

Some Instructional Parameters Related to Children's Copying Performance

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Copying is a common technique for training perceptuo-motor skills such as handwriting. An experiment is described in which stimuli to be copied were presented dynamically or statically close to or distant from children seven and ten years old. The implications of the results for teaching handwriting are discussed.

Theory and Problems

Various researchers have stated that psycho-motor skills, including handwriting, can be explained by a cybernetic theory (Coleman, 1969; Smith & Smith, 1966; Søvik, 1974, 1975). The theory considers learning and performance of such skills to be a direct function of human factors of the performer related to learning situation, instruction, tools, and social interactions. Information on developmental trends of children's dynamic control of perceptual environment is therefore of significance for research into the learning and instruction problems in copying, drawing, and writing skills. Thus great attention is paid to the development of perceptual orientation through infancy and childhood. Controlled comparisons between dynamic and relatively static conditions of social interaction have indicated a progressive development of the social orientation of children between one and three years of age. The level of orientation was significantly greater for the dynamic than for the static images (Smith, 1972). Moreover, several studies on maturation of social tracking accuracy and psycho-motor abilities in general have disclosed a rapid and progressive increase in accuracy of such function between three and nine years, and some further increase between nine and fifteen years (Heinonen, 1957; Søvik, 1975). Although the studies described can be viewed as part of a more comprehensive social-educational program to test the validity of the cybernetic principles, it is important to note that the first stages of copying, drawing, and writing are much based on *dynamic imitation*.

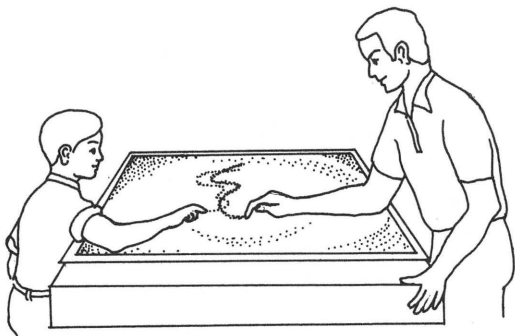


Figure 1. Dynamic, persisting, imitative tracking. Note: Figures 1-4 have been reproduced from Smith (1974) with kind permission of the author.

Cybernetic theory — stressing social tracking/dynamic imitation in connection with children's learning and performance of psycho-motor skills — also considers feedback to be important in development of skills. It should be noted that the information a child receives from his teacher's instruction during and after a copying task at school can improve the effects of the related feedback systems. Developmental trends of skills, including copying and writing, have been found by Fleishman (1969), Heinonen (1957), and Søvnik (1975). But the interaction which may occur between the sensory feedback mechanisms operating in the copying activities related to the age-variable and the specific parameters associated with instruction of this skill is still an open question. Exploratory studies of the interaction are therefore motivated by the implications for instruction of handwriting. This aspect of the present work I will identify as Problem 1; further specifications are dependent on the main factors raised in Problems 2-4.

As the present study was concerned with the effect of different instructional conditions, further information on social tracking in copying activities and related feedback control are needed before formulating the hypotheses under investigation. Recent studies of the various modes of feedback control of social graphic behavior have disclosed many possible types of dynamic imitation in reproduction of letters and in tracing and copying these forms (Romanova & Feigenberg, 1975; Søvnik, 1975, 1976). Some of these principles of social interaction and communication in learning graphic skills are indicated in Figures 1 through 4.

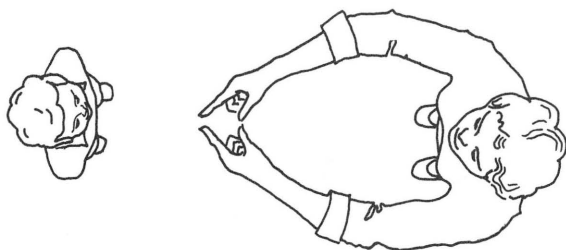


Figure 2. Perceptual, dynamic tracking.

In addition to the principles of dynamic tracking described above, these patterns of behavior include the following:

- 1 Dynamic displaced imitation
- 2 Dynamic delayed imitation
- 3 Dynamic persisting tracking
- 4 Static tracing
- 5 Copying static models
- 6 Delayed or non-persisting static copying

These forms of copying or tracing involve guidance of movements based on *visual tracking*, which is used as the basis of projecting and guiding manual movements in drawing or writing. Also, it has been confirmed that sensory feedback has a more positive effect on the child's copying performances when he can compare his own copying product with the model display (Hertzberg, 1926; Søvik, 1975). At school, however, the principle of copying from static models is followed as often as copying from dynamic ones when children are practicing handwriting exercises. Previous research in this area is very limited, and no guidelines are available for handwriting instructors whether dynamic presentation of the models (numbers, letters, or sentences) should be preferred to static models or vice versa. We thus would like to know how children's use of feedback develops with age and if dynamic structuring of tasks helps because this is supposed to provide extra feedback (Problem 2). A presentation of dynamic models seems to be more closely related to the verbal and motor demonstrations given by the instructor in teaching elementary handwriting, therefore we may hypothesise:



Figure 3. Displaced, reactive, persisting, social tracking.

Assuming learning-instruction conditions to be equal, where the instruction is based on both motor and verbal explanations of the copying tasks, a presentation of dynamic designs in general will give higher accuracy-scores in copying performances of seven- and ten-years-old subjects compared with a presentation of static designs. (H1)

Little research has been carried out for studying the effects of presenting copying models at different distances and angles to children in a classroom with regard to their graphic performance. The findings of a previous study showed that the accuracy-scores of copying/writing performances deteriorate if normal feedback control is changed spatially for copying from normal table control to TV-monitor control, and even more if the feedback control is reversed or inverted spatially in the TV-monitor (Søvik, 1974). However, the displacement problem in handwriting instruction has not been solved, and further research is needed. To simplify the problem it was decided to concentrate on the distance phenomenon only in this study (Problem 3). Since children usually are supposed to copy models from books placed at their desks rather than models presented on blackboard, it was reasonable to expect the highest accuracy-scores from children's copying performances when models were presented in accordance with the close working situation. A second hypothesis may therefore be stated:



Figure 4. Perceptual, dynamic, persisting, social tracking.

Assuming learning-instruction conditions to be equal, with the instruction based on motor and verbal explanations of the copying tasks, a close presentation of the copy designs (2 feet) in general will give higher accuracy-scores in copying performances of seven- and ten-year-old subjects compared with a distant presentation (12 feet) of the same designs. (H2)

An interesting question attached to Problems 2 and 3 is whether the expected effects of the dynamic/static variable and the distance variable would be additive or not. Although these trends were likely to appear while testing H1 and H2, the theoretical background for formulating a hypothesis with regard to this interaction effect seemed to be weak, and only preliminary explorations could be done (Problem 4).

Method

Design

An experiment organized as a three-way (2x2x2) factorial design was conducted. The three independent variables were: chronological age (two levels, CA 7 and 10), dynamic vs. static presentations of copying models (two experimental treatments), and different distances of presenting the copying models (two experimental treatments, i.e., close and distant). The dependent variables were the accuracy of copying and the time taken to complete the tasks.

To follow a more thorough procedure in testing the effects of the two experimental variables, the study was later split into two separate studies (designs) each of which corresponded to the two age-groups under examination. These studies were organized as two-way (2x2) factorial designs with two covariates: Scores of subjects (Ss) on Bender Gestalt Test (visuo-motor integration) and teacher-ratings of Ss with regard to attention/concentration on school work, whereas the two experimental variables and the dependent measures remained the same. Product-moment (PM) inter-correlations were calculated between measures of mental age (MA), visuo-motor integration (BGT), ability to concentrate on school work, quality of handwriting, and the two dependent variables in order to have different measures of Ss' capacities for selecting some adequate covariates.

Ss were sampled according to the principle of equal cell frequencies. The 32 Ss were randomly chosen from the population of children in the Trondheim (Norway) public schools and stratified on chronological age. The Ss were randomly assigned to each of the cells in the design.

Tests and Assessments of Ss

Before the experiments started, each S was tested by Sandven's Modenhetsprøve (maturity test) (Series I & II) which is a group test of intelligence, standardized for Norwegian children aged six to eleven years, and by the Bender Gestalt Test (Koppitz's version and norms). BGT is supposed to measure children's ability of visuo-motor integration. Data concerning reliability and validity of the two tests are considered satisfactory (Sandven, 1962; Koppitz, 1968). In addition, the teachers were asked to rank each S on a scale from 1 (low) to 5 (high) with respect to quality of handwriting and ability to concentrate on ordinary school tasks.

Equipment

Each S was tested individually on a 18 x 20 foot section of an audiovisual laboratory (Figure 5). A special writing desk was constructed of a metal frame 2 x 2 feet in which plate glass ½-inch thick was placed. The writing surface was tilted 30° from the horizontal, and a white sheet of paper for data collection was taped on the lower part (#7 in Figure 5). The upper half functioned as a window through which the copying models were presented when S was given the experimental treatment of close display of the

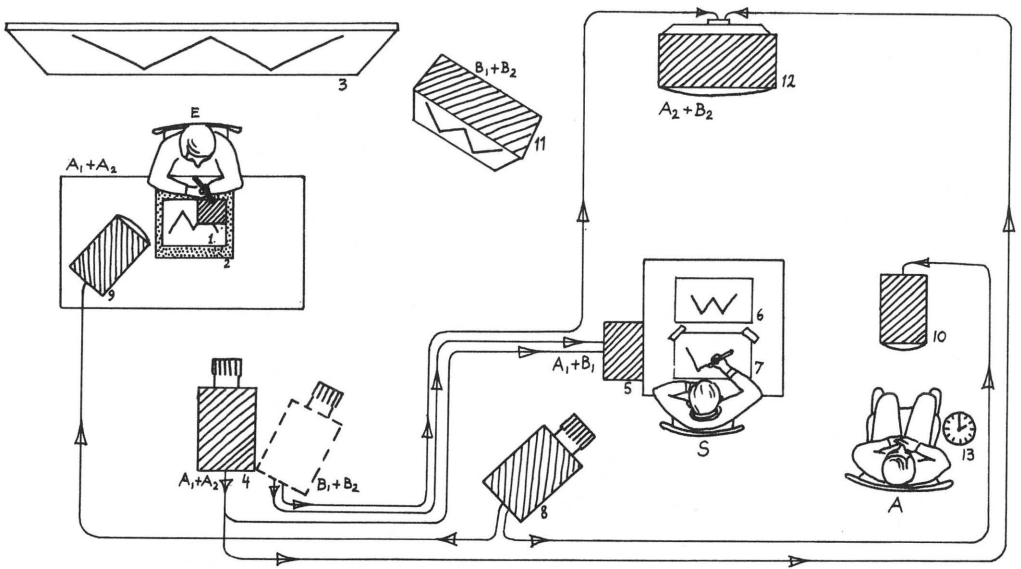


Figure 5. The experimental design and instrumentation.

models (#6). A Penol 200 felt-tip pen was used by S. Figure 5 shows that the experimenter (E) sat at an ordinary writing desk 12 feet to the left of S. On E's desk a 3M 088 over-head light projector was placed (#2). E also used a Penol 97 felt-tip pen when demonstrating dynamic copying models to S. Moreover, on E's desk there was a 12-inch TV-monitor (#9) so that S's copying behavior could be watched by E. Similar equipment (#10) was available at an assistant's desk (A), such that A could also monitor S's copying. The camera (a Philips plumbecum LDH 150) was located to the left of S and close to his desk (#8).

Behind E a white screen (5 x 5 feet) was placed (#3) for the projection of the writing signals produced by E. Another Philips plumbecum LDH 150 camera, placed in front of E and the white screen (#4), could transfer the experimental tasks (copying models) via the related cord system to the optic instruments placed on the floor below S's writing desk (#5). These instruments consisted of (a) an 11-inch TV-monitor, (b) a Leitz episcopes combined with (c) a lens-system taken from a Lara over-head light projector. This combined optic system, constructed for this experiment specifically, would then transfer the copying models through the S's tilted glass-table. A stopwatch was used by A to time S's copying performances.

The above equipment was used when Ss were given the experimental treatment of *close display* of the task variables (dynamic persisting imitation). When Ss were supposed to copy from static models under the condition of close display of the task variables, the models were written on white sheets of paper and placed (one at the time) on a tilted box placed to E's left (#11). In this case, the over-head system at E's desk and the big screen behind him were disconnected from the experimental system, and the TV-camera in front of E was turned in the direction of the box with the models. Pictures were then taken by the camera and transferred to the TV-monitor below S's desk.

Finally, a TV-monitor with screen size 20 x 20 inches placed 15 feet in front of S and 4 feet above floor (#12) was used instead of the optic devices below S's desk whenever the experimental treatment of *distant display* of the models was introduced.

Task Variables

In previous research (Beery, 1967; Bender, 1938; Søvik, 1975, 1976) on children's copying ability, both geometric and non-geometric forms were used as task variables or items in the applied tests. Two designs consisting of simple two-dimensional forms were chosen for training in the present study. Although letter-like copying models would be preferable for handwriting instruction at school, the six geometric forms shown in Figure 6 were chosen as task variables in the experiment. The main reason why these forms were preferred to more letter-like materials (e.g., the twelve Gibson figures) was the greater advantage at scoring Ss' copying performances of the designs in Figure 6.

Experimental Treatments

Ss were assigned to one of the specific combinations of experimental treatments. Before taking part Ss were given an oral orientation of the experimental procedure and they received a short period of training; Ss copied the two figures designed for this purpose (Figure 7). The training was organized with exactly the same instrumentation and experimental method as used in Ss' experimental treatment to ensure that the equipment would function in accordance with the experimental conditions and to familiarize Ss with the experimental situation. During training and experimentation Ss were asked to do the copying in a relatively slow and exact way. In other words, they were permitted to spend the time they

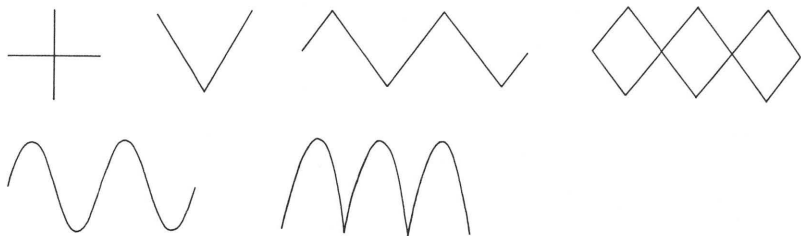


Figure 6. The six designs used as task variables.



Figure 7. The two designs used as training variables.

needed for the execution of the imposed tasks. The experimental treatments were as follows:

1 (A₁) *Dynamic persisting imitation (copying) with close display of task variables.* E presented each of the six copying models (one at a time) by demonstrating the drawing of the figure on the over-head projector placed on his desk. The forms were simultaneously transferred by camera (#4) to the upper half of S's writing desk (#5, 6). E gave detailed oral instructions while he demonstrated the drawing. Ss subjected to this treatment were asked to observe E's hand while he demonstrated the figure and listen carefully to E's verbal explanations how the figure should be correctly drawn (i.e., where each of the separate strokes in the figure started, the direction of the line, and where it ended). Having finished his drawing on the copying model, E asked S to copy it.

2 (A₂) *Dynamic persisting imitation (copying) with distant display of task variables.* This experimental condition was exactly the same as in A₁ except for the presentation of the task variables which now appeared at the big TV-monitor (#12) in front of S. As the copying models under the A₂ treatment were shown at a distance from S six times the corresponding distance given under A₁, the objective sizes of the models at the TV-screen (#12) were enlarged proportionally.

3 (B₁) *Copying from static models with close display of task variables.* This treatment was the same as A₁ with one main alteration: The task variables were presented as static (completed) figures on the box located to the left of E, such that the camera (#4) had to be turned clockwise some 30° to catch the figures. (Before S started his copying work E pointed to the figure and gave his explanation/demonstration).

4 (B₂) *Copying from static models with distant display of task variables.* The fourth experimental treatment corresponded with B₁, but the copying signals were not presented through the upper half of S's writing desk. They appeared at the big TV-screen (#12) (cf. A₂).

In each treatment the copying model remained on the desk/screen as long as Ss were copying. Thus no time limit was set in the experiment. The total time spent on the series of experimental treatments for one S varied from 12 to 18 minutes.

Scoring of data

The main output produced by Ss in the experiment were their copying performances drawn on sheets of writing paper. In addition, time-scores corresponding to the total amount of time spent by Ss in executing each figure were available. The graphic products were rated by two raters trained in advance for the specific task. While scoring Ss copying products the two raters tried to work in accordance with some rules established before the rating procedure commenced. As a general rule three main sources of errors were emphasized: (a) errors caused by deviations from correct proportions of central components of the model, (b) "errors" related to the quality of the copying performance, and (c) frequencies of errors found for each copying product. That is to say, the higher the total error-score was for each of the graphic products (and for the whole series of the six figures) the lower was the accuracy-score of this performance. Inter-correlation data for rating of Ss copying products thus ranged from $r=.27$ to $r=.85$ for the separate figures. The coefficient of correlation between the ratings made by the two raters for total copying accuracy-scores (used for further data analyses) was .67.

Data analyses

Intercorrelation coefficients were first computed among Ss'

Table I. PM-correlations among Ss' abilities and visuo-motor performances for the 16 first-graders.

	MA	BGT	CON.	WRIT.	COPYING	TIME
MA	1.0000	.2402	.8386	.2536	.4940	-.1227
BGT	.2402	1.0000	-.0200	.2137	.5754	-.1603
CON.	.8386	-.0200	1.0000	.5517	.5156	-.0680
WRIT.	.2536	.2137	.5517	1.0000	.5021	.0491
COPYING	.4940	.5754	.5156	.5021	1.0000	-.1654
TIME	-.1227	-.1603	-.0680	.0491	-.1654	1.0000

Correlation coefficients should be at least .35 to be considered significant.

testscores, ranking of some related personality traits, and data from the experiments. Then a three-way fixed effects model ANOVA was used to analyze the accuracy- and time-scores of the experimental data. Finally, the experimental data were re-analyzed as two-way fixed effects model COVAR with two covariates.

Results

Table I presents PM-correlations among six variables: mental age (MA), visuo-motor integration (BGT), ability to concentrate on school work (CON.), quality of handwriting (WRIT.), accuracy-score in experiment (COPYING), and time-scores of copying performances in experiment (TIME) for the 16 first-graders who constituted one half of Ss in the present experiment. The BGT scores and accuracy-scores in copying in Tables I and II have been converted from original scores on the test, i.e., the higher the BGT-scores the better the individual performances (0-point was set for the lowest BGT-score).

Data in Table I show significant correlations between mental age and ability to concentrate on school work, and also between mental age and accuracy-scores in copying. Furthermore, visuo-motor integration correlates even stronger with copying ($r=.58$) than does mental age ($r=.49$). The significant correlation found between ability to concentrate on school work and handwriting performances ($r=.55$) is, of course, of great interest. The CON.-ability also correlates significantly with COPYING ($r=.52$). The relatively

Table II. PM-correlations among Ss' abilities and visuo-motor performances for the 16 fourth-graders.

	MA	BGT	CON.	WRIT.	COPYING	TIME
MA	1.0000	.7185	-.1499	.1332	.2653	-.0707
BGT	.7185	1.0000	-.0163	.4639	.2670	.4360
CON.	-.1499	-.0163	1.0000	-.0490	.4742	.1112
WRIT.	.1332	.4639	-.0490	1.0000	.4185	.8333
COPYING	.2653	.2670	.4742	.4185	1.0000	.2397
TIME	-.0707	.4360	.1112	.8333	.2397	1.0000

Correlation coefficients should be at least .35 to be considered significant.

close relationship which could be expected from previous research between accuracy-scores of copying and handwriting performances ($r=.50$) has again been confirmed by these data. Finally, it is worth noticing that the time-scores of copying performances in the laboratory correlates close to zero with each of the other variables.

The corresponding correlation data in Table II represent the 16 fourth-graders who belonged to the other half of Ss in the experiment. It can be seen that the correlation between mental age and visuo-motor integration is considerable ($r=.72$), whereas the corresponding data for MA and copying is non-significant ($r=.26$). BGT-scores correlate significantly with handwriting performances ($r=.46$), but not so with COPYING ($r=.27$). As far as CON. is concerned, this ability correlates substantially with COPYING also at this age level ($r=.47$). Similarly, a significant correlation finding shows up between handwriting and COPYING again ($r=.42$). Moreover, it is noteworthy that the PM-correlation coefficient between quality of handwriting and time-scores during experimentation was as high as $r=.83$. A general difference between data in Tables I and II can be observed with regard to the time variable which correlates from $r=.27$ to $r=.83$ in Table II, whereas all the corresponding correlations in Table I were close to zero. The correlation findings in Tables I and II are in line with previous research (Koppitz, 1968; Søvik, 1975).

Methodological assumptions for use of analysis of covariance could hardly permit more than two covariates for the experimental

design and sample under investigation. As variables chosen for covariates ought to correlate substantially with the main dependent measure and simultaneously be relatively independent of one another, BGT and CON. seemed to satisfy these requirements. On account of data in Tables I and II these two variables were therefore chosen as covariates in further covariance analyses of data. Three-way ANOVA on accuracy in copying (with age, figure-type, and distance as factors) was performed. Reliable main effects of age ($F [1,24] = 3.81, p=.06$) and distance ($F [1,24] = 3.17, p=.08$) were found. No other significant effects were found. ($p < .10$ is considered significant. Complete ANOVA-tables can be obtained from the author on request.) Multiple classification analysis of the data showed that the significant difference between the two age-groups under study favored the older Ss, whereas the significant difference between close and distant display of models went in favor of the younger Ss. The beta-values of the three independent variables (age, figure-type and distance) were .61, .10, and .56. R^2 equalled .20. The results seemed to make further data analyses a necessity. (cf. the COVAR).

A three-way analysis of variance of the second dependent measure, time-scores in relation to Ss' copying performance, was also done. No significant findings were disclosed, except for the two-way interaction effects between figure-type and distance ($F [1,24] = 3.21, p=.08$). In consequence, no multiple classification analysis of the main effects with respect to Ss' time-scores seemed to be necessary. However, it is noteworthy that no significant findings regarding differences between treatments were revealed as far as time spent on copying the models was concerned.

To throw more light on data presented above analyses of covariance were carried out for each of the two age-groups separately. A regression approach has been used during each COVAR, i.e., all effects — including main effects, covariate effects, and any interaction effects — were assessed simultaneously as in multiple regression. (Also, each effect is the additional contribution to the explained variation after adjusting for all other effects).

As to data from the analysis of covariance for first-graders with accuracy-scores of copying as dependent measure, reliable findings were disclosed for both covariates used in the analysis, i.e. ($F [1,10] = 6.53, p=.03$) for visuo-motor integration (BGT), and ($F [1,10] = 12.34, p=0.1$) for ability to concentrate on school work (CON.). The strong relationships between the two covariates and

accuracy in copying appeared likewise in the two beta-coefficients of -5.93 (BGT) and -14.21 (CON.). Further, a significant difference was found between close and distant display of copying models ($F [1,10] = 5.46, p=.04$), close presentation being the most effective. No other significant effects were found. R^2 for this analysis of covariance equalled .63 which means that variance of accuracy in copying seems to be explained mainly by the two covariate-measures introduced in the specific data analysis for seven-years-old Ss.

Data from the analysis of covariance of the second dependent variable, copying-time, for the sample of first-graders, gave a significant effect of figure-type ($F [1,10] = 4.87, p=.05$). According to data, most time was spent on copying static figures. Furthermore, significant interaction effects between figure-type and distance were disclosed ($F [1,10] = 6.09, p=.03$). The finding indicates that the treatment effects have had different effects for the level of the experimental variables with regard to time. R^2 equalled .32 for these statistical analyses of the time-variable.

Besides data presented from analyses of covariance at the first-grade level, findings from corresponding analyses at the fourth-grade level also became useful information on our explorations related to the problems. As far as data from the analyses of covariance effect was found for ability to concentrate on school work (CON.) ($F [1,10] = 4.79, p=.05$), the regression approach used in this analysis of covariance gave the following beta-coefficients: -2.31 (BGT) and -9.07 (CON.). No other significant results were found in this analysis. However, information presented by the multiple classification analysis seemed to favor dynamic vs. static and close vs. distant display of copying models. The difference between figure-types was considerable when dependent measure was adjusted for independents and covariates. R^2 equalled .43 which was much lower compared to R^2 for the first-graders (.63).

Concerning the analysis of time spent in copying task variables neither the covariates nor the main and interaction effects gave significant findings. The information is of interest when results presented above are to be interpreted.

Discussion and Conclusions

Previous research has found a close relationship between perceptuo-motor abilities and sensory feedback systems function-

ing spatially and temporarily during the execution of a psychomotor skill. Consequently, improved copying and writing performances have been disclosed between ages seven and sixteen (Harris & Rarick, 1959; Søvik, 1975). According to the cybernetic theory, the feedback mechanisms thus play an important role in learning and performance of all kinds of psychomotor behavior, and as a consequence they affect the dynamic social tracking and children's copying performance. The present work is a study in a series of experiments designed to investigate how instructional circumstances may affect the feedback phenomena related to children's copying performance. The study was designed to investigate the effect of varying the graphic model on copying performance combined with an assessment of age effects.

In general, significant correlations were found between accuracy-scores in copying and other variables under study, whereas no significant relationships seemed to exist between time-scores and the same variables. The findings were in line with earlier studies (cf. Koppitz, 1968; Townsend, 1951), and made a control of the ability and time variables related to children's copying performances a necessity for data-analyses of the experiment.

Without changes in writing speed, data from the study indicated that older children (ten years) were more accurate in their copying performances than younger children (seven years). Furthermore, the age factor interacted with neither the proximity of the copying model nor the dynamic/static characteristics of the experimental tasks. The findings might be expected as they are in accordance with the developmental trends of the perceptuo-motor abilities and psycho-motor skills reviewed above. The explorations done so far in response to Problem 1 seem clear with respect to the age and instruction variables under investigation.

According to Problem 2 and H1, presentation of dynamic designs was expected to surpass static ones regarding Ss' copying performances. This trend was detected both at first and fourth grade-levels, but the findings were not statistically reliable. However, the comparable analyses of time-scores confirmed the fact that Ss, first-graders in particular, spent more time on completing copying tasks from static models, although the accuracy of these reproductions was lower than for dynamic models. A reasonable interpretation might be that feedback mechanisms operate more effectively when younger school children copy from dynamic display, or to be more specific: children seem to assimilate information given by dynamic copying models in a better way than infor-

mation associated with static models. On account of the available data, however, no final conclusion can be drawn with regard to H1, except for the fact that further work on Problem 2 seems to be necessary.

As to Problem 3, it was hypothesized that copying under close model display would give higher accuracy-scores than under distant condition (H2). Without changes in writing speed, close graphic models gave better copying performances in the present study, and the hypothesis could be accepted. However, the verification of H2 does not mean that Problem 3 has been completely solved. Two fixed treatments were the only ones tested in the experiment, and both represented different forms of displacement. Future work, therefore, should consider (a) effect of using modes of presentation other than TV; (b) distances other than two and twelve feet. Also, children of ages other than seven and ten years (especially children from age-levels below seven) should be used as subjects for further testing of the cybernetic theory in this field. Dynamic tracking may help the very young where there are no established motor sequencing strategies to decide where copying should start. This point of view may also be applicable to school children having severe learning problems because of dysfunctions in visuo-motor integration.

Only one significant interaction was disclosed in the present study: interaction between figure-type and distance variables when time-scores were taken into consideration (cf. Problem 4). In ordinary copying/writing instruction at school, children's accuracy-scores are supposed to be of greater interest to teachers than the time-scores. Although final conclusiveness and advice for copying/writing instruction concerning model display have to be postponed, *the findings of the experiment seem to support teaching that emphasizes relative close, dynamic presentations of the copying models*. In teaching handwriting, however, effects of ability to concentrate on schoolwork and visuo-motor integration with regard to copying should be noted. This effect suggest the need for individualized instruction which means further investigations of interactions of human factors related to tools, books, audio-visual aids, learning materials, and other instruction parameters. As the principles of *tracing* and *tracking* are emphasized in the cybernetic theory as well as in copying/writing instruction at school, the next studies in our attempts at finding a scientific foundation of efficient handwriting instruction are planned to throw more light on these phenomena.

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