was formed which was characterized by its di-N-methylamide. The latter melted at 138° and showed $[\alpha]_D^{24} = -55.3°$ ($c = 1.410$ in water).

$C_8H_{16}O_4N_2$:

Calculated. C 47.04, H 7.89, OCH_3 15.19, (N)CH_3 14.70
Found. " 47.12, " 7.42, " 15.70, " 13.41

It was also possible to isolate the lactone of this acid which melted at 150–152° and showed $[\alpha]_D^{24} = -1.2°$ ($c = 1.720$ in water).

$C_6H_8O_5$. Calculated. C 45.00, H 5.00, OCH_3 19.37
Found. " 45.15, " 4.98, " 19.22

On direct titration and saponification the alkali consumption corresponded to one carboxyl and one lactone group, respectively. From this it is obvious that in order that lactone formation may take place the hydroxyl group of this acid must be on a carbon atom adjacent to one of the carboxyl groups. This leaves only the β carbon atom as the position for the methoxyl group. Otherwise, the highly improbable assumption of the presence of a β lactone must be made. By reference to the cymarose molecule it follows from this that the methoxyl group is on the third carbon atom of the desoxyhexose.

Details of this work, together with the exact determination of the configuration of cymarose, will appear later.

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THE EFFECT OF PRACTICE UPON INTER-CORRELATIONS OF MOTOR SKILLS

EXPERIMENTS on the interrelations of speed[1] tests in fine motor skills have indicated quite consistently that these tests are either highly specific or at most related only within very narrow groups of movement patterns, *e.g.*, as in McCollom's tapping tests.[2] According to Seashore,[3] an intercorrelation of approximately +.25 would be a representative figure for such tests, but such results have been challenged, since learning curves have been involved, and testing may not have been done near enough to hypothetical physiological limits. The critical test is to train observers until they are making little improvement, comparing the intercorrelations between the various motor tests at the beginning and end of the practice period. If intercorrelations increase materially by the end of the practice period, it would favor the theory that a general factor or perhaps several large group factors are basic to more complex motor skills.

The Koerth Pursuit Rotor[4]—a test of simple eye-hand coordination in following with a stylus a target mounted on an insulating disk, which is revolved quite rapidly by a phonograph motor—and the Brown Spool Packer[4]—a test of eye-two-hand coordination in speed of packing spools into a tray—were selected as unlike performances. If, after practice, intercorrelations raised materially between these qualitatively very different skills, the evidence would strongly favor the theory of a general motor ability or large and overlapping group factors.

To test for a possible narrower group factor, this experiment included two tapping tests which are known to be unrelated in early trials, but which seem qualitatively enough alike to belong to a single "basic motor capacity" which might be determined by a hypothetical physiological limit of neuro-muscular arm speed. These two tests were McCollom's simple tapping of a telegraph key and the alternate tapping of two brass plates with a stylus, both for speed. If sheer physiological limits are the basic determiners of fine motor speeds, this should be shown by a raise in the intercorrelations of these two tests.

A lengthy preliminary study determined the respective learning curves and the number of trials necessary to reach approximate limits of improvement on each test. Practise periods were given by the rotating cycle method, so as to avoid fatigue. A single cycle consisted of: 5 trials of 20 revolutions each on the pursuit rotor; 3 trials of 5 seconds each on the telegraph key; 2 trials of 1½ minutes each on the Brown Spool Packer; 5 trials of 20 revolutions each on the pursuit rotor; 3 trials of 5 seconds each on alternate tapping. Three cycles per day were performed at the same hour on alternate days, so that a total of nine cycles, or about three hours of spaced practice, was had by each observer. Motor tests are usually interesting to men, and the citation of electrical counter scores after each trial added a distinct motivation to the performances.

Fifty male right-handed laboratory students acted as observers, none of them having had previous practise on these tests.

Correlations between scores on cycles 2 and 3 (first day) in each test were determined for reliabilities, and these were duplicated for cycles 8 and 9 (third day). Intercorrelations for the four tests were computed from the total of scores on cycles 2 and 3 (first day) and similarly from totals of cycles 8 and 9 (third day). Since the intercorrelations between the tests were determined from the sum of two cycles, while reliabilities were computed from the correlation

[1] The results of steadiness tests and large muscle athletic coordinations must be considered separately from *fine* motor *speed* coordinations; *cf.* Seashore and Adams, SCIENCE, 78: 2022, 285–287, September 29, 1933.

[2] I. N. McCollom, "Analysis of Factors Determining Individual Differences in Speed of Simple Repetitive Motion," unpublished thesis, University of Oregon Library.

[3] R. H. Seashore, *Jour. of Gen. Psychol.*, iii: 1, 38–66, 1930.

[4] R. H. Seashore, *Psychol. Monog.*, xxxix: 2, 51–66, 1928.

TABLE I

EFFECT OF PRACTISE ON INTERCORRELATIONS OF FOUR MOTOR SPEED TESTS

	Koerth Rot.			Tel. Tap.			Br. Sp. Pkr.			Alt. Tap.		
Koerth Rot.	*.91		*.85	.25		.39	.32		.31	.08		.02
	(.95)	−.03	(.92)		+.14			−.01			−.10	
Tel. Tap.				*.77		*.91	.40		.14	.30		.07
				(.87)	+.08	(.95)		−.26			−.23	
Br. Sp. Pkr.							*.86		*.88	.15		.04
							(.93)	+.01	(.94)		−.11	
Alt. Tap.										*.81		*.84
										(.90)	+.01	(.91)

Light figures = results of first day's practice. Heavy figures = results of last day's practice. Figures showing plus or minus variation as result of practice indicated by algebraic sign. * = reliability coefficients; Brown Spearman figures in parenthesis.

between single cycles, the *reliability* of the measures intercorrelated was estimated by the Brown-Spearman prophecy formula, as shown in parentheses below each of the obtained reliability coefficients.

As seen in Table I, intercorrelations between the four motor skills at the beginning of the practice period (light figures) verify the previous findings of low positive correlation between these separate skills, ranging from $r = +.08$ to $r = +.40$, approximating a value of $r = +.25$. After the practise period the correlations (in heavy figures) are somewhat lower than at the beginning of practise. They now range from $r = -.02$ to $r = +.39$, averaging $r = +.16$. Four of the six interrelationships now approximate zero, suggesting that the effect of intensive practice, if anything, is to make such motor skills not only more specific than they were at first, but practically independent variables. Reliability coefficients for both sets of intercorrelations are high, tending slightly higher after practice.

The correlation between the Koerth Pursuit Rotor and Brown Spool Packer (unlike tests) changed but very little (−.01), denying the importance of general factors of motor skill. The correlation between telegraph tapping speed and alternate tapping speed dropped from $+.30 \pm .09$ at the beginning of practice to $+.07 \pm .10$, denying even the existence of a group factor large enough to include only tapping performances.

It is therefore concluded that with instrumentally controlled testing and statistically reliable measures, the effect of practise on the intercorrelations of speed in fine motor skills is, if anything, to decrease their relationship, thus upholding previous findings as to the specific nature of the skills tested. Our results do not support the hypothesis of one or a few physiological limits, such as neuro-muscular arm speed, which might be thought of as determinants of success in numerous fine motor speed skills.

The results accord closely with studies by Walker and Adams[5] and S. Seashore[6] on knitting machinery, in both of which a battery of motor tests showed negligible predictive relationship to objectively measured complex practical skills. Such continued demonstrations of the specificity and non-predictability of individual differences in fine motor skills make it seem more profitable to direct further research toward the most effective methods of direct training in motor speed skills.

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[5] R. Walker and R. Adams, "Motor Skills: The Validity of Serial Motor Tests for Predicting Typewriting Efficiency," *Jour. of Gen. Psychol.*, July, 1934, 11, No. 1, pp. 173–186.

[6] S. Seashore, *Psychol. Bull.*, 27: p. 653, 1930.

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