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Components of Response Time as a Function of Age, Physical Activity, and Aerobic Fitness

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Research suggests that there are differences in response time (RespT) as a function of age but that aerobic fitness might have a facilitatory effect on RespT. This study was designed to examine this relationship while addressing methodological issues from past research. Men from 3 age groups completed speeded tasks, a physical activity questionnaire, and an aerobic-fitness test. Results indicated that age has a negative impact on RespT (specifically premotor time and movement time). The interaction of aerobic fitness by age was also a significant predictor of RespT (specifically movement time) such that aerobic fitness was positively related to speed of performance for older participants. It is concluded that aerobic fitness might serve a preservative function for speeded tasks in older adults.

Key Words: processing speed, cognition, exercise

Reaction time (RT) is a measure of cognitive functioning that has been used to examine differences in processing speed as related to age. Normative data suggest that as people get older, they tend to exhibit slower RTs (e.g., Birren, Woods, & Williams, 1979; Cerella, 1985; Fozard, Vercruyssen, Reynolds, Hancock, & Quilter, 1994). The implications of this relationship are broad because the slowing of information processing that occurs with age might underlie many of the decrements in cognitive performance that are typically seen with increasing age (Salthouse, 1992). Although normative data suggest slower RT with age, there are individuals who show a resistance to these normal age-related declines. Aerobic fitness is one of the variables that have been proposed to explain these individual differences (e.g., Offenbach, Chodzko-Zajko, & Ringel, 1990; Spirduso, 1975; Spirduso & Clifford, 1978). The rationale underlying this proposition is that higher levels of aerobic fitness might be associated with benefits to the cerebral environment that ultimately have a positive impact on the ability to perform speeded tasks (Dustman et al., 1990).

The bulk of the research in this area to date has used cross-sectional designs in which “fit” and “unfit” participants were recruited for RT assessment. The results

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of these studies have generally suggested that fit people have a quicker RT than do unfit people and that these differences are larger for the older age groups. Three comments with regard to this literature are necessary, however.

First, the method of assessing aerobic fitness in these studies has implications for the nature of the conclusions that can be drawn. In most of this research, aerobic fitness was not actually assessed but was inferred from self-reports of involvement in physically active leisure activities (e.g., MacRae et al., 1996; Sherwood & Selder, 1979; Spirduso, 1975; Spirduso & Clifford, 1978) or from a composite of fitness-related health measures (e.g., Bunce, 2001; Bunce & Birdi, 1998; Bunce, Warr, & Cochrane, 1993; Offenbach et al., 1990). To infer aerobic fitness from self-reports of physically active leisure activities might be reasonable, but the validity of this method for assessing physical activity or aerobic fitness has not been established. Furthermore, this practice does not recognize the conceptual differences between the behavioral variable of physical activity and the biological variable of aerobic fitness. The research that has used composites of fitness-related health measures has typically used some combination of body-mass index, blood pressure, body-composition measures, pulmonary-function measures, and cholesterol levels (e.g., Bunce; Bunce & Birdi; Bunce et al.; Offenbach et al.). These measures, although related to aerobic fitness, do not allow for precise statements to be made about aerobic fitness itself. Aerobic fitness was assessed in a study conducted by Era, Jokela, and Heikkinen (1986), who observed significant relationships between aerobic fitness and components of RT. Nonetheless, Era et al. did not statistically test the interaction of age by aerobic fitness, and we are not aware of any studies in which the interaction between aerobic fitness and age was tested to identify the effects on RT.

Second, the manner in which RT has been operationalized has varied across studies. Most paradigms have required participants to press a button or microswitch and then respond to a stimulus by lifting off of the button or microswitch and pressing a target button. Researchers have then tested either the total response time (e.g., Bunce, 2001; Offenbach et al., 1990) or the components of total response time for differences relative to age and aerobic fitness. Typically, the total response time has at least been broken into RT, defined as the time from stimulus onset to button release, and movement time (MovT), defined as the time from button release to pressing of the target button. Other researchers have further fractionated RT into its component parts of premotor time (PMT), defined as the time from the stimulus onset to observable muscle activity, and motor time (MT), defined as the time from observable muscle activity to button release. The particular manner in which the response time is fractionated has obvious relevance to the findings because the effects of age and aerobic fitness on speeded tasks might be specific to particular components of the response. As an example, MacRae et al. (1996) found that the effects of age and aerobic fitness were limited to the PMT component and were not evident in the MT component. For this reason, studies in which response time is not fractionated to this degree might yield findings in which the differences between groups are masked because of the failure to distinguish between the various components of the task (e.g., Offenbach et al.).

Third, the number of trials that participants performed varied dramatically across studies. This is important because of evidence that both younger and older performers improve their RT with practice and that older participants improve more than do younger participants (Light, Reilly, Behrman, & Spirduso, 1996). For this reason, when relatively few trials are used the differences that are seen in performance as a function of age, fitness, or their interaction are differences that might be related to the novelty of the task. These differences might be more indicative of experiential differences relative to tasks of this nature than to relatively stable differences as a function of the predictor variables. The use of only a small number of trials might also affect the power of the statistical analyses because of the relatively higher variability that is evident in RT during early trials (Light et al.).

Although the results of the cross-sectional studies have been relatively consistent in showing that age and "aerobic fitness" affect RT, the findings with regard to the interaction of age by fitness have not been consistent. In addition, the aforementioned limitations of the research in this area make it difficult to clearly discern the nature of the effects that are found. In particular, the failure to assess aerobic fitness, to fractionate response time, and to provide sufficient practice trials limits the strength of the conclusions that can be drawn from this literature.

Many of these limitations with the cross-sectional research are also evident in the longitudinal research and might explain the failure to produce consistent results when aerobic fitness is manipulated. Dustman et al. (1984) achieved a dramatic increase in aerobic fitness (27% increase in VO_{2max}) and found a concomitant improvement in RT. They used 50 trials in a pre–post design and found that simple RT, but not choice RT, was significantly improved. In contrast, Whitehurst (1991) obtained a 16.4% increase in VO_{2max} but found no change from pretest to posttest for either simple or choice RT performed across 100 trials. Although the number of trials performed was sufficient, the lesser increase in aerobic fitness and the failure to fractionate RT might have been critical. Panton, Graves, Pollock, Hagberg, and Chen (1990) obtained a 20.4% increase in VO_{2max} but found no improvements in PMT, MT, RT, or MovT across nine trials. In this study, the small number of trials might have affected the nature of the results.

In light of the potentially critical role of processing speed relative to the cognitive abilities of older adults, it is important to more clearly identify the nature of the relationship between age, aerobic fitness or physical activity, and speeded responses. Before investing more resources into longitudinal studies, it is worthwhile to use a cross-sectional design to revisit the question of how aerobic fitness and/or physical activity might interact with age to affect response time. Therefore, the primary purpose of this study was to test the impacts of age, physical activity, aerobic fitness, the interaction of age by physical activity, and the interaction of age by aerobic fitness on processing speed. This study will add to the literature because we employed a valid and reliable measure of physical activity, assessed aerobic fitness, fractionated response time, and statistically tested the interaction effect. A second purpose of this study is to add to the extant literature by including participants in a middle-aged cohort to examine with more specificity the possible interactive relationship between age and aerobic fitness (or physical activity) and fractionated response time.

Methods

PARTICIPANTS

Forty-one men between the ages of 18 and 76 years were recruited from a local university and from the surrounding community. Participants were categorized as younger (18–40 years, $n = 17$), middle-aged (41–60 years, $n = 13$), or older (61–76 years, $n = 11$). Participants were asked to read and sign an informed consent that had been approved by the university's institutional review board. Based on responses to questions regarding health and employment, this sample is best described as healthy and college educated. Four participants (1 younger, 2 middle-aged, and 1 older) were excluded from the data analyses because they failed to complete all portions of the physical activity questionnaire. The regression analyses that incorporated the aerobic-fitness terms were conducted with and without these 4 individuals, and the nature of the results was not different between the two analyses. Therefore, for ease of presentation and interpretation, results are presented from the sample that could be included in both the physical activity and the aerobic-fitness regressions.

MATERIALS

Apparatus. Lab View is a software package that allows for the creation of a virtual instrument for collecting physiological data. In this experiment, it was used to program the stimulus lights to illuminate in a specified fashion. Each participant was seated and faced a stimulus-presentation box that housed three lights: a blue light on the left, a white light in the center, and a green light on the right (see Figure 1). The response keys were 70 cm apart, and the start key was centered between them. The response keys and the start key were located on a horizontal line that was 25 cm below the stimulus box. The participant was seated so that his dominant arm was abducted and his elbow was flexed to 90° when his hand was resting on the start

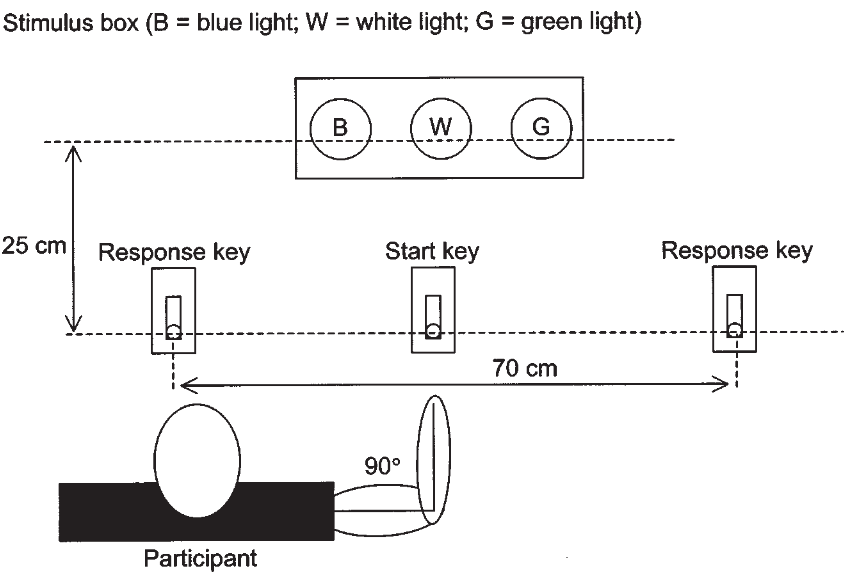

Figure 1. Experimental setup for testing (right-handed participant illustrated).

key. The center of the dominant forearm was lined up with the center of the start key. Thus, a right-handed participant sat to the left of the start key and a left-handed participant sat to the right of the start key. Participants were instructed to press the response key to the left when the blue light was illuminated and to press the response key to the right when the green light was illuminated. For all trials, the white light illuminated first to signal the participant to get ready. Then, after a variable foreperiod of 500–1,500 ms, either the blue or the green light was illuminated and served as the imperative stimulus.

For all trial blocks, participants performed both practice trials and performance trials. Of these trials, one fifth were catch trials during which the white light was illuminated but was not followed by a subsequent imperative stimulus. These catch trials were included to limit any anticipation effects.

Participant Questionnaires. The American College of Sports Medicine (ACSM) guidelines (Balady et al., 2000) state that individuals should be screened with the Physical Activity Readiness Questionnaire to identify those for whom physical activity might be inappropriate. To be included in this study, a potential participant must have answered "no" to all questions. Participants also completed a short medical history to screen for both psychological disorders and physical disabilities that would preclude participation. Education level was assessed as the self-reported number of years of formal education completed. To assess physical activity, participants were asked to complete the Baecke Questionnaire of Habitual Physical Activity (Baecke, Burema, & Frijters, 1982). This questionnaire has been shown to be highly reliable across time in men between 20 and 70 years of age (11-month retest: $r = .80$) and to correlate well with a 3-day activity diary ($r = .66$; Pols et al., 1995).

AEROBIC-FITNESS ASSESSMENT

The guidelines of the ACSM were observed in the conducting of the aerobic-fitness tests. Based on these guidelines and the risk stratification based on age, maximal tests of aerobic fitness were only conducted with participants in the younger age group. Because of the inherent risks associated with older adults performing a maximal aerobic-fitness test (Balady et al., 2000), a submaximal measure of aerobic fitness was used with participants who were 41 years of age or older.

Maximal Measure of Aerobic Fitness. Younger participants completed graded exercise tests on a treadmill to assess maximal aerobic fitness (VO_{2max}). All tests were conducted using a standard Balke procedure and the ACSM termination criteria. Each participant was equipped with a nose clip and a mouthpiece so that expired gases could be collected by the Parvo-Medics True Max 2400 metabolic cart.

Submaximal Measure of Aerobic Fitness. Middle-aged and older participants were asked to cover a distance of half a mile around the circumference of a gymnasium that had distances clearly marked. They were instructed to cover the distance as quickly as possible, and their time to completion was recorded as the dependent variable. Published literature confirms that walk/run tests are valid and reliable measures of aerobic fitness in a variety of samples (e.g., Grant, Corbett, Amjad, Wilson, & Aitchison, 1995; McCormack, Cureton, Bullock, & Weyand, 1991), and this particular walk test has been shown to be a valid predictor of VO_{2max}

in older adults in a study conducted in our laboratory (Traustadóttir, Etnier, & Romero, 2000).

PROCEDURE

On arrival at the lab, participants were asked to sign the informed consent and to complete the questionnaires. They were then equipped with EMG electrodes. The center of the belly of the biceps and the center of the triceps of the dominant arm were located by asking the participant to maximally contract these muscles. Once located, the sites were lightly abraded and cleaned with isopropyl alcohol. EMG electrodes were then attached. The ground was placed on the wrist of the nondominant arm.

Participants were told that they would perform three different trial blocks. For each block, they performed practice trials and actual performance trials. Participants were instructed to respond as quickly and accurately as possible when presented with the imperative stimulus. During each block of simple trials, participants performed 20 practice trials (16 actual and 4 catch) and 80 performance trials (64 actual and 16 catch). One block of simple trials required participants to flex the elbow to press the response key and the other required participants to extend the elbow to press the response key. The order of presentation of flexion and extension trials was randomized and counterbalanced across participants. On the choice trials, participants were instructed to either flex or extend, based on the nature of the imperative stimulus (in the same fashion as during the simple RT trials). Participants performed 20 practice trials (8 flexion, 8 extension, and 4 catch) and 160 performance trials (64 flexion, 64 extension, and 32 catch). Breaks were offered after every 25 trials within a trial block, and a longer break was allowed between trial blocks. After completing the tasks, participants performed the age-appropriate measure of physical fitness.

STATISTICAL ANALYSIS

Response time (RespT) was defined as the time from the display of the imperative stimulus to the pressing of the appropriate response key and was fractionated into RT and MovT (see Figure 2). RT was defined as the time from the display of the imperative stimulus to the lifting of the hand off of the start key. RT was further fractionated into PMT and MT based on the identification of a burst of EMG activity in the appropriate muscle (biceps for flexion, triceps for extension). The burst of EMG activity was identified by visual examination of the signal. MovT was defined as the time from the lifting of the hand from the start key to the pressing of the appropriate response key. Outliers were identified separately for simple and choice trials on a trial-by-trial basis and were defined as RespT, RT, PMT, MT, or MovT values that were greater than 2 *SD* above or below the mean for the individual. Outliers were not included in the statistical analyses.

Because differences in the RespT components as a function of the direction of movement (flexion or extension) were not hypothesized, RespT and all its components were collapsed across direction. Aerobic fitness was tested using different methods for the different age groups; therefore, the aerobic-fitness scores

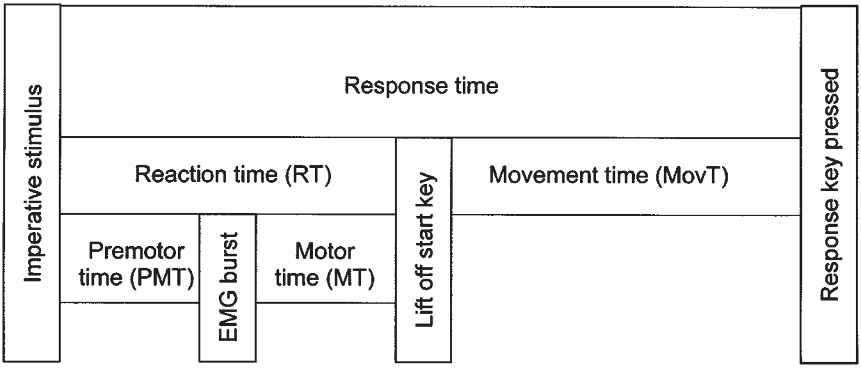

Figure 2. The components of the fractionated RespT.

had to be converted to a common metric. The aerobic-fitness data were converted to *z* scores so that each individual's score represented the distance from the mean for his age group in *SD* units. Thus, the effects of age on aerobic fitness were controlled for and the aerobic-fitness data used in the analyses are indicative of fitness relative to age group. The scores for activity level were centered for the entire sample before the regression analyses. Because differences were not expected as a function of age within each age group, age was dummy coded based on the three age categories (younger, middle-aged, and older). Finally, because physical activity level and aerobic fitness were significantly correlated ($r = .35$, $p < .05$), and to control for the statistical problem of multicollinearity, separate regression analyses were conducted for physical activity and for aerobic fitness.

For all regression analyses, age was entered first, followed by either physical activity or aerobic fitness, followed by the interaction term. Separate regressions were conducted for RespT and for its components (RT, PMT, MT, and MovT). The prediction equations for all criterion variables followed the same general format. The prediction equations for the regression analyses testing the effects of physical activity (ACT) were as follows:

$$Y_{\text{pred}} = b_1\text{AGE}d_1 + b_2\text{AGE}d_2 + b_3\text{ACT} + (b_4\text{AGE}d_1 \times \text{ACT}) + (b_5\text{AGE}d_2 \times \text{ACT}) + b_0$$

The prediction equations for the regression analyses testing the effects of aerobic fitness (FIT) were as follows:

$$Y_{\text{pred}} = b_1\text{AGE}d_1 + b_2\text{AGE}d_2 + b_3\text{FIT} + (b_4\text{AGE}d_1 \times \text{FIT}) + (b_5\text{AGE}d_2 \times \text{FIT}) + b_0$$

Results

Descriptive data for the sample are presented in Table 1. *F* values, R^2 values, and significance levels for the regression analyses are presented in Table 2.

Table 1 Means and Standard Deviations of the Younger, Middle-Aged, and Older Age Groups

	Younger (n = 16)		Middle-Aged (n = 11)		Older (n = 10)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Age (years)	22.56	1.63	48.82	4.73	68.60	4.97
VO_{2max} (ml · kg · min^{-1})	50.64	6.50				
1/2-mile-walk time (min)			4.30	0.59	6.27	1.77
Physical activity	9.56	1.53	8.87	1.48	9.39	1.53

Table 2 R^2 and Significance Level for All Effects and F Values for the Significant Effects for Each Regression Analysis

	Step 1 Age				Step 2 Fitness		Step 3 Interaction	
	F(2, 34)	R^2	Step 2 activity, R^2	Step 3 interaction, R^2	F(1, 33)	R^2	F(2, 31)	R^2
Simple Task								
RespT	8.71	.34**	.01	.02	7.74	.13**	10.78	.22**
RT	5.90	.26**	.01	.00		.01		.03
PMT	5.13	.23*	.00	.00		.02		.03
MT		.01	.03	.00		.00		.00
MovT	6.22	.27**	.02	.03	9.90	.17**	16.00	.29**
Choice Task								
RespT	10.49	.38**	.00	.02	9.33	.14**	9.73	.19**
RT	7.75	.31**	.04	.00		.03		.01
PMT	10.27	.38**	.03	.01		.02		.01
MT		.01	.03	.03		.03		.02
MovT	7.06	.29**	.01	.04	9.69	.16**	18.00	.29**

Note. Fitness = aerobic fitness; Activity = physical activity; RespT = response time; RT = reaction time; PMT = premotor time; MT = motor time; MovT = movement time.
*p < .05; **p < .01.

Table 3 Prediction Equations for the Significant Components for Simple and Choice Tasks and for Each Age Group

Component	Age Group: Younger	Middle-Aged	Older
	Simple Task		
RespT	$Y_{pred} = 494.98$	$Y_{pred} = 494.98$	$Y_{pred} = 625.79 - (84.48 \times \text{FIT})$
RT	$Y_{pred} = 313.01$	$Y_{pred} = 313.01$	$Y_{pred} = 351.08$
PMT	$Y_{pred} = 240.00$	$Y_{pred} = 240.00$	$Y_{pred} = 275.45$
MovT	$Y_{pred} = 181.98$	$Y_{pred} = 181.98$	$Y_{pred} = 273.97 - (70.50 \times \text{FIT})$
	Choice Task		
RespT	$Y_{pred} = 540.38$	$Y_{pred} = 591.41$	$Y_{pred} = 759.63 - (88.35 \times \text{FIT})$
RT	$Y_{pred} = 354.66$	$Y_{pred} = 369.77$	$Y_{pred} = 423.89$
PMT	$Y_{pred} = 277.54$	$Y_{pred} = 296.05$	$Y_{pred} = 349.22$
MovT	$Y_{pred} = 185.69$	$Y_{pred} = 221.53$	$Y_{pred} = 334.97 - (81.84 \times \text{FIT})$

Note. RespT = response time; Y_{pred} = predicted value of the component; FIT = aerobic fitness; RT = reaction time; PMT = premotor time; MovT = movement time.

SIMPLE TASKS

Age. Age was a significant predictor of RespT, RT, PMT, and MovT but not of MT. Examination of the coefficients of the regression equations (see Table 3) indicated that for RespT, RT, PMT, and MovT, the older group had significantly slower performance times than those of either the middle-aged or the younger group (which were not significantly different from one another).

Physical Activity. Neither physical activity nor the interaction of physical activity by age accounted for a significant increase in the predicted variance of any of the criterion variables.

Aerobic Fitness. Aerobic fitness accounted for a significant increase in the predicted variance of RespT and of MovT but was not a significant predictor for any of the other criterion variables. For RespT and MovT, the interaction of age by aerobic fitness predicted a further significant portion of the variance. The resulting prediction equations are shown in Table 3.

CHOICE TASK

Age. Age was a significant predictor of RespT, RT, PMT, and MovT. Examination of the regression coefficients (see Table 3) indicated that the older participants were slower than the younger and middle-aged participants on all of these criterion variables. The middle-aged participants were significantly slower than the younger participants for RespT and MovT. Age was not a significant predictor of MT.

Physical Activity. Neither physical activity nor the interaction of physical activity by age accounted for a significant increase in the predicted variance on any of the criterion variables.

Aerobic Fitness. Aerobic fitness accounted for an additional percentage of the variance for RespT and MovT but was nonsignificant for all other criterion variables. The interaction of age by aerobic fitness was a significant predictor for RespT and for MovT. The resulting prediction equations are shown in Table 3.

Discussion

This study was designed to test the influence of age, aerobic fitness, physical activity, and the interactions of age by physical activity and of age by aerobic fitness on response speed during simple and choice tasks performed by men in three different age groups. This study adds to the literature because we used a valid and reliable measure of physical activity, assessed aerobic fitness, fractionated the response time, used sufficient trials, and tested the interaction terms.

Not surprisingly, the results of this study confirm past research that has shown that performance of a speeded task is negatively related to age (e.g., Birren et al., 1979; Cerella, 1985; Fozard et al., 1994). For both simple and choice tasks, the response times for the younger and middle-aged adults were significantly faster than those for the older adults. Examination of the components of RespT indicated that these age-related differences were apparent for RT, PMT, and MovT but not for MT. This finding is similar to those of Clarkson (1978) and McRae et al. (1996) and suggests that there are age-related declines both in the cognitive component of RT (PMT) and in movements across distances to targets (MovT) but that there are no age-related differences for the motor component of RT (MT).

The results also indicate that the differences in performance between younger and middle-aged participants were significant for RespT and MovT on the choice task. The fact that these differences were only apparent for the choice task and not for the simple task supports the contention of Chodzko-Zajko and colleagues (Chodzko-Zajko, 1991; Chodzko-Zajko & Moore, 1994) that the influence of age on performance should be most evident in tasks that make the largest demands on attentional capacity. The fact that the locus of the differences between the younger and middle-aged participants was in the MovT component of RespT suggests that this component might be most sensitive to age-related declines and that differences in the purely cognitive PMT portion of RT do not become apparent until older age. Future study should be designed to confirm this interpretation by incorporating choice tasks that have an even greater range of attentional demands and include a component requiring movement to a target.

The results with regard to the self-reported measure of physical activity indicate that after controlling for age, physical activity was not a significant predictor of RespT or any of its components for either the simple task or the choice task. This is consistent with past research that has failed to find a significant interaction of age by self-reported involvement in physical activity (e.g., Lupinacci, Rikli, Jones, & Ross, 1993; Spirduso & Clifford, 1978) but contrasts with the conclusions of other studies in this area (MacRae et al., 1996; Rikli & Busch, 1986;

Sherwood & Selder, 1979; Spirduso, 1975). There are two primary methodological differences between the studies that might explain the different findings. One such difference is the number of trials that were used. Spirduso and Clifford (1978) and Lupinacci et al. did not find a significant interaction using 50 trials per condition, whereas Rikli and Busch (1986) and Spirduso used only 10 and 15 trials, respectively, and found a significant interaction. Therefore, the interaction effects for age by physical activity that were reported by Rikli and Busch and by Spirduso might be more reflective of the initial novelty of the task than of true differences in response times. This would explain the lack of a significant interaction in this study, in which 128 trials were used per condition.

Another possible explanation for the different results is related to the measure of physical activity used. Rikli and Busch (1986), Spirduso (1975), Sherwood and Selder (1979), and MacRae et al. (1996) reported significant interactions between physical activity and age, and they all used a similar method for operationalizing physical activity. That is, these authors all categorized participants as active or inactive based on their self-reported long-term involvement in a particular activity (running or racket sports). This method of assessing physical activity might not provide a valid measure of actual levels of physical activity and, because it is based on a long-term commitment to physical activity participation, is likely to reflect other potentially confounding variables. The use of a valid and reliable measure of physical activity in this study might explain the failure for physical activity to emerge as a significant predictor of performance.

In addition to these methodological differences, there are other possible explanations for our failure to find a significant interaction effect for physical activity. One is that we might not have had sufficient statistical power to find the effect, but an examination of the percentage of the variance in performance that was explained by the interaction term indicated that it was low for all components of the response (range 0–.037). This suggests that although a larger sample size could yield significant findings for this interaction term, the percentage of the variance explained is so small that this term does not appear to be a meaningful predictor.

A second possibility that seems the most likely explanation for our results is that the variable of physical activity itself is not related to the performance of a speeded task when physical activity is assessed using psychometrically sound measurement tools and when sufficient trials on the response task are provided. This might help explain the mixed results that have been found in the cross-sectional literature. That is, methodological differences between studies might provide the best explanation of why some studies find that physical activity is a significant predictor of speeded performance and others do not. The findings from this study, then, in which a strong methodological design is used, are likely to be most reflective of the true nature of the relationship between physical activity and speeded performance. This nonsignificant effect of physical activity is logical in light of the proposal that it is the physiological benefits to the cerebral environment that are related to cognitive performance (Dustman et al., 1990) and that these physiological benefits are more closely linked to aerobic fitness than to physical activity.

The results from the regression analyses incorporating aerobic fitness indicated that aerobic fitness and the interaction of aerobic fitness by age predicted a significant portion of the variance in RespT for both simple and choice tasks. In fact, the combination of age, fitness, and their interaction accounted for approximately

70% of the variance in RespT, and the interaction term alone accounted for approximately 20%. This finding is in agreement with that of past research in which composite measures of fitness were used to represent aerobic fitness (Bunce, 2001; Bunce & Birdi, 1998; Bunce et al., 1993) and suggests that the unique interaction of age by aerobic fitness is important for predicting performance on speeded tasks. RespT includes components that vary in terms of their cognitive and motor requirements, and an examination of the regression results for the various components clarifies the nature of this finding. That is, the effects of aerobic fitness and the interaction of aerobic fitness by age were only evident for MovT and were not significant for RT or its components. Taken as a whole, these results suggest that the interaction of age by fitness does affect response time but that the effects are only evident on the component of the task that requires movement to a target.

Before we discuss these findings, it is important to note some of the limitations of this study. First, it was cross-sectional in nature, and, as such, the conclusions that can be drawn are limited to those of relationships rather than of cause and effect. Second, this was a well-educated, healthy sample of fairly active and relatively fit men, so results might only generalize to this population.

The interpretation of these findings is challenging in part because of the mixed literature with regard to the effects of physical activity and aerobic fitness on the age-related slowing of performance. Nonetheless, the results of this study confirm the fact that age is predictive of slowed performance on a speeded task and that the effect is specific to the components of the response that include a cognitive component (RT, PMT, MovT). The results further suggest that the interaction of aerobic fitness by age is a significant predictor of speed of performance and that this effect is specific to the component that combines motor and cognitive demands (MovT).

Thus, when response time is assessed over a sufficient number of trials, age and age-by-fitness differences in speed of processing are evident. These findings perhaps give some guidance to how past research should be interpreted. Studies in which self-reported physical activity participation is used should not be interpreted to be representative of aerobic-fitness relationships. Studies in which relatively few trials are used are not likely to represent stable age or age-by-fitness differences. The results of this study clearly indicate that in simple and two-choice response tasks, the age-by-fitness interaction predicts a significant portion of the variance in RespT, and this effect is localized to the MovT component of the response. Future study should commit to using proper techniques to assess speed of processing and should manipulate aerobic fitness in adults of varying ages to test the causative role of fitness as a preservative factor for speeded performance.

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