

Impact of Non-Specific Fine Motor Training on Intermanual Transfer Learning

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ABSTRACT

Humans perform better at dexterity tasks with their dominant hand, but can training in one hand affect the performance of the other? This study examines the impact of increased non-dominant hand usage in everyday life tasks on intermanual transfer learning. I conducted weekly drawing tests of 14 research participants split into groups that either practiced or did not practice non-dominant hand use between testing. Aiming to lead to a better understanding of the scale and confines human dynamics pose during the process of intermanual transfer learning, the experiment yielded the following results: (1) general, not-task-specific short-term practice improved fine motor skill performance by an average of 1% for group A right-hand (R) accuracy and an increase of 2% for left-hand (L) performance after the first training phase with p-values of 0.61 and 0.23 respectively, which suggests no statistical significance. (2) Short-term non-dominant-hand practice by conducting an increased number of everyday tasks shows a possible close relationship between the factors of time, practice, and side, suggested by $F_{\text{TimeSideGroup}} = 2.53$ and $\eta^2 = 0.17$, which as of now lack greater statistic power with $p = 0.14$. (3) Reducing practice with the non-dominant hand resulted in reduced performance quality, which is visible in the average drop of accuracy by 1% of group A subjects after ceasing training with the non-dominant hand for a week. The connectivity between the factors of the interaction between time, side, and practice can also be observed in the decrease of performance quality when regarding $F = 3.95$ and $\eta^2 = 0.25$ with $p = 0.07$, suggesting lack of statistical relevance. Summing up, though discovering possible impact of training on L and R performance accuracy after a short amount of time, these research results are not sufficient in statistical power to certain a noticeable impact of non-specific practice on cross-hand education. The experiment design, nevertheless, established a paradigm for studying intermanual transfer learning in a school setting and identified methods and limitations to assess drawing skills for quantitative analysis for future research.

Keywords: Neuroscience; Neurobiology; Intermanual Transfer Learning; Cross-education; non-specific training/practice

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INTRODUCTION

Learning and practicing a specific motor skill with one hand and exhibiting an increased ability of said skill using the contralateral hand, is a phenomenon called intermanual transfer learning. To study this, researchers have doubled down their efforts in the last few years. Since the improved learning effects have been confirmed by multiple studies, the focus and interests have shifted towards the neurological systems behind intermanual transfer learning (1, 2). Approaches vary, whether it includes manipulated feedback in transfer learning exercises to observe the effects of visual and sensory feedback on the learning process (3), or observing motor areas and executive networks in the brain to analyze their role in intermanual learning (4).

A more recent study investigates the impact of previously acquired skills on new task learning by examining the correlation of intermanual transfer across different designed tasks with behavioral tests and neuroimaging to predict how far the mirrored task execution of the contralateral hand would improve (5). It was discovered that both positive and negative transfer effects may occur in intermanual transfer learning, which links to excitatory and inhibitory neurometabolites.

Based on the decussation in the motor system, where the vertebrate motor systems operate contralateral to the respective motor areas located in the forebrain as depicted in Figure 1 – describable as the R hemisphere “responsible” for the stimulus processing and response generation of the L half of the human body and vice versa – the neural plasticity associated with intermanual transfer learning must occur via the exchange of information on how to execute a motor skill over the corpus callosum, the “bridge” connecting both hemispheres (6, 7).

Another research continues to widen the understanding of how intermanual transfer learning works, discovering the brain networks that are associated with it. To identify human brain regions involved with transfer learning, researchers have had subjects engage in tasks while being scanned in an fMRI machine (8, 9). One major discovery is the involvement of higher-order transmodal cortexes – primarily the default mode network (DMN) (8), which is usually engaged in internal mentation. Parts of this network associated with cognitive functions project to secondary motor areas. These areas in turn project to the primary motor cortex, which sends direct projections to the spinal cord. Specific brain regions the researchers found active during the skill transferring

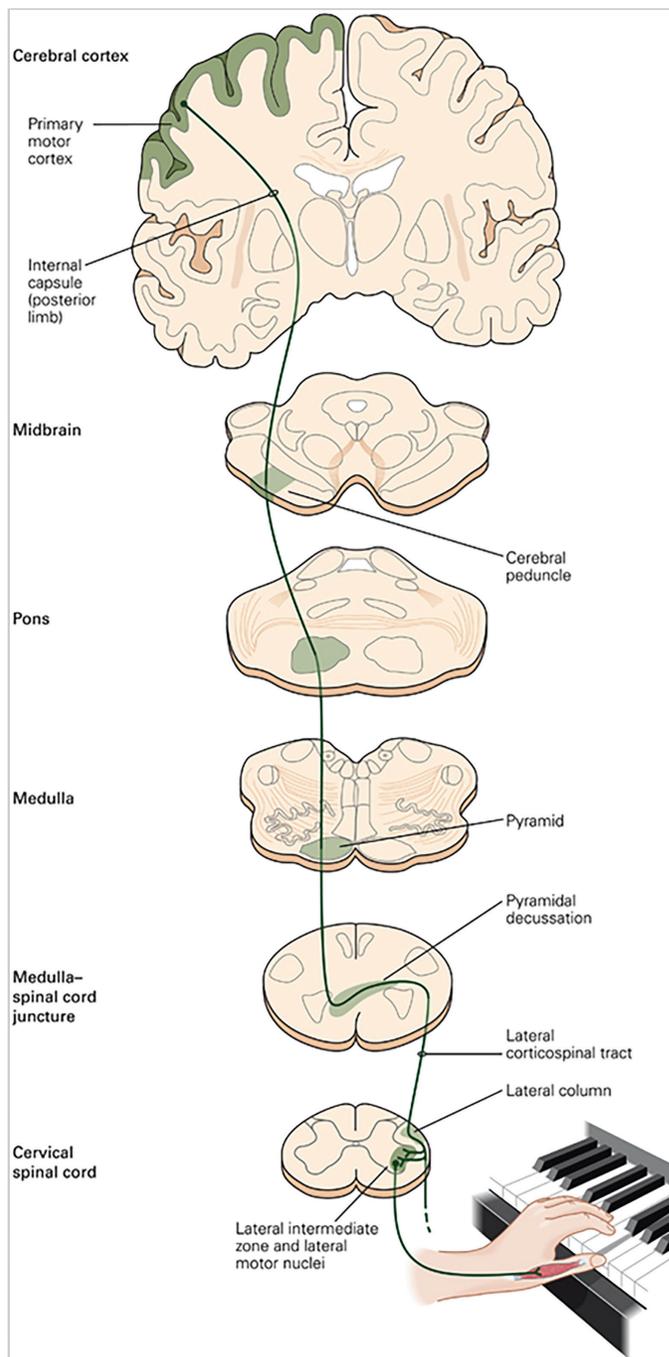


Figure 1. Decussation in the motor system (6). The motor pathway of the L hemisphere connecting the primary motor cortex with the spinal cord undergoes a pyramidal decussation at the medulla-spinal cord junction leading to brain lateralization (5).

process were the medial prefrontal cortex (mPFC), which is involved in higher order processes such as thought, planning, and rule-based decision making; the posterior cingulate cortex (PCC) and precuneus (PCu), which serve as central hubs for integrating self-related and episodic memory information; the angular gyrus (AG), which support perspective taking and semantic processing; the hippocampal formation (HF), including the parahippocampal cortex (PHC), which contributes to memory and imagining future scenarios; and the lateral temporal cortex (LTC), which is involved in conceptual and social knowledge. Thus, intermanual transfer learning paradigms are known to recruit vast areas of the brain, including cognitive brain regions and motor ones.

While reading through numerous studies, one may quickly notice the trend of designing exclusive tasks for the subjects to practice in a controlled environment, which is later tested. Researchers have aimed to observe and explain the confirmed phenomenon of improved motor performance mostly through specified training with the contralateral testing hand, for example pegboard-tasks (2). However, comparatively little has been done to further examine the impact of general training effects on executing a fine motor skill, which has not been specifically trained through a designed task on the contralateral hand through everyday activity.

Instead, the present study has the goal to dive deeper into this existing less-explored niche with the potential of general applicability in the field of rehabilitation and medicine. In order to develop a better understanding of the human dynamics and constraints of intermanual transfer learning and to fill the gaps that still remain due to a lack of further examinations of non-specific motor task impact on cross-hand learning effects, a two-week research experiment has been designed and executed to answer the following three questions regarding the obtained data: (1) does general practice improve fine motor skill performance in the short term? (2) Does non-dominant-hand practice differentially affect L vs. R? Lastly, (3) do general training effects persist and/or transfer?

MATERIALS AND METHODS

Subjects

The research experiment was conducted with 15 (14 R-handed; 1 L-handed) healthy participants, meaning no diagnosed neurological deficits and no indication of symptoms related to any neurological disorders at the time of execution, all aged 17-20 through the scope of the experiment taking place in a high school classroom

setting. To mitigate any potential lateral discrepancy between L and R-handed subjects, acquired L-handed data was not further evaluated. This decision is made based on the potential to negatively influence statistical power.

Ethical Approval

This study was reviewed and approved by the Institutional Review Board of Praelat-Diehl-Schule Gross-Gerau. Written informed consent was obtained from all participants prior to participation.

General Experiment Structure

The experiment at hand yields a duration of two weeks and consists of two phases both marked by an identical testing process at the end of each. Beginning with the baseline testing phase, all research participants were asked to fill out a one-page Baseline Questionnaire, which was set to determine their typical hand usage behavior and baseline fine-motor skills. Due to time constraints, since the experiment is done during regular class sessions, and for greater simplicity, subjects were then assigned to two groups (group A and B) by splitting the class of participants in the middle according to their respective seating, which does not follow a specific seating system. This way, time was saved and participants were sure of their respective group belonging throughout the entire experiment process of two weeks. The two different groups should then follow general hand usage instructions for the following seven days (practice phase 1). Subsequently, another testing phase specific questionnaire (testing phase 1 (T1) questionnaire) was then filled out and the tasks given to the groups were swapped for the week after (practice phase 2). Thus, group A and group B interchange their initial roles of experimental- and control group between the practice phases. The research experiment was finished upon completion of testing phase 2 (T2).

Fine Motor Test

To determine a suitable testing exercise, it was of utmost importance for it to be a fine motor skill that is not regularly practiced by the average person and for it to yield comparable non-discriminatory data, whilst also allowing the comparison of L and R performance. The fine motor test used in every testing phase throughout the entire experiment is the simple exercise of circle-drawing, a practice, which the average student rarely does without drawing aids such as dividers or the “perfect shape” function on mobile devices. All students are given the task of drawing a perfect circle to the best

of their ability with the publicly available program on the website www.neal.fun "Draw a perfect circle". One possible downside of the circle drawing task is the lack of account for speed-accuracy tradeoffs with no reliable method to accurately time the drawing attempts within the preexisting program.

To maintain consistent testing conditions for every person in every testing phase without the possible factor of distinctive pen-holding dexterities, all participants were required to draw directly with their index fingers on the same mobile devices with a total of 20 attempts for every test (eyes open and eyes closed: 10 attempts with 5 attempts for each hand). Since, however, Neal.fun calculates the accuracy of a drawn circle by referencing the radius from the first point to the center point, a shifted perfect circle would result in a lower accuracy score. This constitutes a systematic scoring error. On this account, the eyes-closed data obtained through the examinations were not further evaluated.

Baseline- and Test Phase Questionnaires

Consisting of a total of 14 questions, the baseline questionnaire is a single-select and fill-out test paper designed to determine the total estimated time a subject has spent using L, their self evaluation in drawing skill, which may hold up significance for the motor test, and a spot check for time consumption of several daily activities involving L or R. These questionnaires included questions like how they evaluate their own drawing skills on a scale from one to ten, or how much time they approximately used to brush their teeth with L in total for the past week. Participants are asked to give insight into whether or not they have practiced the specific motor skill directly related to the fine motor test repeated during every testing phase exclusively to rule out any short-term learning effects before the beginning of the experiment. All research subjects participate in said testing and document their scores.

Both of the two testing phase questionnaires feature identical questions to ensure comparability between the test results. As the goal of the present experiment is to determine the efficiency of general non-specific contralateral hand training on a specific motor task through intermanual transfer learning between L and R, the main focus was to identify changes in time consumption of L and R usage overall and in above mentioned daily activities as well as to make sure none had trained the tested motor skill. Unlike in-person-monitored motor test scores, practice tracking relies on self-reported estimates without the possibility to verify due to a lack of resources

and the unrealistic scope of observation needed to confirm. Thus, the self-reported data was only used for general orientation and a medium to motivate research subjects to remain mindful of their group-respective practice tasks throughout the practice phases.

General Training Phase

During the general training phases, one of either group A or B is tasked with the incorporation of L usage into their daily activities, with the explicit prohibition to practice drawing or writing in particular reducing the likelihood of learning effects attributable to specific skill conditioning. This meant that all subjects were prohibited from using the Neal.fun circle-drawing program in all of the training phases. Thus, there are no exclusively designed training exercises to achieve the effects of circle-drawing improvement, but rather an encouraged increase in the usage of the non-dominant hand in a daily life context. In this time period, participants kept track of the duration of executed daily tasks using either hand (e.g. brushing their teeth or picking up and grabbing items). Because of a restricted time frame in which the experiment is executed, training phases in this experiment design are limited to one week, which may mitigate visible effects.

Data Analysis

All acquired data is compiled in a tabular format and ordered by name, group, respective research questionnaire question, and the score on Neal.fun.

Neal.fun scores the accuracy of the drawn circle most likely by calculating the fluctuations of the radius of the brush stroke compared to the distance from its given center point to the starting point of said stroke, which results in a score from 0% (no circle resemblance) to 100% (perfect circle). During previously instructed work on the website, the lowest score received was about 50% by drawing a triangle. Due to this reason, all subjects' scores under 50% are considered invalid scores, as they may fail to meet the basic criteria of the circular shape (no straight lines and no hard corners). Moreover, the program limits the time to draw one circle in one continuous stroke to roughly 10 seconds and disrupts an attempt if the subject is either too slow, too close to the center point, or begins to move their finger against the initial direction of drawing. These attempts were not counted. Eyes-closed data is compromised by the potential of a shifted circle and is thus not used for analysis.

To answer the questions (I) what are the human dynamics of intermanual transfer learning? and (II) does

practicing general everyday life tasks enhance intermanual transfer learning effects of unrelated fine motor skills in the dominant and non-dominant hand? the following pre-testing hypotheses were made: (i.) If a positive correlation between the training of daily non-specific motor tasks with the non-dominant hand and the effectiveness of executing a not specifically trained task with it and the contralateral hand CAN be observed then it is possible to assume that intermanual transfer can also apply to untrained fine motor skills. (ii.) If NO positive correlation between the training of daily non-specific motor tasks with the non-dominant hand and the effectiveness of executing a not specifically trained task with it and the contralateral hand can be observed then it is possible to assume that intermanual transfer does not apply to untrained fine motor skills in the short term. Summing up, this study works with a total of 24 accuracy scores for each participant in total, sourced from baseline testing, T1, and T2. With special regard to the individuality of the results, most of the analysis must be done by within-group comparisons over different timeframes of baseline, T1, and T2. This was achieved by running paired t-tests across the mean and median test results with $n = 7$.

For cross-groups examinations, a $2 \times 2 \times 2$ mixed ANOVA was utilized to determine the relationships between the experimental and control groups A and B, the differences in L and R accuracy in pre- and post-practice tests. Due to limited resources and participants in a classroom setting, the number of subjects only allow an underpowered version of the analysis method with $n = 14$. Making use of 56 total practice scores, the grand mean, cell means, and effect means were calculated together with the respective deviation. The main effects (time, side, group, two-way and three-way interactions) were then determined, yielding results for degrees of freedom, the sum of squares, mean of squares, F-values, p-values, and partial eta squared. To visualize the results of the mixed ANOVA, the values were formatted into APA styled ANOVA tables.

RESULTS

Does General Practice improve Fine Motor Skill Performance in the Short Term?

Throughout the entire practice phases in between baseline and T2, all participants self-reported increased L usage if priorly asked to do so. None of the subjects claimed to have practiced the drawing task specifically during the two weeks, and 2 participants estimated a heightened L drawing skill on the scale of the

questionnaire after practice phase 1. Whilst a general trend of within-hand accuracy improvement across the short time of one week can be marginally observed Figures 2 and 3 – where the x axis represents at a time R and L at T1, the y axis the contralateral hand at baseline, and each dot the performance of the 14 subjects – notice in Figure 2 that the data cluster around the unity line. Consistent with this visualization, the within-group paired t-test revealed no significant difference in quality across the population, yielding means of 1.39% R performance increase and 0.82% L performance increase in Figure 3. A correlation between the training of daily non-specific motor tasks with the non-dominant hand and the effectiveness of executing a not specifically trained task with it and the contralateral hand can be observed regarding t-values of 1.033 for Baseline R vs T1 R and 0.958 for Baseline L vs T1 L, and Cohen’s d of 0.276 and 0.256 in both of these figures.

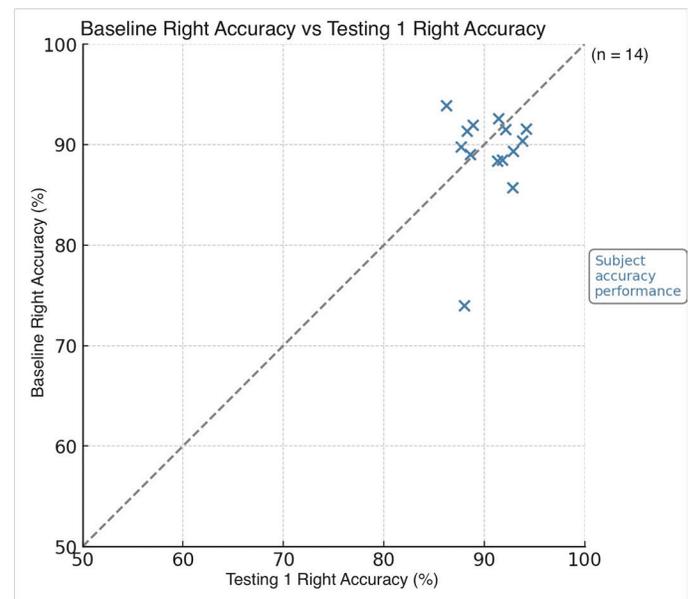


Figure 2. Subject R Performance at T1 vs Baseline ($p = 0.32$; $M = 1.39\%$; $SD = 0.05$; $n = 14$; $t = 1.03$; $df = 13$; $d = 0.28$). This scatterplot illustrates the relation between the average R performances of all subjects at T1 and at baseline, where the x-axis indicates the average accuracy score of each subject in percent at T1 and the y-axis the corresponding scores by the same subject at baseline in percent. The clustering around the unity line shows the tendency of better performance at either baseline or T1, where data underneath the unity line indicate stronger scores at T1 and data above the unity line indicate stronger performance at baseline. A trend towards higher accuracy scores at T1 could be found.

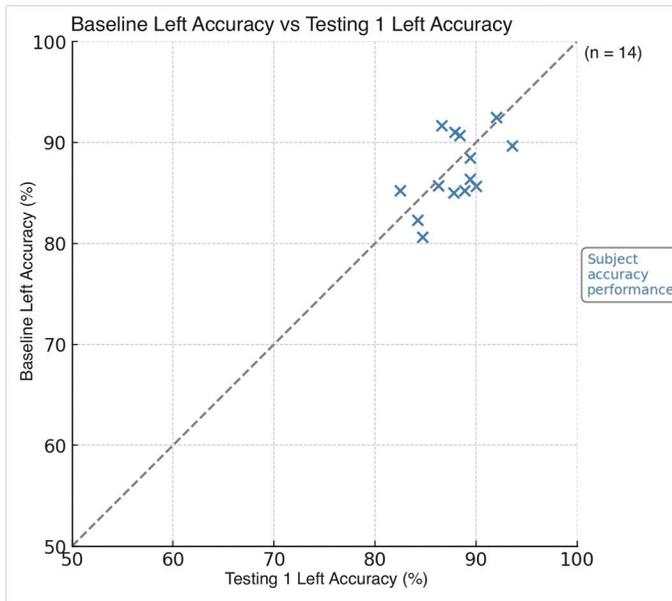


Figure 3. Subject L Performance at T1 vs Baseline ($p = 0.35$; $M = 0.82\%$; $SD = 0.03$; $n = 14$; $t = 0.96$; $df = 13$; $d = 0.26$). This scatterplot illustrates the relation between the average L performances of all subjects at T1 and at baseline, where the x-axis indicates the average accuracy score of each subject in percent at T1 and the y-axis the corresponding scores by the same subject at baseline in percent. The clustering around the unity line shows the tendency of better performance at either baseline or T1, where data underneath the unity line indicate stronger scores at T1 and data above the unity line indicate stronger performance at baseline. A trend towards higher accuracy scores at T1 could be found.

Does Non-Dominant-Hand Practice differentially affect L vs. R?

I wondered how performance quality changed between baseline and T1 for L and R performance in the groups A and B. Figure 4 shows on the x-axis all participants, and on the y-axis the percent change in performance from baseline to T1. Dots on zero would indicate no change. The vertical scatterplot shows the raw difference ranging from -8% to 18% on the y-axis. Notice that the distribution of the performance change over the course of one practice phase appears visually in favor of accuracy increase. However, analysis of how the factors practice, dominant-hand, and interaction terms — listed in Table 1 — affect performance in a mixed ANOVA for the data between baseline and T1, yields overall insignificant results with all $F < 1$ except for the interaction of $time \times side \times group$ with $F = 2.53$, indicating small effect. For this interaction, the p-value is the smallest of all eight effects with $p = 0.14$ ($p > 0.05$).

Do General Training Effects persist and/or transfer?

The general training effects observed in group A during practice phase 1 declined after one week without increased non-dominant hand use, as visible in Figure 5, indicating a loss of short-term intermanual transfer learning gains once training ceased. This visualization, also with performance change primarily clustered around the null line and a tendency to skill diminishment, supports the results of the $2 \times 2 \times 2$ mixed ANOVA. While similar to the $2 \times 2 \times 2$ mixed ANOVA conducted to compare baseline and T1, Table 2 on T1 vs T2 yields mostly $F < 1$, except for the interaction between $time \times side \times group$ where $F = 3.95$ with $p = 0.07$. The partial eta squared for this interaction is 0.25, which indicates a large effect.

Table 1. APA styled $2 \times 2 \times 2$ mixed ANOVA (Time \times Side \times Practice) for Baseline vs T1

Effect	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Square (MS)	F-Value (F)	p-Value (p)	Partial Eta Squared (η^2)
Time (Baseline vs T1)	0.0008552701	1	0.0008552701	0.1775771404	0.6809136336	0.0145823047
Side (Left vs Right)	0.0036857701	1	0.0036857701	0.7652652895	0.3988563646	0.0599490314
Group (A vs B)	0.0002371886	1	0.0002371886	0.0492467546	0.8281109492	0.0040871231
Time \times Side	0.0001128616	1	0.0001128616	0.0234331139	0.8808800959	0.0019489537
Time \times Group	0.0000139308	1	0.0000139308	0.0028924106	0.9579945274	0.0002409761
Side \times Group	0.0006152344	1	0.0006152344	0.1277392514	0.7269945942	0.0105328164
Time \times Side \times Group	0.0121783170	1	0.0121783170	2.5285470965	0.1377882112	0.1740399146
Residual / Error	0.0577959587	12	0.0048163299	-	-	-

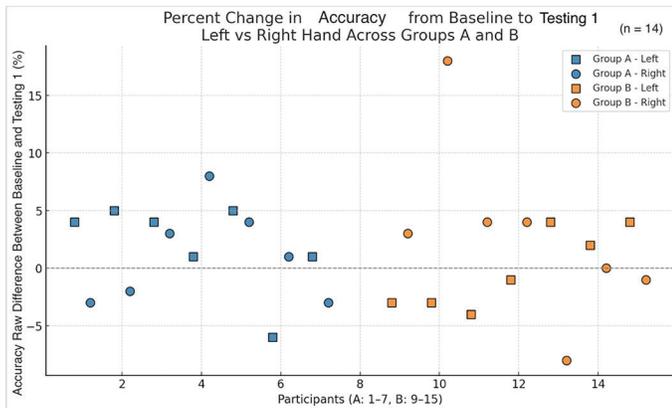


Figure 4. Percent Change in Performance from Baseline to T1 L vs R Across Groups A and B. This scatterplot illustrates the raw difference of accuracy performance change in the motor tests of baseline and T1, where the x-axis numerates the number of participants with squares depicting L performance and circles R performances for each participant. This makes up for seven subjects per group represented by the color blue for group A and orange for group B. The y-axis is labeled with the average percent change of T1 scores compared to their respective baseline scores, where negative values indicate a decrease of performance and positive values an increase in performance. A general trend of increased performance was found when comparing T1 scores to baseline scores.

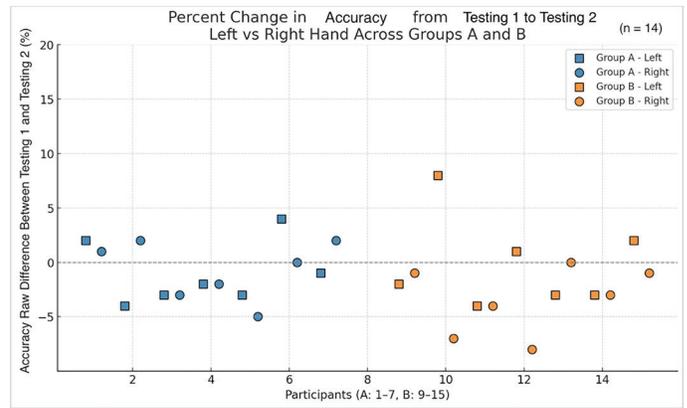


Figure 5. Percent Change in Performance from T1 to T2 L vs R Across Groups A and B. This scatterplot illustrates the raw difference of accuracy performance change in the motor tests of T2 and T1, where the x-axis numerates the number of participants with squares depicting L performance and circles R performances for each participant. This makes up for seven subjects per group represented by the color blue for group A and orange for group B. The y-axis is labeled with the average percent change of T2 scores compared to their respective T1 scores, where negative values indicate a decrease of performance and positive values an increase in performance. A general trend of decreased performance was found when comparing T2 scores to T1 scores.

Table 2. APA styled 2×2×2 mixed ANOVA (Time × Side × Practice) for T1 vs T2

Effect	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Square (MS)	F-Value (F)	p-Value (p)	Partial Eta Squared (η^2)
Time (T1 vs T2)	0.0010443214	1	0.0010443214	0.3386739969	0.5713671466	0.0274481680
Side (Left vs Right)	0.0026035714	1	0.0026035714	0.8443396044	0.3762591976	0.0657363189
Group (A vs B)	0.0006045714	1	0.0006045714	0.1960628371	0.6657940433	0.0160759123
Time × Side	0.0005915000	1	0.0005915000	0.1918237658	0.6691829096	0.0157338040
Time × Group	0.0000857500	1	0.0000857500	0.0278087708	0.8703361780	0.0023120397
Side × Group	0.0005315714	1	0.0005315714	0.1723888981	0.6853246864	0.0141622897
Time × Side × Group	0.0121848571	1	0.0121848571	3.9515556774	0.0701327402	0.2477222760
Residual/Error	0.0370027143	12	0.0030835595	-	-	-

DISCUSSION

Limitations and Considerations

Time and Scope

Originating from a limitation in experiment length and available subjects, the study showed no significant

change in data after practice, which indicates the need for a broader number of research participants with more trials to avoid noisy datasets and fluctuations that might alter the analysis of the observations altogether. This insight aligns with previously conducted research on guidelines to motor learning study designs. The researchers examined what factors are crucial to achieve

solid results in motor learning experiment designs together with common pitfalls. One major aspect, which is addressed is the size of groups. Experiments with groups consisting of 10 to 16 people are already considered as small and thus tend to yield insignificant results.¹⁰ The mixed ANOVAs executed in the present data analysis is also underpowered with $n = 14$. This small size in the number of participants is subject to greater data inconsistency and, due to this reason, leads to lack of statistical significance. Similarly, another study has discovered that statistical power of ANOVAs increases with the sample sizes. Type I error rates with $n < 10$ were significantly higher than $n > 10$.¹¹ In order to make possible learning effects even more apparent and to obtain robust analysis values, a longer practice phase for the research participants has to be implemented. The increased quantity of the acquired data diminishes the impact of extremities and allows a bigger performance change, which in turn facilitates the analysis and interpretation.

Motor Test Sensitivity

“Draw a perfect circle” on Neal.fun ultimately remains a game due to its simplicity in calculating an accuracy score by relying on the initial radius from the starting point to the center. While it does provide comparable statistics when the factors during the test remain strictly the same, such as using the finger directly or having similar hand-eye coordination to draw around the given center point, its constraints to compute a score with consideration to individually set center- and starting points, make the examination of possible visuo-motor skill involvement difficult. In a study, which concerns mirror visual feedback on learning effects in sports, the results suggest that the mirror neuron system (MNS) could be one of the systems underlying transfer learning in motor skills (12). With visuo-motor skills fundamentally linked to the MNS (13), it is thus of great importance to integrate this factor into the research experiment aiming to determine non-specific training impact on contralateral learning effects. Thus, the specific fine motor skill test of drawing a circle may need to be improved in its sensitivity and accuracy when gathering its scores, for example by programming an adapted study-designed version of the Neal.fun game, which can calculate drawing accuracy without a previously determined center point, allowing a more complex calculation of its accuracy scores.

Other Potentially Impacting Factors

With restrictions in general time consumption and a lack of an objectively accurate timing method of the drawing trials, speed-accuracy tradeoffs were not considered in the present study. The time-factor may have deviated between different subjects and consequently lead to a noteworthy discrepancy in speed-accuracy tradeoff (14), meaning participants who tried to finish the motor task as fast as possible are only difficult to compare to individuals who took full advantage of the time given to draw a circle. In future work it will be important not just to measure how accurate the drawing performance was but also how quickly participants completed it. For example, it is possible that non-dominant hand accuracy was high in this study because subjects unconsciously drew more slowly and carefully. The present experimental design would not have captured this, which is why future research experiments should include the timing of drawing attempts in order to respect the potential impact of speed-accuracy tradeoffs for each trial. Additionally, the chance that teenagers between the age of 17 to 20 may have already reached the asymptote in drawing circles is a facility (15), which prior to the execution of the experiment, has not been preconceived. To solve this, the study could be adjusted accordingly and repeated with a younger subject group.

Does General Practice Improve Fine Motor Skill Performance in the Short Term?

The observations made in accordance with the comparisons of performance between baseline and T1 suggests the absence of clear learning effects over the short term through non-specific training. This indication may be seen when the R performance at T1 shows an average of 1.39% increase in accuracy compared to baseline performance. However, subject accuracy clusters around the unity line, which together with the p-value of 0.32, suggest little to no significant difference. Likewise, L performance increase between baseline and T1 of 0.82% with a p-value of 0.35 yields no significant learning effect. On the other hand, both $t_{\text{baselineRvsT1R}} = 1.0334$ and $t_{\text{baselineLvsT1L}} = 0.958$ and $d_{\text{baselineRvsT1R}} = 0.2762$ and $d_{\text{baselineLvsT1L}} = 0.2560$ propose the possibility of correlations between general practice and fine motor skill increase in the long term. To further study this and to confirm, a larger sample size is needed with longer practice phases in order to show learning effects more clearly.

Does Non-Dominant-Hand Practice differentially affect L vs. R?

The accuracy score of the raw difference between baseline and T1 increased for group A R by 1%, L by 2% and for Group B R 3%, L 0%. What is noticeable about the data obtained of the participants before and after training are t-values and Cohen's ds as well. Within-group paired t-tests revealed t-values ranging from -0.0027 to 2.0232, which stand for weak to moderate differences between the two testing phases. Combined with Cohen's d ranging from -0.0007 to 0.5407 indicating negligible to medium effects, it is possible to assume that the possibility of different training effects exists between groups after practice. Additionally, the 2×2×2 mixed ANOVA analyzed the data in Figure 3 for practice effects depending on side, group, and time for accuracy scores obtained at baseline and T1. For $n = 14$, F-value from 0.0029 to 2.5285, $p > 0.05$, and partial eta squared between 0.0002 and 0.174, all effects yielded no statistical significance. The clearly visible difference of the values associated with time×side×group, however, might suggest a connectivity relationship involving time, side, and practice. Thus, the values could suggest the chance of correlation between L- and R performance before and after practice with whether or not participants have conducted non-specific L practice during training phases.

Do General Training Effects persist and/or transfer?

When looking at the average raw decrease of -1% in accuracy between T1 and T2 for group A, whose participants have ceased to practice with their L for the last seven days, notice that group B also shows a decrease of R performance by -3% and consistent accuracy in their L. This might originate from a possible misreport of training time during the training phase of group B, but the trend for group A remains a decrease of performance after quitting the short-term training. Like before, both t-values and Cohen's ds mostly suggest negligible to medium effect with one exception being group B R T2 vs T1. Its values propose a large effect with $d = -1.0568$, $t = -3.9540$, and $p = 0.03$ ($p < 0.05$). Like the ANOVA used to compare T1 to baseline — the 2×2×2 mixed ANOVA, which analyzed practice effects depending on side, group, and time for accuracy scores obtained at T1 and T2 — yielded no statistical significance. What strikes as conspicuous is once again the deviating values from the interaction time×side×group. Unlike

other effects, this interaction provides $F = 3.9516$, $\eta p^2 = 0.2477$, and the lowest p with $p = 0.07$ ($p > 0.05$). Though statistical insignificance, the visible difference of the values associated with time×side×group could indicate a connectivity relationship involving time, side, and practice as well.

CONCLUSION

This study addressed two research questions: What are the human dynamics of intermanual transfer learning? and Does practicing general everyday life tasks enhance intermanual transfer learning effects for unrelated fine motor skills in the dominant and non-dominant hand?

No statistically significant short-term enhancement of intermanual transfer learning for unrelated fine motor skills in either the dominant or non-dominant hand was observed during the experiment. However, the interaction term time × side × group consistently exhibited larger effect sizes and the smallest p-values among all factors included in the ANOVA models, suggesting a potentially meaningful relationship between these variables.

Although the study lacked sufficient statistical power to confirm these observed trends, the potential influence of general practice on transfer learning efficiency remains an important question for further investigation. The present study serves as a behavioral framework for future research, demonstrating that this research question can be explored within a high school experimental setting. With refinement of the experimental design, future studies may be better positioned to investigate this emerging niche within intermanual transfer learning research.

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CONFLICT OF INTEREST

The author declares that there are no conflicts of interest regarding the publication of this article.

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