactness of neural connections contribute to the efficiency of responding to environmental stimuli.

Unfortunately, although RT has been assumed to have sensitivity to certain neurological conditions, its specificity is unknown. That is, because all the factors responsible for slowed RT have not yet been identified, slow RT is not necessarily informative about the specific types of neurological impairment that might exist. Among the neurophysiology factors that have been mentioned as possible contributors to age-related slowing are loss of neurons due to vascular complications, reductions in degree of myelination, extent of dendritic branching, or in the quantity of certain neurotransmitters. Until these alternatives can be discriminated, RT may have limited value as an indicator of particular types of neurological impairment.

There is some evidence that age-related slowing is not simply mediated by poorer health because slower RTs with increased age are still evident in samples of adults who report themselves to be in good to excellent health. However, it has recently been reported that the age-related slowing was greater for individuals reporting incidents of head trauma or general anesthesia, and thus this conclusion should probably be considered tentative until more data are available.

B. Robustness of Age Relations

In an earlier review of adult age differences in speeded performance, it was found that the median of over 50 correlations between age and a variety of speed measures was .45. The magnitude of the relations between age and measures of RT can also be illustrated with results of several recent studies. For example, in a study similar to that of Galton RTs were obtained from visitors to a public exhibition. In a sample of 2190 adults age 20 and older, simple RT to a single stimulus increased approximately 0.7 ms per year.

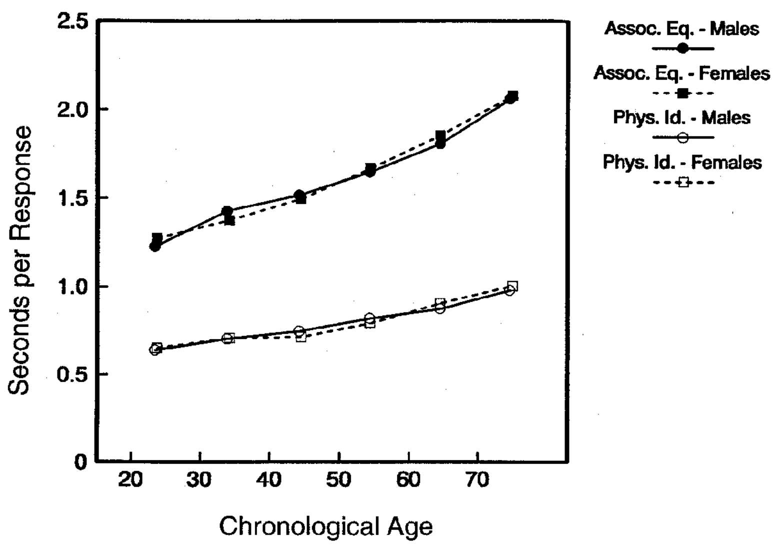

Figure 1 Mean reaction time for physical identity and associational equivalence decisions as a function of age.

Comparisons of simple RT and choice RT are also interesting because the difference between the two times can be interpreted as the time to discriminate between stimuli. That is, choice RT involves a different response for each stimulus, and simple RT consists of the same response to all stimuli, and thus the additional time needed for the choice RT response can be assumed to reflect the duration of the added process. In another study, both simple and choice RT tasks were administered to 1265 adults (833 males, 432 females) between 20 and 90 years of age. The regression equations in this sample indicated an increase of about .5 ms per year for simple RT, and an increase of about 1.7 ms per year for choice RT. Because the age trends are greater in the measure requiring stimulus discrimination, results such as these suggest that age-related effects on RT are not simply attributable to slower sensorimotor processes.

Age relations have also been investigated in more complex RT tasks. For example, a wide range of tasks can be created in which one response (depression of one key) is made when two stimuli are the same in some dimension, and another response (depression of a different key) is made when the two stimuli are different. To illustrate, in one version of the task the stimuli can be pairs of digits, with the decision based on physical identity, and in another version of the task the stimuli can be pairs of digits and symbols, with the decision based on whether the digit-symbol pair was equivalent according to a code table displayed simultaneously with the stimuli.

Figure 1 illustrates means by decade for these two measures in a sample of 583 males and 776 females, with between 70 and 152 individuals in each decade. Notice that the age trends are monotonic and nearly continuous, and that the patterns are nearly identical for males and females. However, the average RTs are greater, and the age-related effects are larger for decisions based on associational equivalence (i.e., digit-symbol) compared to those based on physical identity (i.e., digit-digit). Regression analyses for the physical identity RT measure revealed an increase of approximately 6.4 ms per year, whereas those for the association RT measure had an increase of about 15 ms per year.

The pattern of larger age-related effects on measures in which greater amounts of cognitive processing seem to be required is consistent with a large amount of data in the gerontological literature. That is, when the task is merely to make a predetermined response to a single stimulus the age effects are rather slight (e.g., less than 1 ms per year); when the task requires a choice between different stimuli with a different response to each stimulus, the age effects are somewhat larger (e.g., about 1.5 to 2 ms per year); when the task requires two stimuli to be compared the age effects are larger (e.g., about 6 ms per year); and when stimuli are to be compared on the basis of an association then the age effects are even larger (e.g., about 15 ms per year).

Because similar patterns of age relations have been found with other speed measures, such as paper-and-pencil tests merely requiring simple motoric responses (e.g., connecting lines, copying digits) or also requiring cognitive operations (e.g., comparison or substitution), RT measures have been interpreted as reflections or indicators of a more general processing speed construct. Age relations on four paper-and-pencil tests hypothesized to reflect sensorimotor speed (i.e., connecting lines—Boxes, or copying digits—Digit Copying), and perceptual comparison speed (i.e., comparing letters—Letter Comparison, or comparing patterns—Pattern Comparison) are illustrated in Figure 2. Notice that the age trends are relatively slight (i.e., about 5 ms per year) for the two sensorimotor tasks, but larger (i.e., approximately 20 and 56 ms per year) for the two perceptual comparison tasks.

In addition to similar patterns of age relations, speed measures from paper-and-pencil tasks have also been found to have moderate correlations with RT measures. For example, in two recent samples of 372 adults, the correlations between the paper-and-pencil Pattern Comparison measure and the digit symbol RT measure were .60 and .61.

C. Relation to Cognition

As noted earlier, speed measures have been incorporated into several widely used cognitive test batteries. The fact that paper-and-pencil speed measures have been found to be moderately correlated with more traditional measures of cognitive functioning indicates that some relation exists between speed and cognition. Moderate relations between RT and paper-and-pencil speed measures and a variety of cognitive measures have also been found in several experimental

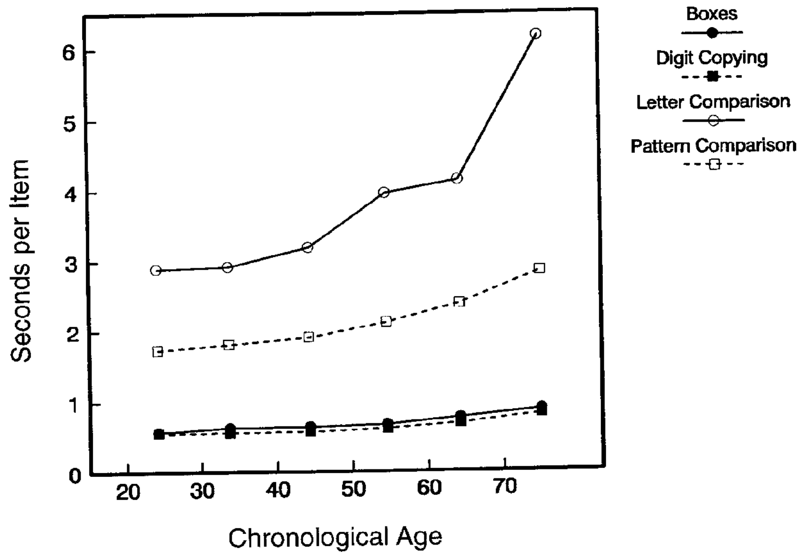

Figure 2 Mean levels of performance in four speeded paper-and-pencil tasks as a function of age.

studies, including some in which the cognitive tests were administered under self-paced conditions with no external time limits.

In several of these studies statistical control analyses have been conducted in which statistical procedures were used to equate people of different ages on an index of speed before examining the relation between age and measures of cognitive functioning. The typical outcome from these analyses has been that the age relations on cognitive functioning are greatly reduced after statistical control of speed. Moreover, with certain combinations of speed and cognitive measures the statistical control procedure has resulted in the complete elimination of the age-related variance in the measure.

Results such as these imply that RT and other speed measures reflect something that is important for the age differences in cognitive functioning. What is not yet obvious is the exact nature of the processes or factors assessed by speed measures that contribute to the age-related variations in cognitive functioning.

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