METHODOLOGICAL COMMENT

SPEED AND AGE: MULTIPLE RATES OF AGE DECLINE

TIMOTHY A. SALTHOUSE

Department of Psychology
Washington University
St. Louis, Missouri 63130

Salthouse, T. A. *Speed and Age: Multiple rates of age decline.* **Experimental Aging Research, 1976, 2, (4) 349-359.** There is frequent reference in the literature on aging and performance to the "slowing with age phenomenon." If there truly is one "slowing with age" phenomenon, then all activities requiring speeded performance should decline with age at approximately the same rate. This report compares relative rates of age decline in several speeded physical activities ranging from simple reaction time to long-distance running events. The activities differ in the rate of slowing, with those requiring a greater muscular involvement or more stamina exhibiting the steepest declines. It is concluded that when one refers to slowing with age it is necessary to be quite specific about the activity to which one is referring because different activities decline at different rates.

One of the most reliable and well-documented findings in the literature on age and performance is that the time required to perform nearly all activities increases with increased age. Indeed, this phenomenon is so pervasive that Birren (1964) has referred to slowing with age as "the principal manifestation of a process of aging within the nervous system" (p. 119). Although never explicitly stated, an assumption that appears to be implicit in many discussions of age differences is that all activities decline in speed at approximately the same rate. For example, Bromley (1974) refers to "*the decline in speed* of performance . . ." (p. 163); Botwinick (1973) uses phrases such as "*the slowing* down of the responses of older people" (p. 154); and "*the loss of speed* with age" (p. 154); and Birren (1964) discusses "*the generalized slowing* of old age" (p. 111). (All italics added.) While these types of statements might be quite justifiable in light of the great number of activities in which it has been observed that older adults perform slower than younger adults, the statements have a connotation that all activities exhibit the same rate of decline with increased age, and this is an issue that has not been directly investigated. A major purpose of the current report was to examine the age-performance functions for a variety of speeded activities in order to determine if all declined at the same rate.

Another purpose of this report was to investigate age differences in speed of performance in complicated activities requiring coordination and stamina in addition to pure speed. Consider the case of running speed. Certainly one's intuition and personal experience would suggest that running speed slows with increased age, but it is not clear whether the rate of slowing would be the same as that found in less complicated discrete tasks, or even whether the rate of slowing would be the same for running events of different distances. A recent study by Moore (1975) attempted to address this second issue. Based on mathematical analyses of age records of running speed, Moore concluded "that age of maximum performance increases with distance" and "that speed deteriorates more slowly at longer distances than at shorter distances." However, an inspection of the data in Figure 1 of that report reveals no apparent differences between the age functions for the 200 m, 400 m, or 800 m events, and only minimal differences between the other functions and the age function for the marathon (42,195 m) event. The present report will describe the results of a reanalysis of the same running speed data utilized by Moore in an attempt to resolve the apparent contradiction between his conclusions and his graphical illustrations.

The method employed to compare relative rates of age decline across different activities involved expressing the performance for any particular age as a ratio of that performance to the best

performance across all ages. In the case of speeded activities, these ratios merely indicate the speed for each age standardized with respect to the fastest speed for any age. Thus, a value of 1.20 would signify that the speed for that age is 20% slower than the best speed. It is important to realize that this method of analysis is based on a relative rather than an absolute metric. That is, the units of measurement are ratios of the maximum performance achieved, and are not the original units in which the performance was actually measured. The original performance measurements had to be transformed in order to provide meaningful age comparisons across different tasks. For example, a 1 second difference does not mean the same thing in the 100 m sprint, in which the 1974 world record was 9.9 seconds, as in the marathon, in which the 1974 world record was 2 hours, 8 minutes and 34 seconds. However, statements expressing the relative speeds do have the same meaning in both events.

The procedure of the current study consisted of extracting relative performance measures from five published sources reporting data on a variety of activities ranging from simple reaction time to long-distance running events. The criteria employed in the selection of the data sources were: (a) the activity had to involve primarily speeded physical activity with minimal cognitive requirements; (b) all subjects had to be male; (c) at least 100 subjects between the ages of 20 and 70 had to be tested; and (d) the data for each of at least five age groups had to be reported.

Method

Two of the published sources from which data were obtained described the results from Galton's Anthropometric Laboratory in the 1880's. The first of these studies (*i.e.*, Koga & Morant, 1923) reported the reaction-time data from 3355 males ranging in age from 8 to 72. Key-press reaction time measurements to a sound stimulus and to a visual stimulus were obtained for each individual.

The second study reporting data from Galton's Laboratory (*i. e.*, Ruger & Stoessiger, 1927) described the results of 15 measurements obtained from over 6000 individuals. For the present purposes, we will be concerned only with the measurement of what Galton termed the 'swiftness-of-blow.' This task involved the subject attempting to drive a padded board forward in space as rapidly as possible by hitting it with one's fist. The measurements from 6915 males ranging in age from 8 to 72 reflected the velocity of the blow in feet per second. Since with this task better performance was represented by larger numbers, the reciprocals of the ratios were reported to facilitate comparison with the other tasks.

A third source of data in this report was a study by Miles (1931) describing the results of 269 males between the ages of 10 and 70 in a manual-reach-and-grasp task. Miles described the task as follows: "Starting from the clock key . . . the subject reached 6 inches to one side, grasped a round pencil 3 inches long which was standing in a vertical hole 1½ inches deep and thrust the pencil in another such opening 1½ inches farther away, then returned his hand to the key, thus stopping the clock."

The fourth data source was a study of Goldfarb (1941) on 180 males between the ages of 18 and 64. The measurements in this study were the times to react and move one's hand, a 'full arm movement' to one of one, two, or five alternative lights.

The final source of data in this report was a compilation of age records for track and field events (*i. e.*, *Age Records*, 1974, Compiled by Shepard, Donovan, & Mundle, 1974). While these data can in no sense be considered to be representative of the general population, they are nonetheless valuable for relative age comparisons since it is reasonable to assume that in all age groups only the most highly-trained and well-conditioned athletes would be participating in the competitions. These comparisons can therefore be interpreted as reflecting the optimum performance achievable at any particular age. In most events, records are reported for each age between 8 and 72, but the total number of individuals competing in those events for each age is not known.

The events for which relative age functions were determined were running events ranging in distance from 100 m to 42,195 m (the marathon).

Results

For each set of data, the maximum performance across all age groups was determined and then the ratios of the performance for each age group to the maximum performance were computed. Table 1 displays the ratios for five-year age groups for the 15 activities examined.

Notice that the steepest age declines are exhibited by the running events, which require approximately 35% to 40% more time at age 60 than at age 20. Moderate age declines are evident in the swiftness-of-blow, manual-reach-and-grasp, and reaction-time-plus-motor-time activities as these activities are performed approximately 15% to 20% slower at age 60 than at age 20. Quite gradual age declines are manifested in the simple reaction-time tasks as these tasks are performed only 5% slower at age 60 than at age 20. Figure 1 portrays graphically the relative rates of age decline for typical activities within each of these three classes.

Another important feature of the data in Table 1 is that the nature of the age functions are nearly identical for running events of different distances. Figure 2 illustrates the detailed age functions for three representative events — the 100 m, the 1,500 m, and the 10,000 m. It is quite apparent that the age functions for these three events are nearly identical. Clearly, there is no indication in these data 'that age of maximum performance increases with distance' or 'that speed deteriorates more slowly at longer distances than at shorter distances.' In both respects, these data contradict the observations of Moore (1975).

Discussion

When interpreting the results of this study several limitations of data must be considered. First, it should be realized that the sample sizes with each set of data varied substantially across different age groups. As an example, the number of individuals in the age-20 group for the reaction time measurements was 1319,

TABLE 1
Relative Rates of Performance as a Function of Age

SOURCE	TASK	AGE 10	15	20	25	30	35	40	45	50	55	60	65	70
Koga & Morant	RT- sound	1.20	1.05	1.00	1.01	1.01	1.05	1.03	1.07	1.01	1.04	1.04	1.11	1.05
Koga & Morant	RT - light	1.17	1.06	1.02	1.03	1.01	1.02	1.06	1.08	1.05	1.00	1.06	1.18	1.12
Ruger & Stoessiger	Swiftness-of-Blow	1.46	1.13	1.03	1.00	1.01	1.03	1.05	1.07	1.08	1.13	1.18	1.21	1.40
Miles	Manual reach and grasp	1.16	1.01		1.00		1.04		1.05		1.10		1.18	
Goldfarb	1- alternative RT & MT			1.17		1.00		1.04		1.14		1.21		
Goldfarb	2- alternative RT & MT			1.04		1.00		1.04		1.15		1.19		
Goldfarb	5- alternative RT & MT			1.03		1.00		1.03		1.13		1.18		
Age Records 1974	100 m.	1.37	1.07	1.00	1.01	1.02	1.05	1.11	1.14	1.18	1.21	1.30	1.41	1.56
Age Records 1974	200 m.	1.38	1.09	1.02	1.02	1.04	1.10	1.14	1.16	1.22	1.25	1.34	1.49	1.66
Age Records 1974	400 m.	1.43	1.11	1.01	1.02	1.04	1.09	1.18	1.19	1.27	1.31	1.39	1.58	1.74
Age Records 1974	800 m.	1.38	1.09	1.01	1.01	1.02	1.07	1.12	1.16	1.23	1.31	1.44	1.51	1.59
Age Records 1974	1500 m.	1.34	1.09	1.01	1.02	1.02	1.05	1.10	1.19	1.25	1.34	1.46	1.52	1.66
Age Records 1974	3000 m.	1.43	1.12	1.03	1.01	1.02	1.05	1.10	1.19	1.37	1.46	1.48	1.56	1.68
Age Records 1974	5000 m.	1.42	1.13	1.02	1.01	1.01	1.04	1.08	1.13	1.28	1.28	1.38	1.47	1.81
Age Records 1974	10000 m.	1.40	1.16	1.02	1.00	1.01	1.02	1.08	1.12	1.18	1.30	1.37	1.44	1.83
Age Records 1974	42195 m.	1.50	1.21	1.06	1.02	1.03	1.05	1.06	1.11	1.15	1.27	1.38	1.46	1.64

but the number in the age-60 group was only 38. It is almost certainly the case that the number of individuals actively competing in track and field events also decreases dramatically beyond the age of 25 or 30. The consequence of these differing sample sizes is that the reliability of the measurements must be considered increasingly suspect as age increases, particularly beyond the age of 60.

A second limitation of the current results is that there is no assurance that the age function for optimal performance is not fundamentally different from the age functions for typical performance. That is, the steeper rates of age decline for the running events than for the other activities might not be evident if the individuals contributing data for these events were randomly selected from the population. Although the possibility that sample type (*i. e.*, optimum individuals *vs.* typical individuals) might interact with age cannot be completely discounted, at the present time there appears to be no evidence that such an interaction exists in the domain of physical skills and capacities.

A third limitation is that the range of speeded activities examined was restricted to those placing minimal cognitive demands upon the subject. It is quite possible that increasing the decision requirements while holding the physical and motor components constant would also produce different rates of decline. The present results merely serve to illustrate that variation in the physical requirements of the task produces differential rates of decline with age; they do not address the issue of whether comparable differences would be evident with a variation in cognitive requirements.

With these reservations in mind, the data can be examined with respect to the issues motivating this study. The data in Figure 2 are relevant to the issue of the rate of slowing with age and the distance of the running event. As the graphs of this figure illustrate, and as the additional data in Table 1 support, there appears to be no trend for either the age of maximum performance or the rate of slowing with age to differ across events of different distances. It is likely that the observations to the contrary in an earlier

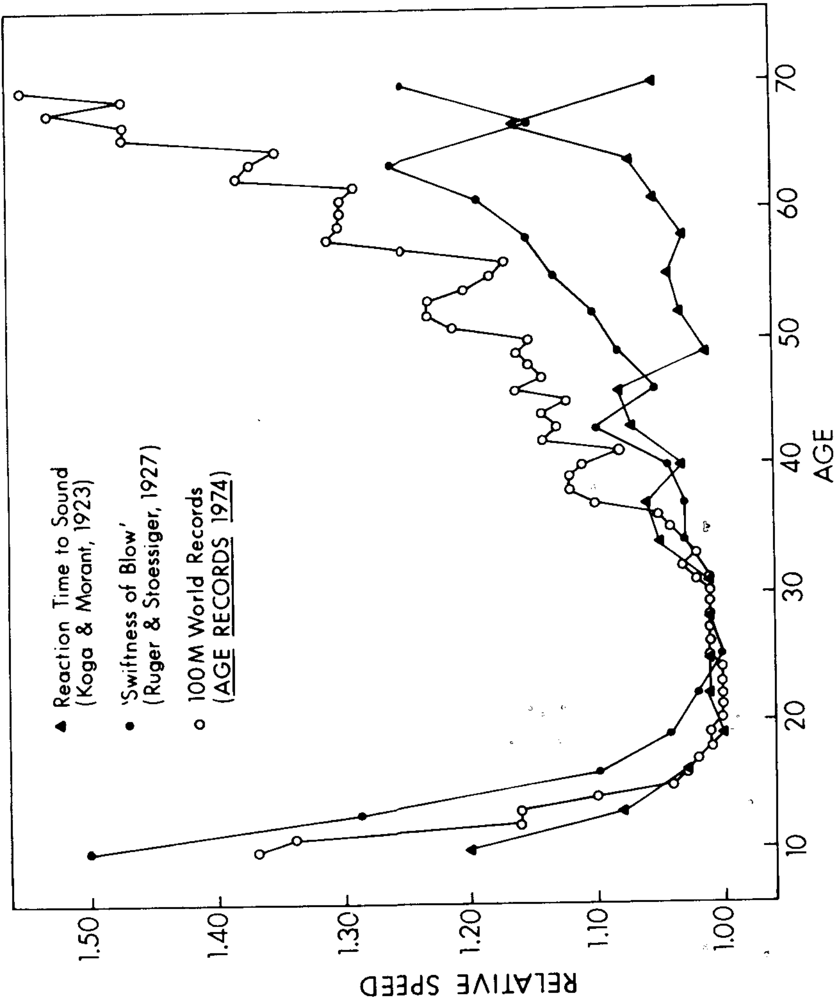

Figure 1. Relative rates of performance for three classes of speeded activities. Each point is determined by dividing the speed for that age by the maximum speed across all ages.

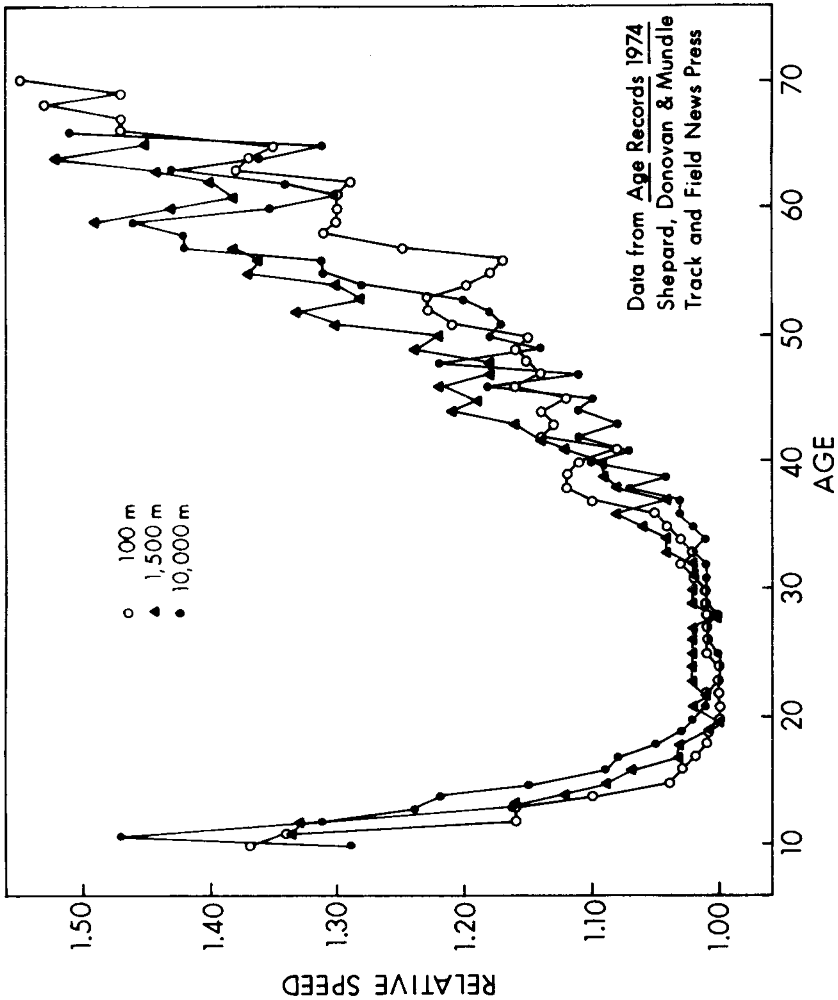

Figure 2. Relative rates of performance for three running events of different distances. Each point is determined by dividing the speed for that age by the maximum speed across all ages.

report (*i. e.*, Moore, 1975) were incorrect because they were based on a mathematical model that gave equal weight to values at extreme ages (which are of dubious reliability) as to values in the young adult range (which are of extremely high reliability). Therefore, the conclusion from the present analyses is that a person of a particular age requires about the same percentage of additional time over that required by a younger person to complete running events of all distances.

The data illustrated in Figure 1 and in Table 1 indicate that three classes of activities can be identified which have different rates of decline with increased age. The two reaction-time tasks form one class of activities which exhibit a quite gradual slowing with age. The swiftness-of-blow, manual-reach-and-grasp, and the reaction-time-and-movement-time tasks are grouped together in a second class because they exhibit a moderate rate of slowing with age. The steepest rates of decline are exhibited by the running events, which are all grouped together in a third class. A possible inference from this pattern of results is that the rate at which performance on an activity slows with increased age depends upon the amount of muscular involvement, physical coordination, and stamina required to perform the activity. Regardless of the ultimate correctness of this inference, the different rates of slowing for different activities suggest that it is inappropriate to refer to the "slowing with age" phenomenon without specifying the particular activity with which one is concerned.

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