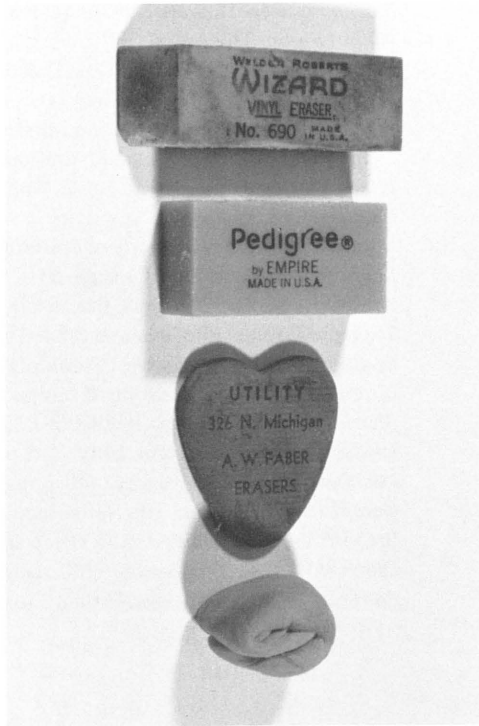


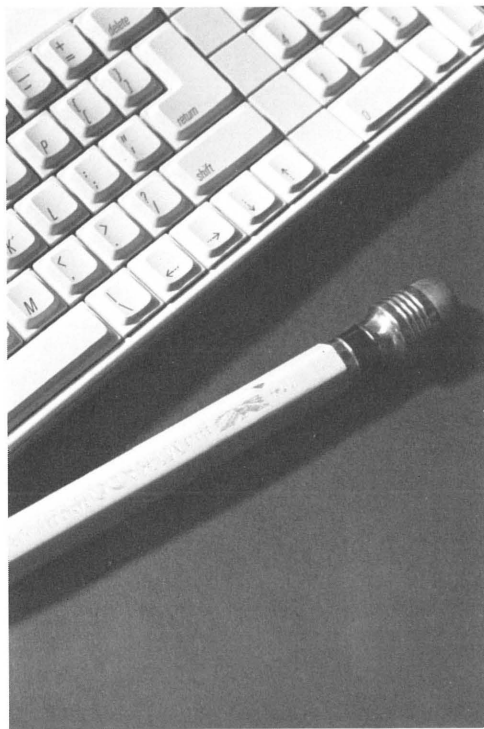
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Psychology, Writing and Computers: A Review of Research

James Hartley

My aim in this paper is to provide a brief review of some of the main issues covered in research on writing and to indicate where this research may be found. For convenience of presentation the paper is divided into four overlapping sections: 1) the nature of writing; 2) learning to write; 3) computers and writing; and 4) evaluating written products.

A fifth topic, the uses of writing, is covered in more detail by Freedman et al (1987), and readers who are particularly interested in social aspects of writing, and how cultures and activities are shaped by, and have been shaped by writing, are especially referred to this paper. Other review papers on more specific topics have been provided by Applebee, 1984; Chandler, 1991; Cochran-Smith, 1991; Durst and Newell, 1989; Fitzgerald, 1987; Freedman et al, 1987; Hayes and Flower, 1986; Humes, 1983; and Huot, 1990. There are, in addition, many books and book chapters on writing, and several of these will be referred to in this review.

The Nature of Writing

- *Process-approaches to writing*

Developments in cognitive psychology, hand-in-hand with developments in computer technology, have had a profound effect on research on writing. The research carried out today addresses different issues and different questions from those asked some twenty years ago. Nonetheless, this does not mean that the earlier research is irrelevant: there is a past literature which it is fruitful to explore in considering where we are now, and where we are going next.

If one compares early educational psychology textbooks with those of the present day, it is also clear that there has been a shift of emphasis in educational practice as far as writing is concerned. In the 1920s the emphasis was on handwriting skills, in the 1950s it was on the grammatical quality of the written products, and today, in the 1990s, it

is on the process of writing—how writers arrive at their end products.

Indeed, it is now commonplace to talk of ‘process-approaches’ to teaching writing. Thus, instead of analyzing classic examples of good practice, and learning the rules that govern it, process-approaches allow learners to explore subcomponents of the writing process in a variety of different contexts. Popular teaching techniques today include those of pre-writing, outlining, group writing, writing for different audiences, and writing without assessment.

Bizzell (1986) describes how research on the process-approach to teaching writing began in the United States with the work of Emig (1971) and in Britain with the work of Britton et al (1975). Emig noted at the time, “of the 504 studies written before 1963 that are cited in the bibliography of *Research on Written Composition* only two deal even indirectly with the process of writing among adolescents.” So her work marked a significant change of emphasis.

Britton et al and Emig worked independently, but they were aware of each other’s work. One of the key ideas that they shared was that the processes used to produce text depended upon the nature of that text. Britton et al distinguished between three main text genres along a continuum: poetic (written for oneself), expressive (written for an intimate friend) and transactional/expository (written for a less personal audience, such as the teacher). Emig described two main kinds of writing—‘reflexive’ (paralleling Britton’s expressive) and ‘extensive’ (paralleling Britton’s transactional).

In carrying out their research Britton et al examined about two thousand essays written by British schoolchildren between eleven and eighteen years of age, and Emig interviewed eight nineteen-year-olds about their writing and provided a detailed case-history, including think-aloud protocols, of the writing processes of one of them. Britton et al and Emig found that their participants generally spent far more time on transactional writing than on expressive writing, but Emig found that her American students much preferred, and spent more time (at home) on expressive writing.

School (transactional) writing was well learned, but it was a mechanical activity. Bizzell (1986) concludes that these

influential research workers brought to the fore two important themes: 1) the process of writing depends upon the nature of the text; and 2) to study writing one needs to examine writers at work.

Table 1 suggests that there are indeed numerous kinds of writing. Writing has different purposes, audiences and genres. And, as we shall see in the following sections of this review, this is important when it comes to examining the acquisition and evaluation of writing skills.

- *The Hayes and Flower model*

There have been many studies of writing processes following this pioneering work (see Freedman et al for references). However, probably the most influential approaches have been those of Hayes and Flower (e.g. Hayes and Flower, 1980a,b; 1983; 1986) and Bereiter and Scardamalia (e.g. Bereiter and Scardamalia, 1987; Scardamalia and Bereiter, 1983; 1985).

Hayes and Flower used think-aloud protocols to develop their cognitive process model of writing. They described the method as follows:

“In protocol analysis the subject is asked to perform a task and to ‘think aloud’ while performing it. In think-aloud studies of writing the writer is asked not only to think aloud but to read and write aloud as well . . . The data from think-aloud studies are contained in the verbatim transcript of the taperecording (with all the um’s, pauses and expletives), together with the essay and all the notes that the writer had generated along the way. The transcript is called a protocol. These materials are then examined in considerable detail for evidence that may reveal something of the processes by which the writer has created the essays. In general, the data are very rich in such evidence. Subjects typically give many indications of their plans and goals, e.g., ‘I’ll just jot down ideas as they come to me’; about strategies for dealing with the audience, e.g., ‘I’ll write this as if I were one of them,’ or about criteria for evaluation, e.g., ‘We’d better keep this simple.’ The analysis of this data is called protocol analysis.” (Hayes and Flower, 1986.)

Using protocol analysis Hayes and Flower constructed the process model of writing shown in figure 1. It can be seen that there are two major areas that impact on the central ‘box’: the task environment, and the writer’s long-term memory.

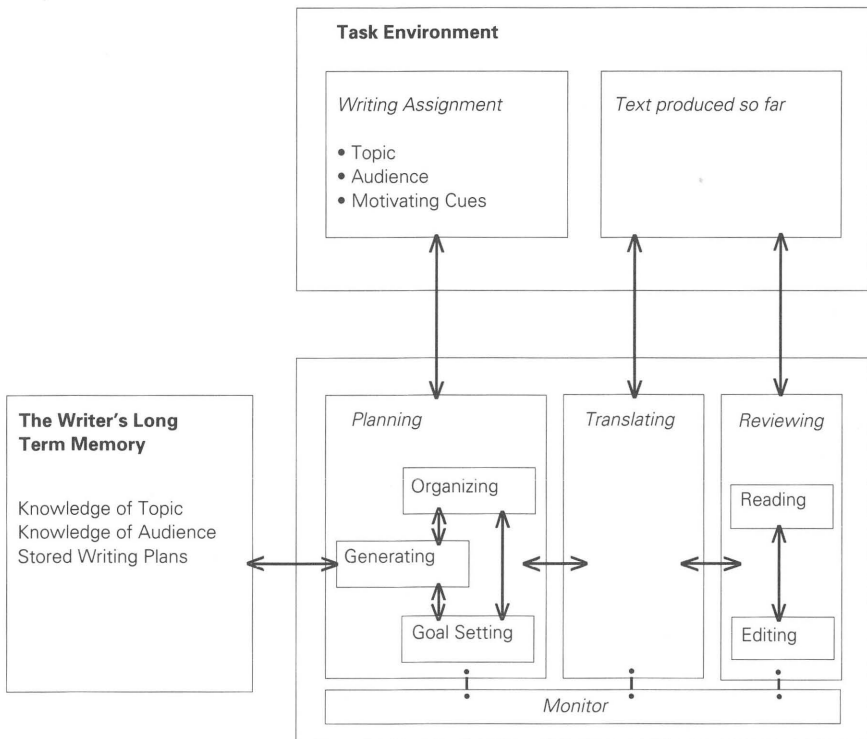
TABLE 1. Aims and examples of different kinds of writing.

| Cognition | | Reproduce | | Organize/Reorganize | | | Invent/Generate | |
|--|--------------------------------------|--------------------------------|----------------|---|---------------------------------------|--|---|--|
| <i>Dominant Intention/Purpose</i> | <i>Primary Content Main Audience</i> | <i>Facts</i> | <i>Ideas</i> | <i>Events</i> | | <i>Things, facts mental states, ideas</i> | <i>Ideas, mental states, alternative worlds</i> | |
| To learn (metalingual) | Self | Copying, taking dictation | | Retell a story (heard or read) | | Note Resumé Summary Outline Paraphrasing | Comments on book margins Metaphors Analogies | |
| To convey feelings (emotive) | Self Other | Stream of consciousness | | Personal story | Personal diary Personal letter | Portrayal | Reflective writing • Personal essays | The traditional literary genres and modes can be placed under one or more of these four purposes |
| To inform (referential) | Others | Quote | Fill in a form | Narrative report News Instruction Telegram Announcement Circular | | Directions Definition Technical description Biography Science report | Expository writing • Definition • Academic essay/article • Book review • Commentary | |
| To convince/persuade (connative) | Others | Citation from authority/expert | | Letter of application | Statement of personal views, opinions | Advertisement Letter of advice | Argumentative/persuasive writing • Editorial • Critical essay/article | |
| To entertain, delight, please (poetic) | Others | Quote poetry and prose | | Given an ending-create a story Create an ending Retell a story | | Word portrait or sketch Causerie | Entertainment writing • Parody • Rhymes | |
| | | Documentative discourse | | Narrative | Constative discourse Explanatory | Descriptive | Interpretive (Expository/Argumentative/Persuasive) | Exploratory discourse Literary |

The task environment includes, in addition to the setting, the writing assignment—the topic and the intended audience—and structural constraints (such as the amount of time available). The task environment also includes the text which the writer has produced so far. This is an important part of the environment because the writer refers to it repeatedly while composing.

The writer's long term memory allows the writer to produce the content based on his/her own knowledge (without constantly having to look things up) and it includes, for the expert writer, a familiarity with spelling, grammar, and writing genres such as those outlined in table 1. The task environment and the writer's long term memory provide the context in which the writing processes operate. Here, the key elements are: planning, translating and reviewing.

FIGURE 1. A schematic representation of Hayes and Flower's model of the writing process.



Planning involves generating content, organising it and setting up goals and procedures for writing. Hayes and Flower (1983) write: "We see Planning as a very broad activity that includes deciding on one's meaning, deciding what part of that meaning to convey to the audience, and choosing rhetorical strategies. In short, it includes the whole range of thinking activities that are required before we can put words on paper. It is important to note that 1) planning goes on throughout composing and 2) the plan may not be encoded in a fully articulated or even in a verbal form. (Plans may be visual images.)"

Translating is the term that Hayes and Flower use to describe the physical act of expressing the content of Planning. Hayes and Flower (1983) write: "Translating is the act of expressing the content of Planning in written English. Although one can reliably distinguish when writers move from Planning (which may produce notes and doodles) to Translating (the attempt to produce prose), this does not mean that writers have a fully formed meaning that they simply express in words. Rather, writers have some more or less developed representation encoded in one form. The act of translating this encoded representation to another form (i.e. written English) can add enormous new constraints and often forces the writer to develop, clarify, and often revise that meaning. For that reason, the act of translating often sends writers back to planning. Often these processes alternate with each other from one minute to the next."

Reviewing involves evaluating either what has been written or what has been planned. Reviewing often (but not invariably) leads to revision. Hayes and Flower draw a distinction between revision (making substantial changes) and editing (polishing).

Finally, writing must be monitored. Hayes and Flower (1983) write: "The Monitor is the executive of the writing process that determines when to switch from one writing process to another, for example, when one has generated enough ideas and is ready to write. The monitor may function differently from writer to writer and from writing task to writing task. Some people move into translation as soon as possible in writing a paper, whereas others will not write a word until they are reasonably certain that planning is complete. Further, a writer undertaking an easy task, for example, a short letter, may do little or no planning before writing the first sentence, whereas the same writer undertaking a difficult task, for example, a

philosophical treatise, may plan for months before writing a word.”

Hayes and Flower (1986) provide more detailed descriptions of the processes of planning, translating, and reviewing together with an account of the research that has stemmed from this approach. Freedman et al summarize their view as follows:

- 1) The writing process is a hierarchically organized, goal-directed, problem-solving process.
- 2) Writing consists of several main processes—planning, transcribing text, reviewing — which do not occur in any fixed order; rather, thought in writing is not linear but jumps from process to process in an organized way which is largely determined by the individual writer's goal.
- 3) Experts and novices solve the problems posed by the task of writing differently.

- *Limitations of the Hayes and Flower model*

Although the Hayes and Flower model has generated much research (which will be discussed below) the model has certain limitations. These seem to be as follows:

- 1) It is not clear how the model was arrived at. There are vague references to studying student writers, but the context in which the model was developed has never been outlined clearly.
- 2) The model is purely descriptive.
- 3) The model says nothing about the effects of the writing medium (pen, typewriter, word processor) on the writing process.
- 4) The model is concerned with a single writer, working in isolation.
- 5) The model ignores (along with the greater part of psychological research on writing) certain other important concerns—such as individual differences in writers' composing styles and their feelings and emotions.

Points four and five are important ones. Writing, we should note, even though it is often a solitary activity, does not take place in a social vacuum. We are usually writing for someone else. Children see writing taking place between their peers, parents, other adults and teachers: they watch and listen to a variety of media, each of which has its accompanying text. Furthermore, there has been an explosion of research on the social nature of writing. There have been studies of writing in pairs and in groups, with and without computers, in industry and in education (e.g. see Barrett, 1989a; Daiute, 1985a; 1988; Duin, 1991; Forman, 1991; Hartman et al, 1991; Irish and

Trigg, 1989; O'Donnell et al, 1987; Rada et al, 1989; Underwood et al, 1990; Webb, 1990). Collaboration between authors and colleagues is becoming increasingly common in academic writing (Faver and Fox, 1982; Over, 1982a), particularly with the development of electronic mail (Murray, 1991; Wilkins, 1991).

Green and Wason (1982) note that most psychological research on expository writing is conducted in a purely cognitive paradigm. However, these two cognitive psychologists maintain that the fundamental problems of writing are emotional, rather than cognitive. One such problem in writing is the so-called 'writer's block'—an inability to get started, or even to write at all. Such a problem is not uncommon: in a questionnaire study of sixty-five academic writers, Hartley and Knapper (1984) found that nearly all of them claimed to have experienced writers' blocks at some time or other. Smith (1982) suggests that blocks occur because writers can be defeated by the magnitude of the task and/or by the fear that the product will fail to measure up to some standard. Smith writes, "This fear has an historical basis. Sitting on the shoulders of many writers is the wraith of a schoolteacher, waiting to jump on every fault of punctuation or spelling, on every infelicity of expression. Writing is so personal and so tangible that we can be questioned on every comma."

Writing with colleagues may resolve some of the difficulties. For the lone writer, Wason's suggested technique of putting down something, even if it is only a set of alternative beginnings to see what each one looks like, might overcome psychological blocks (Wason, 1980). Indeed, the most common form of advice given in this respect by professional writers is to resolve the block by writing—at least something—every day. Some suggest that one should get into the habit of writing something every time that one sits down at a certain place. Others suggest trying to achieve a great deal by rewarding oneself for the achievement of particular goals, however small at first. Blocks, it is argued, can be resolved by lowering one's expectations about what one is likely to produce—initially at least.

Finally, some writers suggest that it is always useful to finish a period of work at a point where it is useful or necessary to rewrite it before carrying on, or to stop in the middle of a section rather than at its end, or even to start by writing the last paragraph that was written the time before. The point of these suggestions is that once writing has started, it is easier to carry on. However, the most

common way of tackling blocks seems to be to leave the material for a while, to do something entirely different, and then to return and try again. Boice (1992, 1983, 1990) has written extensively on these matters, particularly in an academic context, and his 1990 text outlines several procedures that writers can use in order to reduce these problems. Becker (1985) and Wolcott (1990) provide useful, more general, guides.

In addition to research on feelings and emotions there is also research on attitudes to writing, and on personality types associated with differences between individuals on how they tackle the writing task. In a study of eighty-eight highly productive academic psychologists, for instance, Hartley and Branthwaite (1989) found it useful to distinguish (i) between anxious and enthusiastic writers, and also (ii) between those that they termed 'thinkers' and 'doers'. Anxious writers displayed much more self-doubt than did the enthusiastic ones, and they were more likely to experience writers' blocks. The anxious writers produced significantly fewer books and papers than did the enthusiastic ones. 'Doers' were much more mechanical in their ways of working than were 'thinkers.' 'Doers' were more likely to complete one section of a research article at a time, to work in sequence, to spend less time thinking, and to write fewer drafts than did the 'thinkers.' 'Doers' had a significantly higher productivity rate than 'thinkers,' and the enthusiastic doers were the most productive.

Similar distinctions have been drawn between serialists and holists (see Lowenthal and Wason, 1977) and between neat 'Mozartians' and messy 'Beethovians' (Chandler, 1991). Other differences between writers that have been discussed are, regrettably, beyond the scope of this paper. However, the following references may be of interest for readers concerned with discussions of age, personality, and sex differences: Astin and Davis, 1985; Boice and Kelly, 1987; Kyvik, 1990; Jackson and Rushton, 1987; Over, 1982b and 1982c; White, 1984. Chandler (1991) comments that these individual differences undermine any unitary model of the writing process. Unitary models cannot meet the needs of all writers or suit all writing tasks. There is, therefore, a need for more research on how the nature of writing differs for groups of people with different writing styles.

Learning to Write

- *The mechanics of handwriting*

Most children (in the Western world) learn to write at

home and in the preschool, using pencils, felt-tipped pens and biros. Few, if any, children start to learn with electronic keyboards, although Moore (1962) advocated this in the early 1960s. Thus the mechanics of handwriting still occupy a great deal of research attention. Bailey's (1988) review of current research covers topics such as the grasp of the pen, pressure on the writing instrument and surface, and the use, or not, of lines on writing paper, and Blote's (1987) monograph pays particular attention to posture and control. The emphasis on the mechanics of handwriting is particularly strong in the field of the learning disabled, and Maarse et al (1991) report on advances in computer recording in this context. Digitizers with pressure-sensitive pens are being developed that allow for the automatic recording and analysis of handwritten scripts. The development of computer-based systems for teaching handwriting skills (e.g., see Macleod and Proctor, 1979) has not (to my knowledge) yet received serious attention, although there are possibilities in this respect. Commentators are, however, beginning to suggest that children should be taught word-processing skills in the primary or secondary school (e.g., see Chandler, 1991).

- *Pre-writing*

A concern with the mechanics of handwriting, however, is not the only concern of studies of very young children learning to write. Young children recognise and make sense of print from an early age, and they enjoy 'reading' books with adults (Farr, 1985; Mason, 1990). Several researchers have traced the emergence of lettering from children's drawings and scribbles (see e.g., Beard, 1984; Dyson, 1985; Graves 1979; Sarachno, 1990). Bissex (1980), Chomsky (1971) Graves (1979) and Read (1986), among others, have shown how speech and phonetic forms dominate children's early written messages. Hannon and Jones (1990) have described how parents of pre-school and infant children are much involved in teaching their children to read and write, and how parental views often conflict with those of teachers in this respect. Such parental activities are important because measures of children's literacy development at school entry appear to be good predictors of children's subsequent educational development (Wells, 1987; Tizard et al, 1988). Juel (1988) showed that the probability that a poor reader at age six would remain so at age nine was very high, but that early writing skills did not predict later writing skills to the same extent.

- *Developmental changes in writing processes*

Many teachers and researchers have discussed develop-

mental changes in the acquisition of writing processes. (See, e.g. Beard, 1984; Bereiter & Scardamalia, 1987; Daiute, 1985b; Farr, 1985; Martlew, 1983.) Studies in the United Kingdom suggest that primary school children spend about a third of their time on one kind of writing activity or another (although there are wide variations). It appears that much of this writing is of the expressive and narrative kind, rather than expository in nature. Furthermore, most writing is done for the teacher rather than for any other audience. There are also criticisms that junior school pupils spend too much time copying from textbooks and worksheets, and that they learn to regard neatness as the main criterion for success (e.g., see Bennett, et al, 1980; DES, 1978, 1982; Galton et al, 1980).

At the secondary level in the United Kingdom the Assessment and Performance Unit of the Department of Education and Science monitored the writing skills of eleven and fifteen year old pupils between 1979 and 1983. (See White, 1986 for a brief account.) Approximately 2,400 pupils were involved and many different types of writing were tested, including the pupils' abilities to explain, instruct, narrate, report, give an opinion, describe imaginatively, express feelings satirically, and persuade. The results were assessed by a group of experienced teachers working with the research team. The results showed:

- 1) Many pupils found writing difficult—although the majority received marks in the middle of the range. Many fifteen year olds were unable to match the best writing achieved by some of the eleven years olds.
- 2) There was a wide variation in performance according to the nature of the task. There were few tasks which were uniformly hard or easy for each age group, but the hardest task was the use of an appropriate style. For most fifteen year olds, writing a story was easier than making good notes.
- 3) The pupils' own judgment about how to improve their writing were often based on conceptions of neatness and correctness rather than on matters of subject matter, style, or purpose.
- 4) Girls generally performed better than boys. More boys than girls of each age group showed negative attitudes towards writing, and negative attitudes were voiced more strongly by the older pupils (see White, 1987).

Parallel results were found in a similar study of 1,400 fifteen year olds reported by Gubb, Gorman and Price (1987). White (1986) concluded her booklet with a series of recommendations. She suggests that pupils could be helped to

improve their writing skills in the following ways:

- 1) by producing less writing in total;
- 2) by being encouraged to write for a wider range of purposes and for a more varied readership;
- 3) by building on their existing skills as speakers of the language and being made aware of the contrasting demands of speech and writing;
- 4) by constructing for themselves, either as individuals or in groups, a definite purpose for what they write;
- 5) by being given regular constructive and systematic feedback about the quality of their work;
- 6) by being made aware of the place of writing in the process of learning and of the value of notemaking and exploratory drafting; and
- 7) by having opportunities to work collaboratively through stages of composition and revision.

White does not mention computers in her report, but the implementation of some of her recommendation (particularly the last three) could probably be made more effective through computer-aided composition.

- *Expert and novice writers*

Freedman et al, in their account of the acquisition of writing skills, are at pains to point out the complexity of the process. Their review shows that although it is useful to give simple descriptions and prescriptions of the kind listed by White above, there are deeper concerns. Freedman et al point to individual variability in pupils' knowledge of writing processes and particularly to the differences between 'experts' and 'novices.' In the context of learning to write, this interest focuses not so much on the characterizing the differences between them—but more on the processes by which these two different kinds of groups achieve their products.

Freedman et al describe groups of novices which reviewers do not always distinguish among: 1) students at all levels whose skills are developing; 2) basic writers who are behind their peers or age group; and 3) young writers. Freedman et al argue that these different groups have different needs.

Hayes and Flower suggest that good (or expert) writers create 'reader-based' prose, whereas poor (or novice) writers create 'writer-based' prose. Good writers think about how their readers will follow the text, and this helps them to plan their writing better: they use more cohesive ties than poor writers, more links, and more signals to help the reader grasp the structure of the text. Poor writ-

ers, on the other hand, tend not to think so much about their readers while they are writing: they focus less on the meaning and more on the spelling, grammar and punctuation. Good writers have mastered and automated these skills: poor writers have not. Very young writers may follow an orderly procedure as they write, but often they lose their train of thought because they have to attend to more mechanical concerns, such as letter formation, handwriting and spelling.

The amount of knowledge that a writer has about a subject also affects the writer's planning. People who are experts in their subject matter will have greater knowledge about it than the nonexperts. The problem is, of course, that such subject matter experts may have difficulty in conveying this knowledge to others—especially if they are novice writers. Expert writers, according to Hayes and Flower (1986), create more elaborate plans with more interconnecting networks than do novices. Schriver (1986) shows that experts can be taught to predict novice's comprehension problems with text and to adjust their writing accordingly.

A great deal of attention has been paid to differences between good and poor writers in terms of their revision strategies (e.g., see Cochran-Smith, 1991; Fitzgerald, 1987; Kurth, 1987; Hawisher, 1989). Hayes and Flower (1986) summarize findings of the research on revision as follows:

- 1) There are large differences between writers in the amount of revising that they do. Experts revise more than novices. Expert revisors attend to more global problems (e.g., resequencing, restudying, rewriting large units of text) than do novices.
- 2) Experts are better than novices at detecting problems in their text, diagnosing the causes of the problems, and choosing appropriate remedies.
- 3) Writers find it harder to detect problems in their own texts than they do in other people's texts.

One implication of this last point is that better quality writing might be produced if authors collaborate in revising texts. Another, perhaps, is that writers may change their revision strategies if they are assisted by computer technology. Both the reviews of Fitzgerald (1987) and Hawisher (1989) are not, however, optimistic in this respect. Despite numerous studies, it is not yet obvious whether using a word processor affects either the amount or the quality of the revisions. Cochran-Smith (1991) provides a useful discussion of the complexity of the issue.

- *Teaching writers to become more expert*

At this point in the discussion we should draw particular attention to the work of Bereiter and Scardamalia. (See, for example, Bereiter & Scardamalia, 1987.) This work is important because of its concern with how to teach novices to become experts. Bereiter and Scardamalia also distinguish between 'knowledge telling,' or writer-based prose, and 'knowledge transforming,' or reader-based prose. Knowledge telling is more typical of novices: it does not require a great deal of thinking. Knowledge transforming, on the other hand, is more typical of experts: it requires the writer 1) to think in terms of the reader, 2) to diagnose problems that arise from considering the relationship between the text produced so far and the reader, and 3) to evaluate success at resolving these problems. Bereiter and Scardamalia typically provide students with prompts which will help them to execute these strategies while they are learning to write: the ultimate goals being 1) generalization to a wide variety of similar tasks; 2) the withdrawal of these prompts (as they become internalised); and 3) the automatization of these prompted skills through practice so that the writer is freer to concentrate on higher order goals.

Perhaps it might be helpful at this point to provide an example. Scardamalia & Bereiter (1983), for instance, instructed ten to fourteen year olds how to use a set of procedures to help them revise their written compositions. The participants were asked to consider each sentence of something they had written and to check it, first against the list of evaluation statements, and second against the list of directives shown in table 2. The aim of such an approach was to help the learners see what revision entailed, and then to make it a matter of routine. This example demonstrates the advantages of the procedure (it forces teachers to spell out what is meant by revision) and the disadvantages (not everyone will agree that this is what revision entails).

Bereiter and Scardamalia have experimented with giving children similar sorts of prompts and what they term 'consequential composing activities' (see, e.g., Bereiter and Scardamalia, 1987; Scardamalia et al, 1981). For example, when nine to eleven years olds were given appropriate prompts to help them write opinions, they produced more structured elements (reasons, examples, elaborations) than when they attempted to do the same task simply by talking. Similarly, when children were given a choice of 'ending sentences' to strive for in their compositions, this

TABLE 2. Evaluative and directive phrases used to help 10-14 year olds to revise in the study by Scardamalia and Bereiter. Pupils check each of their sentences in turn, first against the list of evaluative phrases, and next against the list of directive statements.

Evaluative phrases

People won't see why this is important
People may not believe this
People won't be very interested in this part
People may not understand what I mean here
People will be interested in this part
This is good
This is a useful sentence
I think this could be said more clearly
I'm getting away from the main point
Even I am confused about what I am trying to say
This doesn't sound quite right

Directive phrases

I think I'll leave it this way
I'd better give an example
I'd better leave this part out
I'd better cross this sentence out and say it a different way
I'd better say more
I'd better change the wording

was found to be more useful than being given a choice of 'sentence openers.' In another study children were encouraged to list 'relevant' words as a part of their planning process. Children adopting this technique doubled the length of their essays and tripled their use of unusual words.

There have now been a number of such studies of learners improving their abilities at writing by using such self-instructional strategies (e.g., see Beal, Garrod and Bonitatus, 1990; Brown & Day, 1983; Graham and Harris, 1989; Wallace and Bott, 1989). Studies by Daiute and Kruidenier (1985), Graham and MacArthur (1988), MacArthur, Schwartz and Graham (1991), and Zellermyer et al (1991) show such procedures can be further implemented by the use of computer technology.

- *Writing and thinking*

More generally, the kinds of procedures described above often take place in the context of studies that are concerned with enhancing children's metacognitive skills (i.e., their knowledge of their own thinking processes). A number of researchers now see writing as a major tool for encouraging the development of thinking skills. Freedman et al write:

"Initially children's language and thinking is embedded in ongoing events. During the preschool and early school

years, children's language becomes free of what they can see and manipulate and thus becomes a tool for thinking and referring to the present, the past and the possible future. Recently researchers have emphasized the contribution of schooling and written language to the freeing of both language and thinking from immediate experience. In school, written language, and much of oral language, exists apart from a familiar social and physical setting—such language is 'decontextualized.' Children must reason about meanings conveyed primarily through words alone.

This ability to transform an experience into language and then think about it, compare it to previous experience, and, perhaps, reinterpret it—is seen as the heart of higher-level cognitive functioning by researchers and theorists who have significantly affected current views on both cognitive and linguistic growth. The goal of education must be, in part, a reflective human being who is capable of 'intellectual self-control'—of monitoring ongoing thinking, stopping and giving pause, considering possibilities and alternate routes, of taking necessary steps to disentangle confusions and make sense. A concern with the development of such a reflective citizenry is evident in the current interest in metacognitive skills, of individuals' knowledge about and control of their own thinking." (Freedman et al, 1987; references omitted)

Several writers have commented on how writing aids thinking (e.g., see Langer and Applebee, 1987; Wason, 1970, 1980; Wolcott, 1990). Writers, with their text in front of them as they produce it, are able to reorganize it, to clarify what it is that they are trying to say, and sometimes to recognize that what they started out by saying is now clearly no longer appropriate and needs changing. Debates concerning the roles of reading, writing and speech in the development of thinking skill have, according to Freedman et al, formed the impetus for the current enthusiasm for 'writing across the curriculum' programs in our schools (e.g., see Fulwiler and Young 1982; Gray, 1988) and the processes-approach to instruction described earlier.

The need to separate out different processes, practice, and integrate them that is advocated in process-approaches to teaching writing is supported by psychological research on the acquisition of other cognitive and motor skills. Authors such as Elbow (1973) and Wason (1970; 1980) recommend separating out composition (thinking) from transcription (writing): they advocate quick rough draft-

ing, and then final polishing, rather than attempting to produce polished prose at the first attempt. However, the evidence to support such recommendations is mixed (Glynn et al 1982; Kellogg, 1988).

Finally, in concluding this section of this review, we should note that some authors (e.g. Applebee, 1986; Hill-ocks 1984, 1986) have criticized the zealous nature of some advocates of the process-approach to teaching writing. Applebee (1986) re-emphasizes that Hayes and Flower's descriptive accounts emerge from the analysis of skilled writers solving difficult problems. In school-based situations, Applebee notes, a process-approach to instruction often means providing novice learners with false tasks, which are then practiced in isolation from the 'real world.' Thus Applebee considers that, 'rather than suggesting a range of strategies for solving problems, process instruction will become just another series of practice exercises.'

Computers and Writing

Throughout this paper remarks have been made concerning how computer-aided writing may change the way in which writers learn to write, or even the nature of writing itself. Indeed, a common question posed by colleagues is 'Does using a word-processor change the way you write?' In attempting to answer such a broad question we need to consider several issues.

First of all we can distinguish between different levels or degrees of computer-aided writing. Three such levels might be:

- 1) Using word-processors simply to process text—making deletions and substitutions, moving text about, and printing it in an attractive format.
- 2) Using computer programs to aid the composition of word-processed text. Spell-checkers provide a limited example at this level, but programs such as Bell Telephone's Writer's Workbench (see below) provide more sophisticated examples.
- 3) Using computer programs to further aid the composing process at a higher level. Programs such as Writer's Assistant or Writer's Partner, which help with planning and organizing, are currently in their infancy, but some discussion of possibilities in this respect is provided below.

Next we need to consider further what we mean by whether or not computer-aided writing changes the ways

in which we write. Here there are two issues of concern:

- 1) Do we mean, because writing consists of various skills, some skills will perhaps receive more aid than others in computer-assisted writing? Perhaps the balance of attention changes, say, from doing more planning and less revising (with pen and paper) to doing less planning and more revising (with a word processor). Perhaps the amount of attention given to various tasks will vary but the way in which these tasks are carried out will not change a great deal. In other words the skills and strategies may remain the same but the computer helps us to perform some of them more effectively.
- 2) Or do we mean that using word-processors will, in fact, change the ways that people think when they are writing and thus, in fact, create new skills?

- *Word processors and writing*

There has been a great deal of research on using word-processors simply to process text, and it is beyond the scope of this paper to review it all. Representative reviews have been provided by Chandler (1991), Hansen and Haas (1988), Hawisher (1989) and Zvacek (1988).

The authors of studies of writing with word-processors at primary school draw particular attention to:

- 1) how much easier it is for young children to write with a keyboard than with a pen;
- 2) how much easier it is for young children to read printed text than handwritten text (see Figures 2.1 - 2.2);
- 3) how much easier it is for young children to make corrections (e.g., of spelling) on screen, compared with when writing with pen and paper. Every version is always neat.

Generally speaking, such authors predict that word-processors will lead to more drafting, longer texts, and texts of better quality. There is some evidence to support these claims, but not perhaps as much as one might wish. (See, for instance, Chandler, 1991; Cochran-Smith, 1991; Hawisher, 1989.)

One problem with many of the reported studies is that they take place over a relatively short period of time and one is not totally convinced that the participants have had sufficient experience with using the particular word-processor in question (compared with that of pen and paper). However, there are some exceptions to this caveat. Dalton and Hannafin (1987), for example, compared the end products of two groups of twelve year old writers after

FIGURE 2.1 A sample of a child's handwriting.

Blind Drunk
I was coming out of a pub, when ten
men come up to me and said to me
do you want to earn some money. I said yes
and signed some pieces of paper. But I
did not know what I had let my self in for because
I was drunk the next day I found my self in
captin Bill crowing and I felt sick so I went
on deck where I found out what I had let my
self in for. I set to inspecting the ship but I went
to bed. the next day I felt better so I went to get an
apple and the cook chopped of his finger because I
sprised him then I saw some people sitting they
~~had~~ had some france.
The end by Adam

FIGURE 2.2 A word-processed story by the same child.

A wild wind.

One day in the heart of the wild west I saw a man running through the street shouting a twister is coming, a twister is coming. All the people started running wild. In about 10 seconds the town was in a panic. I tried to ask a man what was wrong but he just ran away. Then I saw it. It was 80 metres high and 20 metres across. I was very frightened so I ran into a shop to hide. And the next minute the roof fell off and I said to myself these shops aren't built very well. Then the wall collapsed on top of me but I was saved by a tin bath which fell on top of me and covered me up. Later I was rescued from the debris.

THE END BY ADAM

a year of instruction. Group 1 (N = approximately 40) completed two exercises weekly throughout the academic year, using an Apple IIe microcomputer equipped with FreeWriter. This program allowed users to delete and replace text, to move blocks of text around, and to format documents on screen, but it did not include any additional aids, such as a spelling checker. Group 2 (N = approximately 40) completed similar writing assignments using pen and paper. Both groups were tested on a common writing task, a one to two page essay, at the end of the year. All of the participants did this task by hand. The essays were then marked 'blind' by three judges, who rated them in terms of structure and organisation, correct usage of parts of speech, punctuation, capitalization and spelling.

There were two main results. First of all, there was no significant difference between the quality of the essays written by the two groups. The average mark for the word-processing group was 76 percent, and for the pen and paper group, it was 73 percent. However, there was an interaction with ability. The two treatments had similar effects for high-ability students (word processing 77 percent, pen and paper 78 percent) but word-processing significantly helped the less-able pupils (word-processing 74 percent, pen and paper 69 percent). Dalton and Hanafin comment particularly on how word-processing aided the revision process for the less-able students—'making it less tedious for low-ability learners.' They also suggest that the pupils with the word-processors spent less time planning and more time revising than did their counterparts, and that initially it took a long time for some of the participants to learn how to use the word-processors efficiently.

In passing, we might consider two further points here. First, a number of studies have specifically examined the use of word-processors with less-able children, and most report some success (e.g., see Graham and MacArthur, 1988; MacArthur et al, 1990, 1991; Vacc, 1987). Likewise Hartley's (1992) text contains papers that report on the successful uses of technology with writing by the blind, the deaf, the physically handicapped and the aged. Second, computers may facilitate writing in other problematic areas. If, for example, girls are better at writing than boys, but boys prefer computing to girls, then possibly computer-aided writing will facilitate the writing of boys (and negate the writing of girls)? Such speculation is, of course, premature and it is not in fact true that boys always have

more positive attitudes to computers than do girls (Trueman, 1990; Underwood and Underwood, 1990).

- *Computer-aided writing programs*

Several computer programs have been developed that writers can apply to their written productions in order to see how they might be improved (e.g., see Britton and Glynn, 1989). One typical suite of programs is The Writer's Workbench developed at Bell Laboratories in the United States. The number of programs available in this suite is constantly expanding, but Table 3 lists some of the major ones.

These programs were created to help technical writers, but the suite has been evaluated in different contexts. Gringrich (1983), for instance, observed two groups of technical writers, one more experienced than the other, using Writer's Workbench over a ten-week period. Both groups of writers found the programs helpful, they liked the immediate feedback the programs provided and the detailed suggestions on how to revise their texts. Interestingly enough, the writers thought they spent less time editing their documents when they used the Writer's Workbench programs although, Gringrich reports, the total time spent on writing and editing did not change.

Kiefer and Smith (1983) used a sample of the Writer's Workbench programs with students taking Freshmen English at Colorado State University. Students used the programs for about an hour a week for fourteen weeks. Their results on pre- and post-test editing and essay writing tasks were compared with those of control students. Both the experimental (N = 38) and control groups (N =

TABLE 3. A sample of computer programs available in 'The Writer's Workbench' system developed at Bell Laboratories.

Programs which indicate:

- spelling errors
- punctuation errors
- word repetitions
- split infinitives
- use of passives
- use of nominalizations
- use of abstract words
- acronyms
- long sentences
- sexist phrases
- awkward choices of words/phrases (with suggested improvements)

Programs which give:

- parts of speech for each word
- readability scores
- average length of sentences
- number of sentence types (simple, complex, compound, compound-complex)
- comparison figures on details such as those for other 'model' technical texts

Programs which:

- summarize the content—by listing headings
 - summarize the content—by giving the first and last sentence of each paragraph
 - segment the lines of the text according to line-length requirements and syntactic rules
-

46) performed equally well on editing 'errors of mechanics,' but the computer group outperformed the control group on 'revision for simplicity, directness and clarity.' There was no significant difference between the scores of the two groups on the overall quality of the post-test essays. The students expressed very positive attitudes towards computer-assisted writing, after using the program.

Sterkel, Johnson and Sjogren (1986) used programs from the Writer's Workbench suite with business studies students for three terms over an academic year. At the end of each of the three terms experimental and control students were compared on their editing skills (detecting errors in provided materials) and on an end of term assignment (writing a business letter).

In terms of editing skills there was no significant difference between the two groups at the end of each term, but both groups improved significantly (comparing terms one and three). In terms of the writing assignment, there were no significant differences between the groups in terms one and two, but in term three, the computer-aided group outperformed the conventional group on their overall scores, and on subscales of 'concreteness' and 'conciseness.'

In this study the time the students reported that they had spent on subcomponents of their writing assignments were recorded. In the first two terms the computer-aided groups spent significantly longer on their assignments, but in the third term this position was reversed: the computer-aided group performed slightly faster than the control group. The data suggest that with sufficient experience the computer-aided students were beginning to spend less time on outlining and making the first draft and slightly more time on revising. And, as in both of the previous studies, the student reported favorable attitudes towards computer-aided writing.

These three studies indicate that computer-aided writing programs are popular, and given time and practice, they seem to produce marginal gains for the end-products: the documents are improved. However, in a sense, the computer programs used in the studies reported above are limited: they tend to focus more on aiding transcription and revision than on planning and composing. Some critics remark harshly on the assumptions involved in creating packages of this kind (e.g., see Collins, 1989; Theisemeyer, 1989) perhaps forgetting that they are meant to assist relatively competent writers rather than novices.

A number of investigators are now considering how programs might be written that will aid the composing process. Kellogg (1986) for instance discusses three main difficulties that writers face: i) 'attentional overload'—having to cope with too many processes all at once; ii) 'idea bankruptcy'—a failure to generate usable ideas; and iii) anxiety and emotion. Kellogg describes a variety of computer programs that help to deal with these fundamental difficulties. 'Funnel' programs channel the writers' attention into only one or two processes at a time. 'Inventor' programs help writers to form and relate concepts; and 'therapist' programs give feedback and reassure the writer. Several computer programs are outlined under each heading, as well as programs that combine these different functions. Frase (1987) provides a similar list of functions and programs—although they are classified a little differently. Frase discusses programs that help writers generate ideas, organise thoughts, compose, and obtain feedback.

In the United Kingdom work on developing programs to aid the thinking processes of writers is being conducted by, among others, Sharples and his colleagues at Sussex University. Sharples, Goodlet and Pemberton (1989) provide the following scenario to illustrate how a writer might use their Writer's Assistant:

"A writer wants to produce a study of 'Pottery in North Eastern Brazil' so, on entering the system, she selects the option for creating a new document. As she is writing for a newspaper color supplement she selects Newspaper Article from a menu of options, getting a structure template and set of constraints appropriate to that type of text. The writer has a fairly firm idea of how the article will fit together, so she starts working in the structure view, sketching an outline for the body of the text by calling up the structure guide to instantiate four main sections headed 'background,' 'development of pottery industry,' 'evaluation' and 'conclusion'. . . With the overall structure established, our writer chooses to brainstorm ideas for the 'development of pottery industry' section. She turns to the notes network view where she sees a note for each of the sections she created in the structural view. She creates notes for subtopics, linking them to the main note with 'aspect' links. To concentrate on one subject—'description of pottery'—she selects a presentation of the notes network in which that note is displayed in the center of the screen and then creates further notes to surround it. . . The author might then switch to a linear view to find that the system has made an attempt to linearize the notes

network into a list of sections and subsections, based on link types. After making some rearrangements she fills out the section headings with text for the article, moving between different perspectives of the linear view to see sections detail or outlined, until the article is finished.”

Other papers describing similarly complex approaches to developing computer aids to individual and cooperative authorship have been described by Barrett (1989a), Duin (1991), Ferraris et al (1990), Forman (1991) and Streitz and Hannemann (1990).

- *Word-processor—tool or prosthesis?*

As mentioned earlier there is some debate whether using a word processor alters the amount of attention we pay to different aspects of the writing process but leaves the skills much the same, or whether using a word processor changes the way people think when they are writing and whether or not this leads to improved documents. Readers will have observed that in my accounts of the experiments described above, I have included, where possible, information concerning the quality of the end product, and the amount of time devoted to various aspects of the writing process.

The accounts above (together with those of other studies) suggest that writers spend less time planning and more time revising with word processors (see Kellogg and Mueller, 1990; Cochran-Smith, 1991; Haas, 1990; and Hawisher, 1989). Haas (1990) notes that this typical finding may depend upon the nature of the writing task, for she found that writers were more likely to resort to pen and paper for more difficult tasks. Teles and Ragsdale (1989) report that academics claim to revise more with word-processors that they do with pen and paper but Hawisher (1989), Underwood and Underwood (1990) and Chandler (1991) report several studies where writers stick to their methods, regardless of the tools they are using. It appears that if writers revise a lot with pencil and paper, then they will revise a lot with a word processor. In their study of productive academic psychologists, Hartley and Branthwaite (1989) observed that many of them commented that the use of word processors had not altered their fundamental method of attack. There was, however, a shift of approach with experience in that novice users of word processors were more likely to use them to edit handwritten drafts, whereas more experienced users were more likely to compose directly with the machine.

Three studies known to the author focus specifically on this question of whether word processors simply alter the amount

of attention paid to sub-components of the writing task, or whether they change an author's writing skills. Kellogg and Mueller (1990) carried out two such studies, one with relative novices (N = 16) and one with more experienced users of word processors (N = 69). In both experiments the participants—college students—were trained to classify their thoughts about their writing processes and, when asked, to press one of four keys to indicate which of four possible subcomponents they were doing: planning, translating, revising, or some other unrelated process. After training and practice for thirty minutes with IBM's Writer's Assistant, the students each composed an essay (within a thirty-minute time limit), half with a word-processor and half in long-hand. They were interrupted approximately every thirty seconds and they responded by pressing appropriately one of the four keys each time.

The results of Experiment 1 showed no significant differences between the written products on marks for content, but that the writers with the word processors devoted more effort to revising and planning, and less to translating that did those using longhand (who spent about an equal amount of effort on each). The results of Experiment 2 were very similar, with the more experienced users showing the effects slightly more clearly than the less experienced ones. Kellogg and Mueller conclude that word-processors restructure the process of writing, but fail to improve writing performance.

However, the word processing system used by Kellogg and Mueller would, in terms of my earlier description of different levels of system, be at level one. The participants used an IBM PC with IBM Writing Assistance Software. This included only basic text editing functions (insert, delete, move, copy and print). More complicated software may be required if one is to alter the nature of writing.

Zellermayer et al (1991) used a specifically designed computing tool, The Writing Partner, for their experiment. This suite of programs was designed mainly on the basis of work done by Bereiter and Scardamalia (1987) discussed earlier. The programs were designed to help high-school pupils (aged thirteen to fifteen) move from knowledge-telling of author-based prose to knowledge-transforming of reader-based prose. They aimed to achieve this by providing three kinds of help during writing: 1) memory supports; 2) guides concerning evaluation, elaboration and coherence; and 3) guides reminding the writer of rhetoric, writing goals, and the writer's audience.

Zellermayer et al studied three groups. Group 1 (the control group) wrote five essays with a conventional word processor. Group 2 wrote five essays with a word processor using The Writing Partner. Group 3 wrote five essays with a second version of The Writing Partner that provided guidance only on request. The resulting essays were assessed 'blind' by two trained writers on a single holistic rating scale and on five analytic scales designed to measure: number of ideas; coherence; idea development; cohesion and connectedness; and ending.

The results showed that the group with The Writing Partner produced significantly better essays overall than both the control group and the group who could solicit the programs when they wished. (The mean overall quality scores were 146.8, 131.5, and 128.6 respectively).

In order to test whether or not the computer aided writing programs had changed writing performance, members of all three groups completed another essay, two weeks later, using pen and paper. The argument here was that if writing performance had changed then this would show itself on such a post-experimental writing task. The results were very similar to those described above. The essays written by Group 2, who had trained with The Writing Partner were significantly better than those written by the control group and those who had been able to solicit The Writing Partner when they wished. (The mean overall quality scores this time were 42.6, 33.3 and 35.4 respectively). Zellermayer et al argue that the pupils who used The Writing Partner first of all internalized the cognitive writing strategies offered and then came subsequently to use them on data collected from a questionnaire about effective writing strategies that the pupils completed just before they wrote their post-test essays.)

These three studies then, those of Kellogg and Mueller, and that of Zellermayer et al, suggest a possible reconciliation between those who feel that word-processing simply restructures writing processes, and those who feel that it changes the nature of writing. It is clear that the nature of the assistance provided by the computer-aid is crucial. In terms of my earlier discussion of levels of support, we might expect that the greater the support, the more likely writing with word-processors will change writing skills, particularly with extended practice.

Such a conclusion may help to resolve some of the differences in the current findings. However, it over simplifies

many issues, notably those posed by different writing tasks, different writing tools, different writing experiences and habits, and different way of assessing the effectiveness of writing. These complexities will be discussed further in the final section of this paper.

Evaluating Written Products

It is not easy to evaluate the quality of a piece of writing, or to decide whether one piece of writing is better than another. Indeed, it is tempting to think that if we have re-written something, then it must be better than it was before. But, if we are to move beyond opinion and value judgment, and to try and assess whether or not, for example, computer technology alters how well people write, then we need to collect and analyze some data.

As noted in the previous section of this review there have been many attempts to evaluate the effects of writing with word processors in our educational systems. And in that section, I pointed out that many of the early studies were limited because of the brevity of the intervention program. Other problems arise from the small sample sizes and the quality of the programs used. However, later studies, which remove some of these deficiencies, still seem to produce equivocal results (see, for example, the review by Hawisher, 1989).

Dunn and Reay (1989), in reviewing some of these later studies, point to the difficulties of making comparison studies. They emphasize, in particular, that investigators need to equate keyboard speed in the experimental groups with handwriting speeds in the control groups before drawing conclusions. In their study, for example, Dunn and Reay found no significant differences between the quality of the writing of their twelve and thirteen year olds using word processors and those using handwritten composition when keyboard skills were ignored. However, when keyboard skills were taken into account, those writers who were adept (i.e., faster on the keyboard than by hand) did better on measures on writing quality, and those writers who were less competent (i.e., slower on the keyboard than by hand) did worse. These results may not seem surprising, but they point to the fact that in carrying out comparison studies (or indeed studies of any kind) one has to collect appropriate data.

The comparison study seems to be the *sine qua non* when it comes to evaluating new methods and techniques in

education. A great deal of energy has been expended, for example, in assessing the value of educational television programs and computer assisted learning using this approach. Once, however, it has been determined that certain media accomplish some things rather well and some things rather badly (compared with human instruction) then the focus of evaluation usually turns to examining how one can make more effective use of the medium concerned. It may be that we have not yet fully arrived at this stage in assessing the effects of computers on writing—although the current interest in writing processes may mean that we shall arrive at this position rather more quickly than was the case with other media.

Of course, assessing the effects of different processes on writing quality is not a simple matter—and it probably can never be done perfectly. My purpose in this final section of this review is to indicate the variety of tools available to researchers in this respect. The aim is to classify them in some way—to see what is available and to discuss the varieties and constraints that exist.

- *Different types of writing*

There seem to be at least three dimensions along which one can classify an evaluation study. First of all, as we saw in table 1, one can categorize writing in terms of different types. Clearly the tools appropriate for evaluating one kind of writing may not be appropriate for another.

- *Different research methods*

Second, we can also categorise research methods into different types or genres. Jaeger (1988), for instance, distinguishes between experimental (comparison) methods; quasi-experimental methods; survey methods; case-study methods; ethnographic methods; historical methods; and philosophical methods. The authors in Jaeger's textbook discuss the advantages and disadvantages of each in detail. As Shulman (1988) puts it: 'What distinguishes the methods from each other, by virtue of their contrasting disciplinary roots, is not only the procedures that they employ but the very types of questions they try to raise.' So, the kinds of methods used in an evaluation study will depend upon the kinds of questions being asked. If we want to find out how teaching methods have changed, a survey method may be appropriate; if we want to compare the efficacy of different methods of instruction then a quasi-experimental procedure may be best; and, if we want to explore the feelings of participants, and underlying social and political issues, then we might opt for an

ethnographic approach. In many cases, of course, more than one method will be appropriate.

Bereiter and Scardamalia (1987) make a similar point in the context of research on writing when they outline six levels of enquiry. Table 4 shows how research at different levels poses different kinds of questions, and utilizes different methods of approach. Bereiter & Scardamalia conceive of the different levels as each having advantages and disadvantages, but all feeding into each other.

- *Different measures*

Third, we can consider the variety of measures that might be appropriate for one or more of these research levels. Shriver (1989), for example, describes three approaches to evaluating text text-focused, expert-focused, and reader-

TABLE 4. Six levels of enquiry in research on writing—as outlined by Bereiter and Scardamalia in *Research on Writing: Principles and Methods*, edited by Peter Mosenthal et al.

| Level | Characteristic Questions | Typical Methods |
|-----------------------------------|--|---|
| 1 Reflective inquiry | What is the nature of this phenomena? What are the problems? What do the data mean? | Informal observation Introspection Literature review Discussion, argument, private reflection |
| 2 Empirical variable testing | Is this assumption correct? What is the relation between x and y ? | Factorial analysis of variance Correction analysis Coding of compositions |
| 3 Text analysis | What makes this text seem the way it does? What rules could the writer be following? | Error analysis Story grammar analysis Thematic analysis |
| 4 Process description | What is the writer thinking? What pattern or system is revealed in the writer's thoughts while composing? | Thinking aloud protocols Clinical-experimental interviews Retrospective reports Videotape recordings |
| 5 Theory-embedded experimentation | What is the nature of the cognitive system responsible for these observations? Which process model is right? | Experimental procedures tailored to questions Chronometry Interference |
| 6 Simulation | How does the cognitive mechanism work? What range of natural variations can the model account for? What remains to be accounted for? | Computer simulation Simulation by intervention |

TABLE 5 Methods of Evaluating Text Quality: The Continuum from Text- to Reader-Focused.

| Text-Focused | Expert-Judgment-Focused | Reader-Focused |
|--|--|--|
| Readability Formulas <ul style="list-style-type: none"> ✓ Flesch Reading Ease Score ✓ Fog and Gunning Index ✓ SMOG Formula ✓ Dale and Chall Formula ✓ Fry Formula ✓ Kincaid Formula <ul style="list-style-type: none"> • word frequency/length • length of sentences | Peer Review <ul style="list-style-type: none"> • style (local & global issues) • audience analysis • graphics & typography • organization & access features • adherence to conventions • consistency & completeness | Concurrent testing <ul style="list-style-type: none"> ✓ Cloze Testing <ul style="list-style-type: none"> • lexical predictability ✓ Keystroke Protocols <ul style="list-style-type: none"> • number of keystrokes • time on task • number & type of errors/assists • error recovery behaviors • number of failures to recover ✓ Eye Movement Protocols <ul style="list-style-type: none"> • number & location of fixations, saccades and regressions • total gaze duration ✓ User Edits & performance Testing <ul style="list-style-type: none"> • reading time • time on task • number & type of errors/assists • error recovery behaviors • number of failures to recover • cognitive load • access & retrieval behaviors • memorability/recall/retention |
| Computer-based Stylistic Analysis Programs <ul style="list-style-type: none"> ✓ Writer's Workbench (UNIX™) ✓ Epistle-1 (IBM) ✓ Critique, formerly Epistle-2 (IBM) ✓ Star (GM) ✓ Grammatik III (Reference Software) ✓ MacProof 3.2 (Lexpertise Linguistic Software) <ul style="list-style-type: none"> • proofreading • readability/grade level • grammar & style (sentence-level) • sentence complexity • personalized dictionary | Technical and/or Subject-Matter Expert Review <ul style="list-style-type: none"> ✓ Content Evaluation <ul style="list-style-type: none"> • accuracy (visual & verbal text) • completeness and depth • match with functionality of a machine, product, etc. • match to stated goals for text ✓ Presentation & Delivery Critique <ul style="list-style-type: none"> • market/audience analysis • competitive analysis | |
| | Editorial Review (in-house) <ul style="list-style-type: none"> • style & copyediting • adherence to conventions, specifications, boilerplate or guidelines (visual & verbal text) • consistency & completeness | |
| | External Review <ul style="list-style-type: none"> ✓ Text Features Evaluation ✓ Holistic Rating (primary trait scoring or general impression marking) <ul style="list-style-type: none"> • style (local & global issues) • audience analysis • graphics & typography • organization & access features • persuasiveness & believability • competitive analysis • personal & corporate identity ✓ Consumer Advocate Review <ul style="list-style-type: none"> • competitive analysis • truth & ethics • legal, health & safety implications ✓ Gatekeeper Review <ul style="list-style-type: none"> • appropriateness of content • context(s) for use/dissemination ✓ Document Design Process Critique <ul style="list-style-type: none"> • document development cycle • audience & task analysis • style guides/standards/tools • project management • communication channels • education & training methods | |
| Guidelines & Maxims <ul style="list-style-type: none"> ✓ Felker et al. ✓ Harcourt, Brace & Jovanovich ✓ Hartley ✓ Strunk & White ✓ Williams <ul style="list-style-type: none"> • principles of style for visual or verbal text • visual or verbal text features to avoid or use sparingly • audience analysis | | Retrospective Testing <ul style="list-style-type: none"> ✓ Comprehension (true/false, etc.) <ul style="list-style-type: none"> • paraphrase • recall/summary/gist • recognition • inference ✓ Surveys, Interviews & Focus Groups <ul style="list-style-type: none"> • rank/rate visual & verbal test • comprehension • persuasiveness & believability • satisfaction/preference • attitudes & beliefs • inference ✓ Critical Incidents/Storytelling <ul style="list-style-type: none"> • key events & incidents • relevance/severity judgments ✓ Reader Feedback Cards <ul style="list-style-type: none"> • comprehension • satisfaction/preference • attitudes & beliefs |
| Checklists <ul style="list-style-type: none"> • recommended or required visual or verbal text features • visual or verbal text features to avoid or use sparingly • audience analysis • consistency & completeness • probable translatability • adherence to conventions | | |
| <ul style="list-style-type: none"> ✓ an example of a particular method or individuals who developed or elaborated a method. • a typical focus or dependent measure during evaluation. | | |

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focused and discusses a variety of measures under each heading. Table 5 summarizes her account.

- *Concluding comments on evaluation*
My aim in writing this section of this review has been to show how one might classify approaches to evaluating the quality of writing in terms of a three-dimensional matrix: different text types x different research methods x different evaluation measures. It is perhaps not too surprising, then, to find that we cannot reach an overall simple conclusion concerning such questions as: Does using computers improve writing? Different investigators have used different cells in this matrix to tackle the question, and there is very little agreement as to what constitutes the best approach. Not only do so many different components interact in so many different ways, but we also need to remember that for each cell in the matrix, as pointed out by Dunn and Reay (1989), there is the question of whether a choice of any particular text type, method or measure can ever be entirely appropriate.

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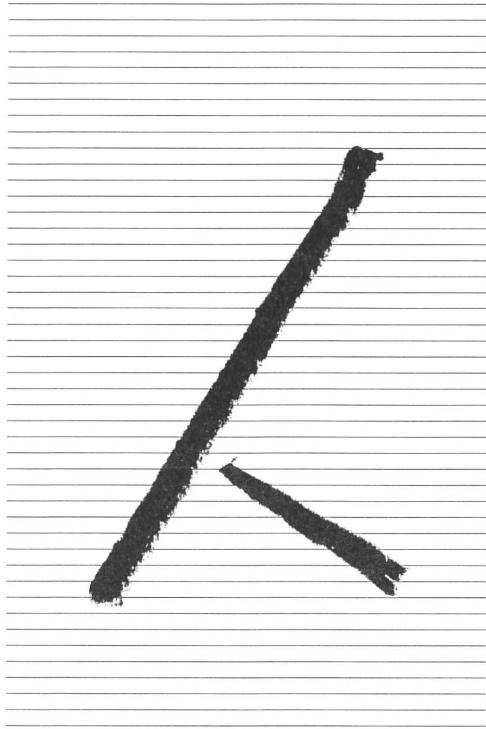
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**The Effects of Drawing
Method on the Discrimina-
bility of Characters**

*Michael L. DeKay &
Jennifer J. Freyd*

Three experiments were conducted to investigate the effect of drawing method on the subsequent discriminability of hand-drawn characters. A novel set of eight characters and two drawing rules were developed for use in these experiments. In Experiment 1, angle measurements performed on hand-drawn characters indicated that members of characters pairs drawn using dissimilar stroke directions became more differentiated while members of character pairs drawn using similar stroke directions remained relatively undifferentiated. In Experiment 2, subjects were better able to distinguish between members of differentiated characters pairs than between members of undifferentiated character pairs. In Experiment 3, subjects also appeared to be better at distinguishing between members of character pairs which had been drawn using their own drawing rule, though such a finding may depend on the exact nature of the task.

Deciphering handwritten script is a task that most of us undertake on a daily basis. In most cases, the writer has encoded the message fairly legibly and we are able to unscramble the complex stimulus material with remarkably little effort. However, if the writer's note is hurriedly scribbled, the task becomes much more complicated. We attempt to piece together the meaning of the passage from the most legible words and use the resulting context to inform our attempts at deciphering the more ambiguous text. Pressing still further, we might focus on the features of troublesome letters or mentally retrace the path of the writer's pen in an effort to uncover the process which led to the distorted traces on the paper. Finally, we may ask for the assistance of others, waiting patiently as they go through a similar sequence of steps.

There are several aspects of this process that are interesting to psychologists. First, there is the process through which the ambiguous script is generated in the first place. Does illegibility result from random distortions of accepted letter forms or are the distortions partially deter-

mined by the stroke sequence used to create the letters? Can we predict which letters or letter combinations will become ambiguous by looking at the forms of undistorted characters or the accepted stroke sequences for writing them? Does the use of a nonstandard stroke sequence lead to distortions that are substantially different from those that follow from the standard stroke sequence?

Second, what are the cognitive processes involved in deciphering ambiguous script? Context certainly plays a role, but context alone rarely supplies sufficient information to decipher a truly ambiguous word; more fine-grained perceptual processes are also called upon. How do these processes work? Do we maintain a cognitive catalogue of accepted or familiar distortions for each letter or letter combination or do we consciously or unconsciously retrace the path of the writer's pen? In other words, is the decoding process a static, feature-based approach, or is it more dynamic, like the encoding process of the original writer? In either case, how important is it for the writer and reader to share a common writing method?

In this paper, we attempt to answer three of these questions. First, we ask whether differences in writing methods (e.g., differences in stroke direction) determine the types of distortions that are generated from a set of characters. Second, we ask whether these distortions are important determinants of the ambiguity or illegibility of handwritten characters. Finally, we ask whether familiarity with the method in which characters are created facilitates recognition of ambiguous characters.

Previous Research

- *Examples of Ambiguous Characters*

There are several factors which might account for the difficulty of correctly identifying individual letters in handwritten script. According to Wing and colleagues, different writers may use different forms for a given letter (Wing, 1979) and individual writers may use different forms of the same letter depending upon the surrounding letter context and the position of the letter in a word (Wing, 1979; Wing, Nimmo-Smith and Eldridge, 1983). In addition, slight distortions of some common letter forms often render the letters indistinguishable from similar forms of other letters or letter combinations. For example, script forms of the letters *i* and *r* or *b* and *f* can be difficult to distinguish (see panel A of *figure 1*). Thus, *i/r* and *b/f* can be called confusable characters pairs.¹ Sommer (1977) provides a number of other examples in which characters

FIGURE 1. Examples of ambiguous character pairs and ambiguous words.

Panel A: Ambiguous character pairs i/r and b/f.

miss Mrs box fine

Panel B: Ambiguous character pairs bi/lr, bu/lri, by/bij/lrj, ur/wi, urj/wy, u/ji and d/cl and ambiguous words win/urn, twin/turn and twined/turned.

be bu by ur uy u cl
win turn twined

Panel C: Ambiguous words went/event that results from the ambiguous character pair w/ev.

event

Panel A examples from "Variability in Handwritten Characters," by A.M. Wing, 1979, *Visible Language* 13:3, 284. Panel B examples from "A Note on 'Graphonyms'" by R. Sommer, *American Journal of Psychology*, 90, 527-528. © 1977 by the University of Illinois Press. Reprinted by permission. Panel C example from "An Interactive Model of Reading" by D.E. Rumelhart. In S. Dornic, ed. *Attention and Performance VI: Proceedings of the Sixth International Symposium on Attention and Performance*, 579. Reprinted by permission, © 1977 Lawrence Erlbaum Associates, Inc.

or combinations of characters are confused with other combinations of characters, sometimes creating ambiguous words (see panel B of figure 1). Nash-Weber (1975) provides yet another example in which an ambiguous word results from a simple distortion (the actual script in panel C of figure 1 is Rumelhart's 1977 adaptation of Nash-Weber's example).

Confusions like those represented in figure 1 occur only if the writer is somewhat sloppy. If the writer properly dots his i's and j's and properly closes his d's, the ambiguities begin to disappear. However, because most of us write in a sloppy manner from time to time, especially when we are in a hurry, it seems reasonable to expect that minor distortions will occasionally result in ambiguous words or letters. Moreover, the examples presented in figure 1 do not exhaust the set of possible ambiguous character distortions. Suen's (1983) confusion matrices for print, manuscript and cursive letters provide evidence for a wide variety of ambiguous letter forms. For example, the most common confusions for cursive script are c/e, c/i, e/i, g/q, g/y, h/b, k/h, n/w, o/a, q/g, r/i, v/u and w/u, few of which are represented in figure 1. One can imagine the number of confusable letter combinations that might arise from these individual letters.

- *Drawing Method as a Source of Ambiguity*

Why might some pairs of hand-drawn² characters be more or less distinguishable? We propose that the discriminability of graphically similar characters depends on the method in which they are drawn. Specifically, we hypothesize that hand-drawn versions of two graphically similar characters will become more differentiated if they are drawn in dissimilar ways (e.g., using a different stroke order or direction).³

Such a finding would be consistent with Macleod and Procter's (1979) suggestion that the "*process* used to create cursive script has subtle yet profound effects on the appearance of the product" (p. 29, italics added). Lindsey and Beck (1984) also cite confusion with directionality as a major source of handwriting difficulties. Given Macleod and Procter's observation that incorrect stroke order and direction lead to a progressive deterioration from the standard form, it is plausible to hypothesize that differences in the dynamics of character formation could lead to differences in the discriminability of certain character pairs.

Mirror reversals. Other evidence suggests that there is a similar connection between the writing process and the discriminability of written products for the printed alphabet. Goodnow and Levine (1973) have hypothesized that certain printing errors are linked to the rules children use when copying simple characters. Specifically, they attribute the asymmetry in the number of reversals for b- and d-shaped figures to subjects' adherence to rules specifying that figures should begin with a vertical line and then progress from left to right. Thus, the method in which the characters were drawn is thought to be responsible for errors in which one member of a character pair was drawn as the other member of the pair. However, since adherence to drawing rules was examined only for a different set of four characters and not for the b- and d-shaped figures themselves, it is not possible to be certain that such errors were due to the way in which the individual characters were drawn.

However, there appears to be some disagreement as to whether children's drawing rules extend to printing. Lewis and Lewis (1965) have reported a mirror reversal asymmetry for printing and Cohn and Stricker (1979) have reported a similar effect for reading. In addition, Nihei (1983) has found that Japanese preschoolers' mirror reversals of nonletters have a left to right bias. Although the

author does not examine mirror reversals for Japanese letters (*Hiragana*), he does demonstrate that the covert principles for the organization of strokes follows the same developmental pattern for drawing and handwriting. However, Nihei's study used only right-handed subjects.

In contrast, Simner (1984) reported that both left- and right-handed kindergarten children reverse b-type letters more than d-type letters. This result contradicts Lehman and Goodnow's (1975) assertion that the two groups should use opposing motor rules when drawing letters. Furthermore, Simner shows that the left-to-right mirror reversals made by left-handed subjects when printing are not the result of a general left-to-right preference for horizontal strokes. Thus, his results cannot be explained by assuming that left- and right-handed subjects have different rules for drawing but a common left-to-right rule for printing. Following the arguments of Frith (1971), Simner suggests that the mirror reversal asymmetries may be the result of familiarity effects arising from the greater frequency of b-type letters in the alphabet. Children may be more likely to write or read b- and d-type characters as b-type characters for unconscious reasons (because children are simply more familiar with the characteristics of b-type letters) or conscious reasons (in order to capitalize on chance).

In summary, evidence for the notion that mirror reversals are the result of the application of a particular set of drawing rules is mixed at best. Still, a method- or rule-based explanation of b/d reversals appears to have been one of the main forces behind the creation of the D'Nealian alphabet (Thurber, 1983, 1984). In D'Nealian manuscript, b's and d's are formed more differently than in traditional ball-and-stick systems. Research presented by Thurber (1984) indicates that the D'Nealian approach is successful in reducing the number of mirror reversals.

More subtle distortions. Of course, the difficulties involved in deciphering handwritten messages usually do not arise from such gross errors as the reversal of individual characters. For example, the ambiguous characters of figure 1 and the confusion matrices in Suen's (1983) article reflect errors that are less severe than outright reversal. Ullmann (1974) refers to most of these more subtle distortions as *continuous* because the distorted characters are "related to the ideal characters by stylistic variations and random combinations of dilation, translation, and rotation" (p. 294). Mirror reversals, as well as a few of the

more subtle errors (e.g., failure to dot an i), can be thought of as *discontinuous* distortions.

Freyd (1983) has taken the notion of continuous distortions one step further by suggesting that distortions are not solely the products of random processes. She suggests that the likely form of a distorted character is rooted in the method (e.g., stroke direction) used to draw the character. For example, strokes may be lengthened or connecting strokes added in a way that is consistent with the drawing method. Thus, different drawing methods may be expected to produce different distortions. Such distortions may be generated purposefully by the experimenter (as in Freyd, 1983) or unintentionally by naive subjects (as in Babcock and Freyd, 1988). Interestingly, a computer model for the generation of continuous trajectories from discrete stroke instructions has been developed by Morasso, Ivaldi and Guggiero (1983). Continuous trajectories can lead to connecting strokes within characters (as in Freyd's studies) or between characters (as in cursive writing).

While any distorted character is likely to be more difficult to recognize than an undistorted one, a truly ambiguous character results only when the distortion of the character corresponds to a possible distortion of another character. The more likely the distorted versions of the two characters, the more likely either character will be drawn in an ambiguous fashion.

- *Knowledge of the Drawing Method as a Key to Deciphering Ambiguous Characters*

There is an interesting corollary to the notion that ambiguous characters may result from the method used to create those characters. Specifically, we suggest that ambiguous characters will be easier to decipher if the reader has knowledge of the method that was used to create the characters in the first place. In practical terms, this means that persons who have learned the same method for creating a set of characters will have less trouble communicating than persons who have learned to create the same characters in different ways. We refer to this corollary as the "common method hypothesis."

We should note that the plausibility of this hypothesis does not depend on whether characters are perceived in a static manner, by comparing the features of the characters to those of undistorted prototypes, or in a more dynamic manner, by mentally retracing the strokes of the writer's instrument. Static feature-analytic theories, such as those

reviewed by Gibson and Levine (1975), would predict better performance for readers who share the writer's production system because the distortions made by the writer are similar to distortions that the readers make when they write. This is true even if the distortions are the direct result of the drawing method used to create the characters. If the characters look familiar, they will be easier to recognize. Alternatively, a theory which emphasizes dynamic cues would consider many of the configural properties of the distorted characters to be dynamic in origin. Therefore, the presence of such cues would serve to convey information about the method in which the characters were drawn. This methodological information could later be tapped by readers, regardless of their familiarity with the drawing method. However, such information would clearly be most useful if the characters were drawn in the reader's own method, since only familiar cues would be present.

The dynamics of character perception. Although it would be folly to suggest that the static features of characters are not a very important part of the character recognition process and, indeed, the reading process as a whole, recent research indicates that dynamic processes may also be at work. For example, Kosslyn, Cave, Provost and von Gierke (1988) have shown that mental images of letters and letter-like forms are created in a dynamic fashion. Furthermore, the way that novel letter-like forms are imaged depends upon the order in which the strokes are initially learned. In their study, the time it took subjects to decide whether a probe fell on images of letter-like forms increased steadily for segments farther along in the sequence. This result is consistent with Zimmer's (1982) finding that subjects' images of certain script letters are more accurate when the subjects are asked to image them in a dynamic fashion (visually, kinesthetically or both) than when they are asked to image the letters in a static form. It is also worth mentioning that some optical character recognition programs have used contour- and stream-following models which attempt to identify characters by sequentially retracing the original writing process (see Ullmann, 1974, for references). Presumably, these models are able to use dynamic information resident in the static character trace.

However, not all of the evidence supports a dynamic model of character perception. In a study by Calis, Teulings and Keuss (1983), subjects viewed two component letters (e.g., c and i), which together composed a third

letter (e.g., a), and identified the most salient letter or letters of the three. The letters were presented in typing and writing modes in forward (left-to-right) and reverse (right-to-left) directions. Although the results of their three experiments are rather difficult to summarize, the authors claim that there were "no effects due to typing versus writing that would suggest the existence of a handwriting-like activity in the recognition phase of letter perception" (p. 313).

On the other hand, if characters are mentally represented in terms of dynamic processes rather than as sets of static features, it is not surprising that dynamic presentations of letters and letter-like characters facilitate more accurate copying. For example, copying performance is increased when letters are presented using animation (Wright and Wright, 1980) or live modelling (LaNunziata, Cooper, Hill and Trap-Potter, 1985). Similarly, copying performance is improved for nonletters when videotape is accompanied by the teacher's hand motion (Søvik, 1976) and when projected images are presented close to the subject in a dynamic fashion (Søvik, 1979). It is important to note that performance is not improved by some static techniques (e.g., the use of overlays by students to correct their own handwriting illegibilities; Burkhalter and Wright, 1984), even though the procedures are plausible on the surface and involving for the students. These results suggest that more dynamic methods could be profitably employed to teach proper letter formation in elementary schools.

Tests of the common method hypothesis. There have been several studies which bear on the common method hypothesis. For instance, Freyd (1983) has shown that certain types of distortions make characters more difficult to identify than do others. In her experiment, subjects viewed novel characters as they were drawn on a computer graphics screen in one of two methods (e.g., stroke directions). Later, subjects were asked to identify distorted and undistorted versions of the characters they had learned. Results indicated that subjects performed better on undistorted characters and on characters which were distorted in a way that was consistent with their learning method. In addition, one category of consistently distorted characters, "sloppy lines," actually facilitated character recognition, suggesting that some distortions might contain useful information. Presumably, subjects' tacit knowledge of the method in which the characters were drawn during the learning task aided their recognition of the distorted forms when the distortions could reasonably

result from the original drawing method. These results suggest that readers will perform better when they share the writer's production system. However, it should be noted that the distorted characters used in the recognition task were created by the experimenter and not by subjects trained in a particular drawing method.

More recently, Babcock and Freyd (1988) have demonstrated that some information about the method in which characters are drawn is available to others who later view the static character traces. Their study included an implicit detection task, in which subjects who learned static characters that had been drawn in a particular method (e.g., stroke direction) were more likely to draw the characters in a similar fashion, and an explicit detection task, in which subjects demonstrated an ability to recreate the stroke pattern in which the static characters had been drawn. Although these results indicate that information regarding the drawing method had been incorporated into the static character traces, the exact nature of the information was not investigated in a systematic fashion. Moreover, the experimenters did not look for an effect of these method-based differences on the recognizability of the characters, so there was no test of the common method hypothesis. However, the very presence of discernable method-based differences in a set of hand-drawn characters suggests that such a test is possible.

A more direct test of the common method hypothesis is found in Suen's (1983) article. One group of left- and right-handed subjects generated a large number of characters by writing a sentence in each of three styles: printing, manuscript and cursive. After the sentences had been dissected into individual letters, a second group of left- and right-handed subjects were required to identify each of the letters. If one considers the letters produced by left- and right-handed subjects to be written using different methods, then the common method hypothesis would predict that left-handed readers would be better at recognizing letters written by left-handed writers and that right-handed readers would be better at recognizing characters written by right-handed writers. The implied interaction between the handedness of the writer and the handedness of the reader was not found.

However, there are at least two reasons that this test of the common method hypothesis was not a strong one. First, it is not clear that the left- and right-handed writers used entirely different methods for forming the letters in the

first place. Another experiment in the same paper investigated the actual methods (e.g., stroke orders and directions) used by the same group of subjects when writing characters in boxes. The quickest method for writing a particular letter was the same for left- and right-handed subjects in twenty-one of twenty-six cases (the most common method used by the two groups to form each character is not reported). Second, data regarding the writing methods used by readers was not collected. Thus, it is possible that the group of left- and right-handed readers used different writing methods than their same-handed writer counterparts. In fact, it is entirely possible that there was as much variability within handedness groups across writing and reading conditions as between handedness groups within writing and reading conditions. A stronger test of the common method hypothesis would use writers and readers whose writing methods are known and a set of characters known to be produced in different ways by the two method groups.

In summary, the data regarding the common method hypothesis are equivocal at best. On the positive side, Freyd's (1983) experiment suggests that readers are better at recognizing distortions that are consistent with their "writing" method, but the distortions were generated by the experimenter and the subjects never actually wrote any characters themselves. Babcock and Freyd's (1988) study indicates that readers are sensitive to method-based information present in the static traces of characters. In principle, such information could form the basis for a common method effect if such characters were used in a recognition task similar to that in Freyd's (1983) study and if subjects in the recognition task were practiced in one of the two drawing methods. On the negative side, Suen (1983) reports that there is no interaction between the handedness of writers and readers in a character recognition task. However, the investigator was primarily interested in other questions, so the test of the hypothesis was rather weak.

The Current Research

- *Unanswered Questions*

In this paper we focus on three related questions. First, does the ambiguity of hand-drawn characters vary with the methods in which the characters are drawn? Freyd's (1983) finding that some types of distortion facilitate character recognition suggests the possibility that some character pairs might be distorted in ways which make the members of the pairs more distinguishable, whereas the

finding that other types of distortion make character recognition more difficult suggests that character pairs might also be distorted in ways that make members of the pairs less distinguishable. In other words, if character distortions are somewhat predictable on the basis of drawing method, it should be possible to demonstrate that the use of a common drawing method for two graphically similar characters leads to ambiguity, whereas the use of different drawing methods for the two characters leads to character differentiation. We hypothesize that any marked differences between character pairs drawn using similar and dissimilar methods should be evident in the appearance of the hand-drawn characters themselves. We should be able to measure these differences using a quantitative geometric scale.

Perhaps more importantly, does the use of different drawing methods for members of character pairs lead to distorted versions of the characters that are more distinguishable to humans than the distorted versions of the characters that result from the use of similar drawing methods? In other words, are the effects of drawing method large enough to enable humans to distinguish characters that result from different methods, and are the characters that result from similar methods truly ambiguous to humans? This is really the same question as the first, but the measure of character differentiation is human performance in a recognition task rather than a geometric assessment of the characters. We prefer to keep the questions separate because human performance may be better or worse than geometric measures of character differentiation lead one to predict.

Finally, there is our question about the importance of a shared character production system. Is a subject's ability to correctly identify hand-drawn characters dependent upon the consistency between the method he or she uses when learning the characters and the method used by other subjects when producing the stimuli to be identified? The common method hypothesis suggests that recognition should be better when the writer and reader share a common method for writing the characters. Freyd's (1983) finding needs to be replicated using more naturalistic hand-drawn distortions instead of computerized forms. The results of Babcock and Freyd (1988) suggest that hand-drawn characters might contain enough information to be used as test stimuli in a recognition task similar to that in Freyd's original study.

We should point out that distinguishing between dynamic and static theories of character perception is not one of the goals of this work. Thus, the results of our experiments are consistent with either theoretical stance.

- *An Experimental Approach*

We believe that many of the difficulties associated with much of the research cited above can be overcome if a more experimental approach is used. For instance, we believe that one of the major problems with the mirror reversal research is that the studies are correlational in nature. Except for the D'Nealian research, the drawing "rules" are inferred from the behavior of the subjects and used to predict the kinds of errors that should occur if those rules are overused. In the case of D'Nealian manuscript, there are many variables that could be responsible for the decrease in mirror reversals. It remains to be demonstrated that the use of particular drawing rules actually *causes* any errors at all. It doesn't matter whether the errors are mirror reversals or more subtle distortions like those in figure 1. Drawing rules need to be experimentally manipulated before one can come to any concrete conclusions about the causal relation between rules and errors.

Thus, we believe that subjects should be randomly assigned to drawing rules. Because our college-level subjects already have extensive experience with the methods for writing letters and numbers and in recognizing the distortions that may result from different writing methods, the creation of novel drawing rules necessitates the use of novel characters as well. The use of nonletters is not without its benefits, however. Frith (1971) and Simner (1984) have suggested that the English alphabet is biased toward certain types of characters, leading to alternative explanations of effects once thought to be rule-based. The use of nonletters allows us to eliminate such alternative explanations in the experiments that follow. Frith (1974) also reports that adults have acquired "schemata" for letters that affect both production and recognition processes. These familiarity effects can also be avoided if nonletters are used. Also, it has been suggested elsewhere (e.g., van Galen, 1984) that more research is needed with artificially constructed graphemes.

Finally, we choose to study individual characters rather than groups of characters because it simplifies the experimental process. Thus, the results of our experiments are more applicable to the study of letter formation and recog-

dition than to higher processes involved in writing and reading. We are, of course, aware that letter formation and recognition are dependent on the surrounding context (Gibson and Levine, 1975; Rumelhart, 1977; Wing, 1979; Wing, Nimmo-Smith and Eldridge, 1983). However, a large body of research has shown that the formation of individual letters is the single most important determinant of handwriting legibility (Graham, 1986a, 1986b; Graham, Boyer-Shick and Tippetts, 1989; Graham and Miller, 1980; Quant, 1946; Rondinella, 1963). It therefore seems reasonable to ask our questions at the individual character level.

Experiment 1

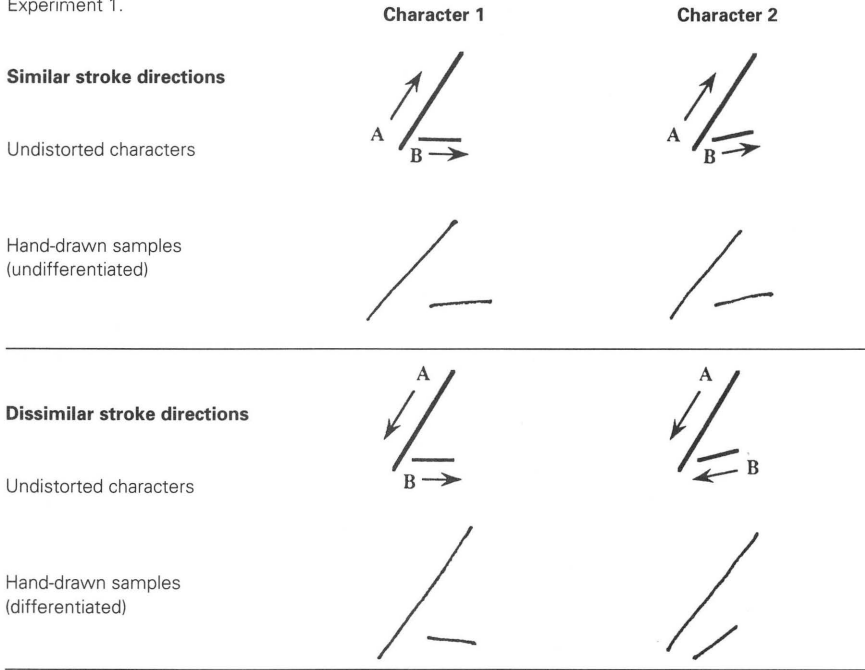
The primary purpose of the first experiment was to determine if the methods used to draw graphically similar characters affect the extent to which such characters become differentiated. A secondary goal of this study was to generate a large pool of naturalistic stimuli to be used in subsequent experiments.

In principle, a drawing method for a particular character or set of characters might have several important aspects, such as stroke order, stroke direction, or the inclusion or exclusion of connecting lines between successive strokes. However, in the interest of simplicity, we varied only stroke direction in the present study. Since it is plausible to expect that the inclusion of additional differences in drawing method might contribute to a higher level of discriminability in the hand-drawn products, the approach taken here is conservative.

We created pairs of graphically similar characters which we thought would remain undifferentiated if drawn using similar stroke directions but would become differentiated if drawn using dissimilar stroke directions. Figure 2 illustrates the manner in which different stroke directions might affect the discriminability of one pair of graphically similar characters. The letters A and B indicate stroke order (A first, then B) and the arrows indicate stroke direction.

When the two characters are drawn using similar stroke directions, as in the top portion of the figure, there is little reason to expect any method-based differences in the appearance of the hand-drawn versions of these two characters, even if they are practiced repeatedly. This is because the drawing methods for the two characters are as similar as possible given the slight difference in the angle of the short stroke, B. We expected this pair to remain

FIGURE 2. The possible effects of stroke direction on the discriminability of a pair of characters. When drawn using similar stroke directions, the characters are expected to remain relatively undifferentiated. When drawn using dissimilar stroke directions the characters are expected to become differentiated. The hand-drawn examples were selected from those produced by subjects in Experiment 1.



relatively undifferentiated if drawn using similar stroke directions. When the two characters are drawn using dissimilar stroke directions, as in the bottom portion of the figure, we anticipated method-based differences in the appearance of the hand-drawn characters. We expected that the difference in direction of the short stroke, B, if practiced repeatedly, would enhance the subtle angle difference present in the original characters. Specifically, we expected that the acute angle between the two strokes A and B would change for one or both of the characters in a way that would make the characters more distinguishable. Since these angles differ for the undistorted characters (the acute angle of character 1 is larger than the acute angle of character 2 by 14 degrees), an enhancement of this difference could lead to a larger angle in hand-drawn versions of character 1, a smaller angle in hand-drawn versions of character 2, or both. In any case, such distortions would result in the acute angle of character 1 being larger than the acute angle of character 2 by an amount that is greater than 14 degrees. Thus, we expected this

character pair to become differentiated if drawn using dissimilar stroke directions.

- *Method*

Subjects. Ten right-handed subjects from the University of Oregon community were paid for their participation in this study. Left-handed subjects were excluded in an effort to simplify the experimental design. This simplification becomes increasingly important in later experiments.

Character construction. Eight two-stroke characters were created and paired with the numbers one through eight (see *figure 3*). However, subjects in this experiment were not aware that the characters were numbered. Each of the characters has at least one diagonal with a positive slope. This is a key feature which allows for a stroke to be drawn in two different directions without feeling awkward.

Two drawing rules were created for each character: a “top-to-bottom” rule and a “left-to-right” rule. Complete statements of these two rules are given in table 1. When either drawing rule is applied to the entire eight-character set, the result is that two character pairs are drawn using similar stroke directions and two character pairs are drawn using dissimilar stroke directions (see *figure 3*). Thus, it was possible to investigate stroke directions (similar or dissimilar) as a within-subjects variable while requiring

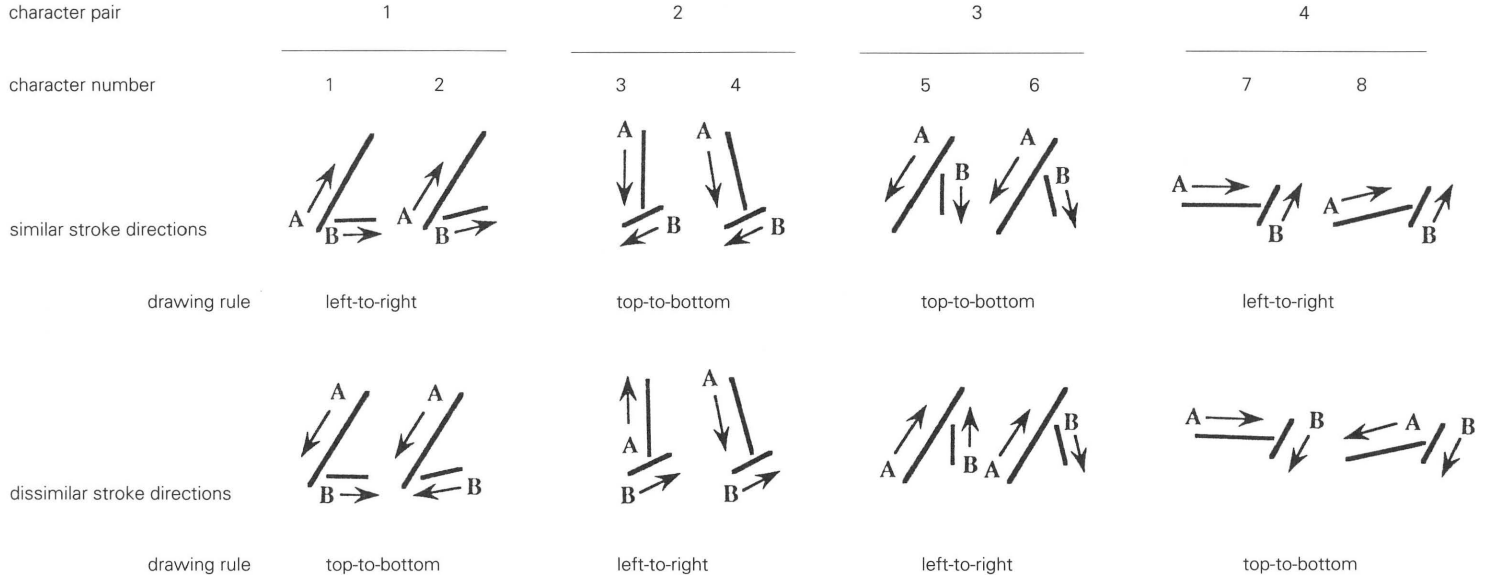
TABLE 1. Complete statements of the two drawing rules.

| Drawing rule | Statement of rule |
|---------------------|--|
| Top-to-bottom | Draw the long stroke before the short stroke. Draw all strokes from top-to-bottom unless they are <i>exactly</i> horizontal. Draw exactly horizontal strokes from left-to-right. |
| Left-to-right | Draw the long stroke before the short stroke. Draw all strokes from left-to-right unless they are <i>exactly</i> vertical. Draw exactly vertical strokes from bottom-to-top. |

that individual subjects learn only one of the two drawing rules.

Practice and test booklets. Two booklets for each drawing rule were created: a practice booklet, illustrating the novel characters and the proper methods for drawing them, and a test booklet. The characters measured approximately 1 x 1 inch and were composed of lines approximately 1/16th inch wide. Space was provided in the booklets so that

FIGURE 3. For each of the eight characters in the two drawing rules, stroke order is indicated with the letters A and B (A first, then B) and stroke direction is indicated with arrows. Members of character pairs drawn using dissimilar stroke directions differ in the direction of one of the two strokes, whereas members of character pairs drawn using similar stroke directions do not differ in the direction of either stroke.



subjects could copy the characters in close proximity to the exemplar characters. The nineteen-page practice booklet consisted of three sections separated by blank pages. The first section contained eight pages, one for each character, presented in numerical order. One character was presented at the top center of each page, along with the letters A and B to indicate stroke order, and two arrows to indicate stroke direction. The rest of the page was blank. The second section was two pages long and consisted of twenty-four characters presented in a random order. Characters were arranged twelve to a page in three lines of four characters each. Letters and arrows were not shown in this section. The third section was seven pages long and consisted of eighty characters (ten copies of each character) presented in a random order. Presentation of the characters was the same as in the previous section, except that there were only two rows of characters on the last page. The test booklet was identical to the third section of the practice booklet.

Experimental procedure. The experiment lasted approximately one hour, including instructions and debriefing. Subjects were tested individually. Five subjects were assigned to each of the two drawing rules (top-to-bottom or left-to-right) and completed a practice booklet and a test booklet using that rule. Subjects used a black roll-tip pen to copy the characters.

After subjects had finished reading the instructions for the entire experiment, they were briefly told one of the two drawing rules and presented with the appropriate practice booklet. In the first section of the booklet, subjects practiced the first character in the correct method for one minute before being told to go on to the next page. This process continued until all eight characters had been practiced.

For the second section of the booklet, subjects were told to copy each row of characters in the space provided beneath that row. Each character was to be copied once using the correct stroke order and direction. This section was included to make sure that the subjects were reasonably familiar with the drawing method before proceeding to the speeded copying in the third section. If the subject made an error when drawing a character, the experimenter immediately pointed out the error and asked the subject to draw the character again in the correct manner. No criteria were set for the appearance of completed characters; only errors of method were corrected.⁴

The procedures used in the third section of the booklet were the same as those used in the second section, except that, in addition to correcting the subject, the experimenter recorded the total number of errors made and the total time spent on the eighty-character copying task. Subjects were told that this was a speeded copying task in which they would be penalized ten seconds for each error made. It was made clear that time and method were of the utmost importance. (A speeded copying task was used because we wanted to maximize the natural distortions that subjects would make in copying the characters.) The procedures used in the test booklet were identical to those used in the third section of the practice booklet. Only data from the test booklet were used in the following analyses.

Angle measurement. The angle of each stroke (relative to the page) was later measured for each of the hand-drawn characters in the test booklets using a protractor and T-square. If a subject had made an error, only strokes from the second, correctly drawn character were measured. Individual subject means for each stroke of each of the eight characters were then computed. Individual subject means for the acute angle between the two strokes of each character were then computed by subtracting the mean angle of one stroke from the mean angle of the other stroke. Finally, composite means for each of the eight characters drawn using similar and dissimilar stroke directions were computed from the individual subject means.⁵

- *Results and Discussion*

Composite means for the acute angles of the eight characters drawn using similar and dissimilar stroke directions are presented in table 2. The difference between these angles is also given for each pair of characters (larger differences indicate that the members of the pair are more differentiated). Within each character pair, the character which has the larger acute angle in the undistorted version (see *figure 3*) also has the larger angle in the distorted hand-drawn versions of the characters, regardless of whether the characters were drawn using similar or dissimilar stroke directions.

However, it was the *size* of these differences that we predicted would vary with the stroke directions used. As predicted, the angle differences between members of character pairs are greater when the characters are drawn using dissimilar stroke directions than when they are drawn using similar stroke directions. Thus, for character pairs 1 and 4,

TABLE 2. Differences between mean acute angles for character pairs drawn using similar and dissimilar stroke directions.

| Pair | Number | Similar stroke directions | | Dissimilar stroke directions | |
|------|--------|---------------------------|-----------------------|------------------------------|-----------------------|
| | | Acute angle (degrees) | Differences (degrees) | Acute angle (degrees) | Differences (degrees) |
| 1 | 1 | 45.6 | 15.4 | 59.3 | 32.3 |
| | 2 | 30.2 | | 27.0 | |
| | | left-to-right | | top-to-bottom | |
| 2 | 3 | 49.8 | 11.4 | 50.5 | 34.3 |
| | 4 | 61.2 | | 84.4 | |
| | | top-to-bottom | | left-to-right | |
| 3 | 5 | 33.3 | 21.3 | 30.2 | 39.9 |
| | 6 | 54.6 | | 70.1 | |
| | | top-to-bottom | | left-to-right | |
| 4 | 7 | 46.3 | 17.2 | 59.3 | 27.6 |
| | 8 | 29.1 | | 31.7 | |
| | | left-to-right | | top-to-bottom | |

Note: Larger differences indicate that the members of the pairs are more distinguishable. Regardless of the drawing rule used, angle differences are greater when the character pairs are drawn using dissimilar stroke directions.

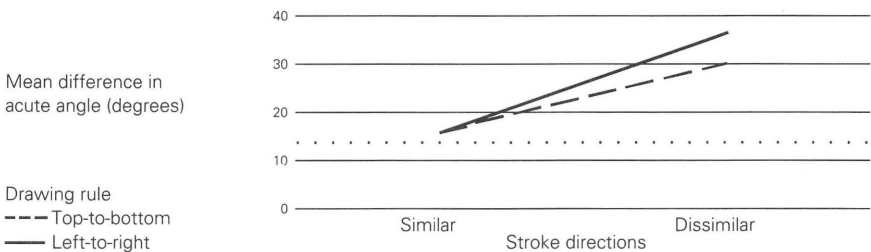
the angle differences between the members of the pairs are greater when the characters are drawn using the top-to-bottom rule. For character pairs 2 and 3, the angle differences are greater when the characters are drawn using the left-to-right rule.

Angle differences between the members of character pairs were subjected to a two-way analysis of variance (ANOVA) using drawing rule (top-to-bottom or left-to-right) as a between-subjects factor and stroke directions (similar or dissimilar) as a within-subjects factor. As expected, the results indicated that drawing rule was not significant [$F(1,8) = 1.16, p = 0.314$]. However, the angle difference between members of character pairs drawn using dissimilar stroke directions ($M = 33.6$ degrees) was significantly greater than the angle difference between members of character pairs drawn using similar stroke directions [$M = 16.3$ degrees; $F(1,8) = 74.70, p < 0.001$]. The effect of stroke directions was larger for character pairs drawn using the left-to-right rule than for character pairs drawn using the top-to-bottom rule, but this interaction was not significant [$F(1,8) = 3.22, p = 0.111$]. The main effect of stroke directions was significant for the top-to-bottom drawing rule [$F(1,4) = 22.82, p < 0.01$] and for the left-to-right drawing rule [$F(1,4) = 56.03, p < 0.01$].⁶ These results are depicted in figure 4.

Since the difference between the acute angles of two members of the same character pair is the same for all pairs of undistorted characters (14 degrees), it was meaningful to compare angle differences for character pairs drawn using similar and dissimilar stroke directions to this value. Single distribution *t* tests revealed that the angle differences for pairs drawn using dissimilar stroke directions were significantly greater than 14 degrees [$t(9) = 9.06, p < 0.001$]. The angle differences for pairs drawn using similar stroke directions were also greater than 14 degrees, but the difference was not significant [$t(9) = 1.24, p = 0.247$]. The results are similar when the two drawing rules are considered individually. For the character pairs drawn using the top-to-bottom rule, the angle differences for pairs drawn using dissimilar stroke directions were significantly greater than 14 degrees [$t(4) = 4.90, p < 0.01$], whereas the angle differences for pairs drawn using similar stroke directions were not [$t(4) = 0.617, p = 0.571$]. Analogous results were obtained for character pairs drawn using the left-to-right rule [$t(4) = 11.81, p < 0.001$ and $t(4) = 2.08, p = 0.106$ for pairs drawn using dissimilar and similar stroke directions, respectively; see note 6].

In summary, these results indicate that only those character pairs which were drawn using dissimilar stroke directions actually became more differentiated, at least as evidenced by differences in angle measurements. Thus, drawing any of the character pairs using dissimilar stroke directions differentiates the members of the pair in the process, whereas drawing the same character pairs using similar stroke directions leaves the pairs relatively undifferentiated. It is important to remember that the labels differentiated and undifferentiated refer only to the distorted hand-drawn versions of the character pairs and not

FIGURE 4. Mean differences in the acute angle for character pairs drawn using similar and dissimilar stroke directions in each drawing rule. The line at 14 degrees represents the acute angle difference for all pairs of original, undistorted characters.



to the original undistorted pairs or to the drawing methods that might have facilitated or hindered differentiation.

Experiment 2

This experiment was designed to investigate whether the perceptions of subjects would mirror the results of Experiment 1. That is, would subjects actually be better able to distinguish between members of character pairs drawn using dissimilar stroke directions in the previous study? To answer this question, we developed a forced-choice tachistoscope task emphasizing within-pair choices. We hypothesized that subjects would be better able to recognize members of pairs drawn using dissimilar stroke directions than members of pairs drawn using similar stroke directions. Secondly, using the Experiment 1 characters as stimuli in a recognition task provides an opportunity to test the common method hypothesis. We thought that subjects might be more accurate when identifying characters which were drawn using their own drawing rule than when identifying characters which were drawn using the other drawing rule.

Given the results of Experiment 1, it may seem that our first prediction is a foregone conclusion. However, the fact that angle differences are greater when pairs of characters are drawn using dissimilar stroke directions than when the same pairs are drawn using similar stroke directions does not imply that subjects will be able to perceive these differences. For instance, subjects might recognize individual characters without reference to knowledge about other characters in the set. Even if subjects do perceive the angle differences measured in Experiment 1, there is no reason to believe that this is the only criterion subjects would use in identifying characters. Other character features (such as stroke length, hooked strokes, or the angle of one stroke relative to the page) might diminish the saliency of the angle between the two strokes. Since we measured only stroke angles in Experiment 1, it is impossible to predict the pattern of discriminability that might arise from subjects' focusing on other character features in the recognition task. This is not to say that a prediction based on the similarity of stroke directions is unwarranted, but rather that any such prediction needs to be tested experimentally.

- *Method*

Subjects. Twenty-one right-handed subjects from the University of Oregon community took part in this study: thirteen received course credit in introductory psychology and eight were paid for their participation. Of those receiving course credit, two were excluded because they failed to

meet the pre-set accuracy criterion described below and three chose not to complete the experiment because it was "too difficult."

Practice and criterion booklets. One twenty-page practice booklet was created for each drawing rule. The first section was four pages long and consisted of two repetitions of the character set. The characters and their corresponding numerals were presented in order, four per page. Letters and arrows were shown to indicate stroke order and direction. Space was provided to the right so that subjects could copy the characters and numerals. In the second section, characters were presented with their corresponding numerals, but without letters and arrows. Four repetitions of the character set were shown in a mixed order in which no character ever appeared twice on the same page. The third section showed characters without letters, arrows or numerals. Four repetitions of the set were shown in a different mixed order. A two-page criterion booklet was also created for use in screening subjects. One repetition of the character set was shown in a random order with no letters, arrows or numerals.

Stimulus and choice cards. Two sets of eighty stimulus cards were created from the characters generated by subjects in Experiment 1: one set composed of characters drawn using the top-to-bottom rule and one set composed of characters drawn using the left-to-right rule. Two examples of each character were selected from the center portion of each of the test booklets in Experiment 1. The characters came from exactly the same locations in each of the ten test booklets. No characters were excluded because they did not look right. If a subject had made an error, only the second, correctly drawn character was used. The individual characters were enlarged by approximately sixty-one percent to a size of about 1 x 1 inch and mounted in the bottom center of 4 x 6-inch tachistoscopic cards. Twenty percent of the characters in the test booklets of Experiment 1 were used to make stimulus cards. A statistical analysis of the selected characters revealed all of the trends previously found for the entire character set (see figure 5).⁷

In addition to the two sets of stimulus cards, a set of fifty-six choice cards was also created. One sixty-point Helvetica numeral appeared in each of the top corners of each choice card. These cards represented all possible presentations of non-redundant digit pairs using the numerals one through eight.

One-inch squares were cut from the top corners of the stimulus cards so that one stimulus card and one choice card could be presented simultaneously, the stimulus card in front of the choice card, using only one tachistoscope field. This procedure allowed the experimenter to select individual examples of characters independently from the choice cards.

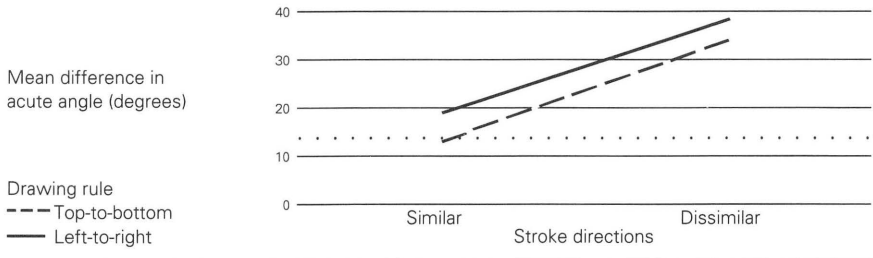
Experimental procedure. The entire experimental procedure lasted about one hour. Subjects were tested individually. Of the sixteen subjects retained in the experiment, eight completed booklets using the top-to-bottom drawing rule and eight completed booklets using the left-to-right drawing rule.

For the practice booklet, subjects were instructed to copy each character once in the correct manner and to write the corresponding numeral beside the character they had drawn. This task remained the same throughout the three-section booklet. The experimenter corrected drawing errors as in the previous experiment. If the subject wrote an incorrect numeral beside the character, the experimenter pointed out the error and told the subject the correct number. Depending on the type of error, the subject either re-drew the character in the correct manner or wrote the correct numeral.

After the practice booklet had been completed, the subject participated in a forced-choice task on the tachistoscope. There was one twenty-trial practice block followed by two eighty-trial experimental blocks. Each experimental block used characters from one of the two drawing rules. The order of the experimental blocks was counter-balanced across subjects. The practice block used the same stimulus cards as the first experimental block. Subjects were not told when the practice block was over and the first experimental block began.

In each trial, one stimulus card (showing a hand-drawn character) and one choice card (showing two numerals) were presented on the tachistoscope.⁸ The subject's task was to decide which of the two numerals corresponded to the hand-drawn character, and to respond by pressing one of two hand-held buttons (the left button if the correct numeral appeared on the left, and the right button if the correct numeral appears on the right). As soon as the subject responded, the cards disappeared and the computer recorded the subject's answer and response time. If the subject did not respond within three seconds, the

FIGURE 5. Mean differences in the acute angle for character pairs drawn using similar and dissimilar stroke directions in each drawing rule. Only data from characters used as stimuli in the recognition task of Experiment 2 are included. The line at 14 degrees represents the acute angle difference for all pairs of original, undistorted characters.



computer beeped, the cards disappeared and no responses were recorded. Other than this limit on response time, no feedback was given during this portion of the experiment.

In each experimental block, the trials were chosen randomly and without replacement from an eighty-trial file that had been skewed in favor of within-pair choices. Of the ten stimulus cards created for each character, four were shown with choice cards depicting within-pair choices and six were shown with choice cards depicting the six possible between-pair choices. The side on which the correct answer appeared was balanced across each of these two trial types. The procedure for the practice block was the same except that only twenty trials were selected from the file. Because the stimulus cards used in the practice block were reused in the first experimental block, it is fairly likely that at least one of these stimulus cards was presented with the same choice card in both blocks (a 77.3 percent chance). However, such occurrences were not expected to affect the results of the experiment.

After the tachistoscope task, subjects completed the two-page criterion booklet. Subjects were asked to write the correct numeral by each character in the booklet in any order they wished. They were not required to copy any of the characters. If the subject did not correctly identify all of the undistorted characters, his or her data from the forced-choice task were excluded from the analyses below.

- *Results and Discussion*

Since we were primarily interested in determining which character pairs were more distinguishable, only within-pair choices were included in the analyses. The fraction of within-pair responses that were correct and the mean

response time for these correct responses were computed for each character pair in each experimental block. Trials in which subjects' response times were less than 250 ms or greater than three seconds were not included in these computations. Less than one percent of the data were excluded on this basis.

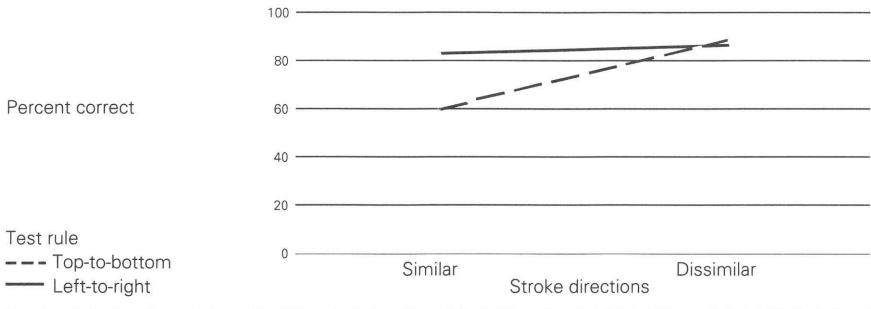
Two separate analyses of variance (ANOVAs) were performed: one for the fraction of responses which were correct and one for the mean response time for correct responses. In both ANOVAs, learning rule (top-to-bottom or left-to-right) was a between-subjects factor and test rule (top-to-bottom or left-to-right) and stroke directions (similar or dissimilar) were within-subjects factors. Learning rule refers to the drawing rule that the subject used in his or her practice booklet, whereas test rule refers to the drawing rule used to create the characters that were shown on the tachistoscope. Initially, block order was also considered as a between-subjects factor. However, since there were no significant main effects or interactions involving this factor, the data were collapsed across block order for these analyses.

There were no significant main effects or interactions when response time was used as the dependent measure. However, several interesting trends were evident in the accuracy data. As predicted, subjects were significantly more accurate when considering members of character pairs drawn using dissimilar stroke directions ($M = 86.5$ percent correct) than when considering members of character pairs drawn using similar stroke directions [$M = 71.5$ percent correct; $F(1,14) = 44.43$, $p < 0.001$]. There was also a significant main effect of test rule [$F(1,14) = 13.59$, $p < 0.01$]. Subjects were more accurate on characters drawn using the left-to-right rule ($M = 83.8$ percent correct) than on characters drawn using the top-to-bottom rule ($M = 74.3$ percent correct).

The interaction between these factors was also significant [$F(1,14) = 53.84$, $p < 0.001$]. The accuracy difference between members of character pairs drawn using similar and dissimilar stroke directions was much greater when the pairs were drawn using the top-to-bottom rule (28.2 percent) than when the pairs were drawn using the left-to-right rule (1.9 percent). These results are shown in figure 6.

As expected, there was no main effect of learning rule ($F < 1$). However, the expected interaction between learning rule and test rule was also absent ($F < 1$). Thus, the results of this experiment do not support the hypothesis that recogni-

FIGURE 6. Accuracy levels of Experiment 2 subjects viewing members of character pairs drawn using similar and dissimilar stroke directions in each test rule. Data are shown for each of the two test rules, but have been collapsed across learning rule and block order.



tion is improved when readers and writers share a common production system. However, it may be that in this instance the predicted interaction was masked by the unexpectedly large main effect of test rule. Alternatively, subjects may not have been given enough practice at drawing the characters to fully master the drawing rules. This is quite possible, since the practice booklet used in this experiment contained only ten repetitions of the character set, compared to well over thirty repetitions (more or less, depending on the number of characters drawn in the first section of the practice booklet) in the booklets of Experiment 1. If the subjects failed to learn a particular drawing rule adequately during the practice booklet, there would be no reason to expect that they would perform better on characters which had been drawn using the same rule.

The main effect of test rule and the interaction between the test rule and stroke directions factors both appear to be primarily the result of subjects' unexpectedly high level of accuracy on trials depicting members of character pairs drawn using similar stroke directions and the left-to-right drawing rule (i.e., the trials represented by the upper left-hand point in *figure 6*). Why were subjects so accurate when viewing these characters?

One possible explanation is evident from *figure 5*. The members of these character pairs have acute angles that differ by 19.2 degrees whereas the members of character pairs drawn using similar stroke directions and the top-to-bottom drawing rule have acute angles that differ by only 12.1 degrees. Neither of these means is significantly differ-

ent from the 14-degree value for undistorted characters, especially if the Scheffé correction for post hoc comparisons is employed [$t(4) = 2.06$, $p = 0.108$ and $t(4) = -0.42$, $p = 0.694$, respectively; see note 6]. However, this difference only gives us a measure of the amount of additional differentiation, if any, that resulted from the drawing rule. Such a comparison is much less useful here than in Experiment 1. Perhaps the minimum angle difference that is sufficient for subjects to adequately distinguish hand-drawn versions of similar characters in this character set lies somewhere between 12 and 19 degrees.

Alternatively, subjects may have used some other factor to distinguish between members of similar character pairs in the recognition task. For example, subjects may have been sensitive to the angle of one stroke relative to the page rather than to the angle between the two strokes of each character. To test this hypothesis, a second analysis of the subset of Experiment 1 characters used in Experiment 2 was conducted using the angle of one stroke (relative to the page) as the dependent measure. For each character pair, only the stroke which distinguished between members in the dissimilar stroke directions condition was considered. In character pair 1, for example, only the angle of stroke B was considered. We reasoned that subjects might use only the angle of stroke B (and not the angle between strokes A and B) to distinguish the members of pair 1. Likewise, stroke B was considered for pair 3, and stroke A was considered for pairs 2 and 4 (see bottom row of figure 3 for distinguishing strokes).

Using this measure, members of character pairs drawn using the left-to-right rule (test rule in Experiment 2) and similar stroke directions were found to be significantly more differentiated than their undistorted counterparts [$t(4) = 13.68$, $p < 0.001$; see note 6]. All other results were the same as in the original analysis of the characters used in Experiment 2. In other words, some pairs of characters found to be undifferentiated using the "acute angle between strokes" measure were found to be differentiated using the "angle of distinguishing stroke" measure. Thus, it is entirely possible that the subjects' use of criteria other than the difference in acute angle may have resulted in improved performance on the characters in question. Subjects may have used other criteria throughout the recognition task, either in conjunction with, or instead of, the difference in acute angle, or they may have resorted to other criteria only when the difference in acute angle failed to adequately distinguish between similar charac-

ters. The angle of the distinguishing stroke is one such alternative criterion that may have improved subjects' performance on members of character pairs drawn using similar stroke directions and the left-to-right drawing rule.

In summary, the results of this experiment lend support to the hypothesis that subjects are better at distinguishing members of pairs labelled differentiated in Experiment 1. However, this was only true for character pairs drawn using the top-to-bottom rule. Apparently, members of all character pairs drawn using the left-to-right rule were differentiated to a sufficient extent to make the forced-choice task relatively easy for subjects in this study, regardless of whether the characters were drawn using similar or dissimilar stroke directions.

The anticipated interaction between learning rule and test rule was not observed. Thus, there is no evidence for a common method effect in these data. However, it once again seems likely that the high degree of differentiation in character pairs drawn using the left-to-right rule made choices between members of those character pairs easier for all subjects regardless of their learning rule. On the other hand, the practice booklet may have been too short for subjects to adequately learn a drawing rule before progressing to the tachistoscope task. The next experiment was designed to investigate the possibility of a common method effect while avoiding these problems.

Experiment 3

The purpose of this experiment was to retest the hypothesis that subjects would be more accurate when identifying characters which were drawn using a familiar rule than when identifying characters which were drawn using an unfamiliar rule. In order to avoid possible ceiling effects resulting from subjects' high level of performance on characters drawn using the left-to-right rule, we decided to use only those stimulus cards which depicted characters drawn using the top-to-bottom rule. Subjects learned half of the character set using the top-to-bottom rule and half of the character set using the left-to-right rule. Because test rule was not varied in this experiment, the hypothesized relationship between learning rule and test rule (the common method effect) would be seen as a main effect of learning rule. To insure that subjects adequately learned the correct drawing rule for each character pair, a longer practice booklet, similar in form to the booklets used in Experiment 1, was used in this experiment. We were also interested in determining the time-course of

such learning rule effect, if it existed. For instance, subjects might learn to identify characters drawn using one rule more quickly than those drawn using another. Alternatively, there might be no change in the magnitude of a learning rule effect over time. Since we had no reason to suspect that either of these possibilities was more likely than the other, we made no predictions regarding the time-course of the anticipated learning rule effect.

- *Method*

Subjects. Fifty-nine right-handed University of Oregon undergraduates received course credit in introductory psychology for participating in this study. Data from twenty-seven of these subjects were excluded from the analysis because the subjects failed to meet the pre-set accuracy criterion, described below.

Accuracy criterion. Our pre-set accuracy criterion, designed to be independent of the experimental factors of interest, was that a 75 percent overall accuracy rate be achieved by the end of the recognition task. This accuracy level represents the half-way point between chance and perfection. Although we suspected that the brevity of the recognition task (one eighty-trial block with no practice) might present some difficulty for subjects, we did not anticipate that it would be necessary to test fifty-nine subjects in order to get the planned thirty-two subjects (eight subjects in each of four conditions). In fact, we thought that greater familiarity with the characters (resulting from longer practice booklets) would offset the brevity of the tachistoscope task. A post hoc inspection of the data collected on the twenty-seven excluded subjects suggests that the high percentage of excluded subjects did not affect the experimental results.

Learning rules. We required that each subject learn one character pair using similar stroke directions and one character pair using dissimilar stroke directions in each of the two drawing rules. Eight subjects completed the experiment in each of four learning rule/stroke direction combinations.

Practice booklets. Subjects practiced drawing the characters in booklets very similar to practice and test booklets used in Experiment 1. However, characters in the first section of the booklet were not presented in numerical order as in that experiment. Instead, characters were presented in a mixed order in which members of the same pair were grouped together. The exact presentation order used for the eight characters in this experiment was 6, 5, 7, 8, 4, 3, 1, 2.

The test booklet of Experiment 1 was included as a fourth section of the practice booklet in this experiment to insure that subjects had as much practice at drawing the characters as did the subjects who generated the characters used for the stimulus cards. There was no test booklet in this experiment.

Stimulus and choice cards. Only those stimulus cards from Experiment 2 which depicted characters drawn using the top-to-bottom rule were used. All of the choice cards from that experiment were used. In addition, one set of eight cards depicting the undistorted characters was made. These characters were identical to those in the booklets. Each of the undistorted characters was mounted in the bottom center of a 4 x 6-inch tachistoscope card. The top corners were not cut out of these cards as they were not intended to be shown simultaneously with choice cards.

Experimental procedure. As before, the individually-tested subjects completed the experiment in about one hour. Because the experimenter was required to monitor the subjects' drawing methods and quickly correct subjects if they made any mistakes, it was not possible to run subjects from the four learning rule/stroke direction conditions in a random order. Instead, the experimenter continued running subjects in one condition until eight subjects had met the pre-set accuracy criterion. Only then did he move on to the next condition.

Subjects completed the practice booklet according to the procedure in Experiment 1. However, since the subjects learned half of the characters using the top-to-bottom rule and half using the left-to-right rule, it was not possible to tell them a simple drawing rule which applied to all of the characters. This made completion of the practice booklet somewhat more difficult. The experimenter corrected subjects' errors in the last three sections and timed the subjects in the last two sections of the booklet, just as in Experiment 1.

After the subjects completed the practice booklet, they participated in a forced-choice task on the tachistoscope.⁹ The task was very similar to that described in Experiment 2. There were several important differences, however. The subjects' task was to learn to pair the numerals one through eight with the characters they had already practiced. To facilitate this learning task, subjects were given auditory feedback by the computer. If the response was correct, a short, high-pitched tone (250 ms, 1800 Hz) was

played. If the response was incorrect, a longer, lower tone was played (1000 ms, 600 Hz). In either case, the stimulus and choice cards disappeared as soon as the subject responded. If no response was made within three seconds, the cards disappeared and a pulsing tone was played (five 50-ms, 1200-Hz tones separated by 50 ms of silence, for a total duration of 950 ms). These tones were demonstrated to the subjects before the task began.

Also, to reduce the amount of guessing during the initial trials, cards depicting the undistorted characters were shown in order, one through eight. Each card appeared in the viewing field for three seconds. During this time, the experimenter told the subject the number that corresponded to the character being shown. The test trials began immediately thereafter.

Individual trials were identical to those in the previous experiment. However, the eighty experimental trials were divided into five blocks of sixteen trials each so that the time-course of subjects' learning might be investigated. Subjects were not aware that the trials had been divided in this way. Since we were interested in monitoring subjects' progress beginning with the very first trial, there were no practice trials in this experiment. Within each of the five blocks of experimental trials, there were eight within-pair choices and eight between-pair choices. Each character appeared once in each of these trial types. The side on which the correct numeral appeared was chosen randomly for each trial.

The fraction of responses that were correct and the mean response time for correct responses were computed for within-pair choices for each of the four character pairs in all five blocks of the experiment. In addition, the fraction of responses that were correct was computed over all trials (including within-pair and between-pair choices) in each of the five blocks. As before, trials in which subjects' response times were less than 250 ms or greater than three seconds were not included in these computations. Less than three percent of the data were excluded on this basis.

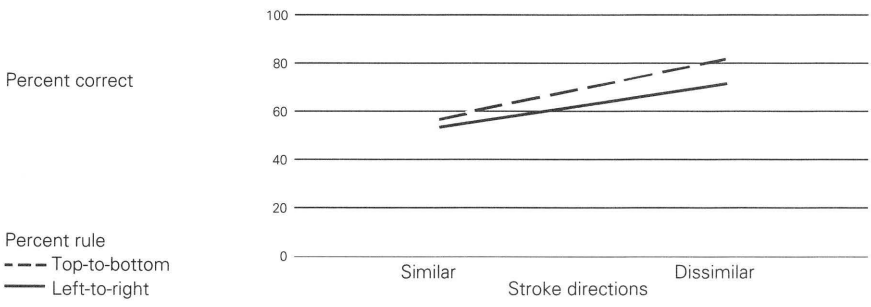
The fractions of responses that were correct (computed over all trials) for the last two blocks were averaged for each subject and the resulting fraction was used as a criterion for inclusion in this study. Data from subjects who did not average 75 percent correct responses over all trials in the last two blocks were excluded from the analysis below.

- *Results and Discussion*

As before, only within-pair choices were considered in the data analysis. Because of the large number of cells in which individual subjects made no correct responses, we were unable to consider the mean response time for correct responses as a dependent measure. Hence, data were analyzed using only the fraction of responses that were correct. A three-way ANOVA was conducted using learning rule (top-to-bottom or left-to-right), stroke directions (similar or dissimilar) and block number (1, 2, 3, 4 or 5) as within-subjects factors.

In contrast to Experiment 2, the results of this experiment indicate a significant common method effect, which shows up here as an effect of learning rule [$F(1,31) = 5.76, p < 0.05$]. Subjects were more accurate when viewing members of character pairs they had learned using the top-to-bottom rule ($M = 69.7$ percent correct) than when viewing members of character pairs they had learned using the left-to-right rule ($M = 63.8$ percent correct). In other words, subjects were significantly more accurate when viewing characters which had been drawn using the rule they had learned during the practice session. This effect of learning rule was in the predicted direction for all four character pairs. The effect of stroke direction was also significant [$F(1,31) = 51.94, p < 0.001$]. Subjects were more accurate when viewing members of pairs drawn using dissimilar stroke directions ($M = 77.2$ percent correct) than when viewing members of pairs drawn using similar stroke directions ($M = 56.2$ percent correct). These results are depicted in figure 7.

FIGURE 7. Accuracy levels of Experiment 3 subjects viewing members of character pairs drawn using similar and dissimilar stroke directions in the top-to-bottom rule. Data are shown for each of the two learning rules, but have been collapsed across block order.



Block order also yielded a significant effect [$F(4,124) = 6.52, p < 0.001$]. Subjects became more accurate as the experiment progressed. There were no interactions between any of the three factors.

The results of this experiment indicate that the method in which subjects practice drawing characters significantly affects their ability to pair those characters with their corresponding numerals. This common method effect holds for all four character pairs in the study. However, there was no indication that the method in which subjects practiced drawing the characters had any bearing on the time course in which the corresponding numbers were learned. It should also be noted that subjects in this experiment learned the characters and their names (in this case, their corresponding numerals) in an unusual way. Normally, people would be expected to practice the character name simultaneously with the drawing method, as in Experiment 2. We deviated from this procedure in Experiment 3 so that we could monitor the time-course of the learning process for the corresponding numbers. Thus, we have demonstrated only that learning to draw characters in a particular method affects subjects' ability to learn the corresponding numerals in a later task. It remains to be demonstrated that a similar common method effect occurs when the characters and their corresponding numbers are learned simultaneously.

General Discussion

The answers to the first two of the three questions raised at the beginning of this paper now seem fairly clear. First, drawing method can affect the appearance of individual characters and the differentiation of character pairs in a predictable manner. Second, these differences can be shown to affect the performance of human subjects in a character recognition task. Thus, the results of the first two experiments provide further confirmation of Babcock and Freyd's (1988) finding that the method in which characters are drawn affects the final static traces of the characters. However, these results extend their findings in two important ways. First, the method in which the characters were drawn was shown to affect their appearance in a way which was quantifiable by a simple geometric measure, whereas Babcock and Freyd's study relied only on subjects' perceptions to demonstrate differences in the static character traces. Second, these results show, for the first time, that drawing method can affect the discriminability of character *pairs*. Differences in character pair discriminability were found when the character pairs were measured

geometrically and when subjects identified members of the character pairs in a forced-choice tachistoscope task.

On the other hand, the answer to our third question is much less clear because Experiments 2 and 3 provide conflicting information about the presence of a common method effect. Although Experiment 2 provides no evidence for such an effect, there are several alternative explanations for the negative finding. In Experiment 3, the finding that subjects are better able to correctly pair characters with their corresponding numbers when viewing characters which were drawn in their own method is consistent with the results of Freyd's (1983) study and the notion that recognition performance is increased when readers and writers share a common production system. However, this result must be interpreted cautiously because subjects learned the characters in an unusual way. Still, these results represent the first evidence of recognition differences which are directly related to the dynamics of the learning method for *hand-drawn* characters.

The common method effect of Experiment 3 does not distinguish between static and dynamic theories of character perception, however, because subjects saw not only the undistorted characters in the learning process (as in Freyd's 1983 experiment), but also many examples of their own distortions. Therefore, the observed common method effect is consistent with theories of either type. Static feature-analytic theories would predict enhanced performance for members of differentiated pairs on the basis of real configural differences like those shown to exist in the first experiment, even though such differences were clearly the result of the different methods used to create the characters. Likewise, subjects would be better at recognizing characters drawn in their own method, since such characters would look more like the ones that the subjects generated themselves.

In contrast, a dynamic theory of character perception would consider any configural differences in characters generated in Experiment 1 to be dynamic in origin. Therefore, the presence of such cues would serve to convey information about the method in which the characters were drawn (as in Babcock and Freyd, 1988). This methodological information could be later tapped by subjects in the character recognition task. Clearly, such information would be most useful in recognizing characters which were drawn in the subject's own learning method (since only familiar dynamic cues would be present) and in

recognizing members of character pairs drawn using dissimilar stroke directions (since members of these pairs would contain different, and therefore distinguishing dynamic cues). Thus, these experiments do not provide any information which favors either static or dynamic theories of characters perception per se. However, the results presented do echo previous suggestions that the dynamics of the learning process are indeed important.

Although in the strictest sense the results of these experiments are generalizable only to novel character pairs which are highly confusable, we feel that these conditions will be met by certain character pairs in the English alphabet. Specifically, we feel that the results are applicable to confusable character combinations like those presented earlier because those characters may be considered novel to a child who is just learning the alphabet. It is not known how long the reported effects may persist in the face of continued experience with the character set.

Even so, the finding that the drawing method in the learning process affects both the appearance of the characters and the writer's perceptions of characters drawn by other individuals may have implications for the teaching of handwriting. The results of Experiments 1 and 2 suggest that confusion between similar characters will be reduced if different stroke orders or directions are used for those characters. Thus, the confusion between the script versions of b and f or d and cl might be reduced by altering the method of production for one of the members in each confusable pair.

However, Freyd's (1983) results and the results of Experiment 3 suggest that creating new drawing methods for characters might make those characters more difficult to recognize for individuals who have already learned to form them in the currently accepted way. It might not prove beneficial to create new drawing methods to disambiguate similar characters since such a change might lead to confusions for the individual characters themselves.

Nonetheless, if there were ever a broad-based movement to standardize the methods of character production, say, for English script or Arabic numerals, it is possible that such confusions would be short-lived. The interim difficulties might be outweighed by the long-term benefits of a more unified vehicle for communication, just as the benefits of adopting the metric system in the United States would probably outweigh the costs of the changeover. In

any case, it seems clear that there should be more emphasis on teaching students a common writing method and less emphasis on students' ability to conform to the standard model for each character.

ENDNOTES

- 1 Character pair refers to two characters that may be confused with each other (i.e., the c/e character pair) and not to two linked characters (i.e., cl) that may be confused with another character (d, in this case).
- 2 We use the term hand-drawn rather than handwritten because we are interested in nonletters as well as letters. Nonletters are used in the experiments reported in this paper.
- 3 The terms differentiate, distinguish and discriminate have very similar meanings, as do their derivatives. Throughout this paper, we use the term differentiated to refer to pairs of characters that, as the result of the writing process, have become more different from each other than were the original, undistorted exemplars. We describe the characters as distinguishable if such differentiation is noticeable to later observers. If the differentiation is noticeable, then the characters (or character pairs) are said to have the property of discriminability.
- 4 Two types of errors were considered drawing method errors: errors of stroke order and errors of stroke direction. If a stroke drawn in roughly the same direction as the long stroke, A, was followed by a stroke drawn in roughly the same direction as the short stroke, B, the character was considered to be drawn using the correct method. Stroke direction was determined by comparison of the beginning and ending points of the stroke and was based on experimenter judgment. In principle, this could have presented a problem in the case of lines that were drawn nearly perpendicular to the correct stroke direction. However, since no hand-drawn strokes differed from the correct angle by more than about 45 degrees, such judgments were not difficult and do not represent a source of bias in the final set of hand-drawn characters. Incorrect stroke length or placement were not errors of method since they did not violate the drawing rule. Such errors were not corrected by the experimenter. All of the characters accepted by the experimenter could be described as "reasonable distortions" of the characters being copied. Other authors (e.g., Suen, 1983) have also used experimenter judgment as a basis for real-time error correction.
- 5 The angle between the two strokes was determined by subtraction rather than direct measurement because the strokes usually did not intersect. Direct measurement would have required extending the strokes to their point of intersection, potentially introducing greater measurement error. Subtraction always resulted in a measure for the angle that corresponded to the acute angle between the strokes of the undistorted character, even though this angle may have been greater than 90 degrees for some individual hand-drawn characters. Subtracting the mean angle of one stroke from the mean angle of the other stroke yields the same result as subtracting first and then computing the mean.
- 6 For all significant post hoc comparisons, F values for simple effects and F values that correspond to stated t values ($F = t^2$) exceed the Scheffé adjusted critical value for F [for example, the adjusted critical value equals $3 \times F_{\text{critical}}(3,16) = 9.72$ in the first case].
- 7 A table analogous to table 2 is available from the first author.
- 8 Stimulus and choice cards were presented using a Gerbrands G1135 four-field tachistoscope equipped with a Gerbrands 404A lamp driver. The tachistoscope was controlled through a Gerbrands G1157 computer interface that had been adapted for use with an IBM PC/XT.
- 9 The tachistoscope and computer were the same as used in Experiment 2.

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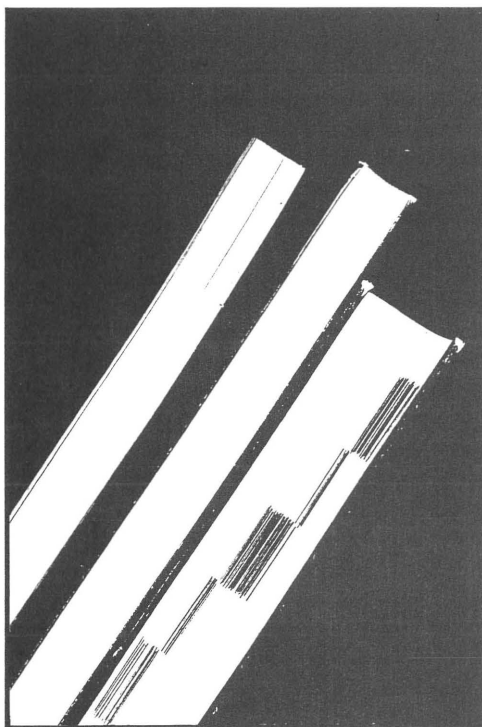
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ACKNOWLEDGEMENTS

This research was supported by the National Institute of Mental Health grant RO1-MH39784 and National Science Foundation Presidential Young Investigator Award BNS-8451356 to the second author. The manuscript was prepared in part while the second author held fellowships from the Center for Advanced Study in the Behavioral Sciences and the Guggenheim Foundation. We wish to thank J.Q. Johnson, Charles Lehman, Teresa Pantzer, Marjorie Taylor and two anonymous reviewers for their comments on earlier versions of this paper.

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Language and Typography. Cal Swann. New York: Van Nostrand, 1991. 94 pages, large format, amply illustrated, many photos, black and white. \$19.95

Cal Swann's book, *Language and Typography*, is a useful, concise and well-illustrated contribution to the array of introductory works published about document design. It is, as its back cover states, "a[n] introduction to the basic theories of language and its visible transmission as typography." Swann aims his book at "students of design and language and all those who seek an opening into either or both of the two fields."⁹ With this focus on language and design, Swann's central thesis is to suggest how typography operates on both linguistic and graphic levels. He ultimately prescribes that the creator of visible language should pay greater attention to and even investigate further how the basic principles of these two subjects are intertwined in visible language.

Swann divides his book into five chapters, each dedicated to important concepts about creating visual communication. Chapter 1, "Introduction to Language as Human Communication," is the first of two chapters he uses to establish a foundation of knowledge for the readers he targets. He addresses fundamental concepts about language and communication—defining what language is and what its components are, describing the evolution of world languages, and explaining the communication process and communication codes. The focus of this chapter is to show how verbal language and printed, visual symbols of a language are linked. It also introduces the importance of context to any act of communication, especially as symbolically designed messages are fixed in the context of their written/printed/painted forms.

In chapter 2, "A Developing and Living Language," Swann completes his introductory material by exploring in more detail the historical development of language, especially in the typographic forms that have evolved over the centuries. He explains the global impact that English has had and how certain Americanisms have permeated other cultures. Swann's objective is to show how the changes in language also affect the typographic, symbolic presentations of it.

Typographic and orthographic systems manage how well messages are sent and perceived in print. Chapter 3, "The Visual System," begins the substance of Swann's work. He explains some general guidelines for spatial and contex-

tual use of typographic elements. Swann uses many visual examples of the concepts he describes, many of which come from signs, logos, marquees and others from everyday use. Dovetailing with his earlier discussion in chapter 1 about the connection between verbal and visual language, and applying his analysis about the historical development of symbols for language, Swann explains the sensory reception of language through the human body's aural and visual systems. The most notable segment on the aural-visual connection between language and typography is the discussion about "prosodic visual cues." As Swann states, "In speech, variations in pitch, loudness and speed are referred to as 'prosody.' In print different letter forms have been used to signify stress or emphasis . . . The small variations in weight or style of type may have little effect upon the legibility of the visible language, but they can have an important effect on the tone and attitudes which the author wishes to convey." (48) Swann discusses the impact of various formats to illustrate his analysis about the visual system of language. He examines the usability of list formats in a telephone book and a train schedule, the artistic rendering of words to form shapes in visual poetry, the design of forms for bureaucratic purposes, and the visual explanation of a process shown in a flow chart.

Swann's fourth chapter, "Forms and Connotation," takes a significant leap into his argument about the relationship between the symbols of language and the visual presentation of a message. He argues that "Content and form are essential elements in making a message . . . Placed in an appropriate context as the important third element, communication can take place . . . Written language and typography have parallel levels of content, form and context. The content is the spelling, syntax and semantic structure of the words and the form is the visual nature and arrangement of the typography." (54) Similarly, the context of a visual message is established through "[t]he style of the letterforms, size, weight and spatial distribution." (54) Swann takes this analysis through various examples to show how the visual aspects of a written/printed message contribute to a reader's reception of a message and lead to understanding its meaning, including the impact of aesthetic appeal, size and space of typographical elements, form versus function, and function versus form of typographical design.

Swann's fifth and final chapter, "Visible Speech," ties together his preceding analyses about the linguistic connections between the spoken word and its printed forms.

He argues that there is an “aural and [a] visual literacy” that we only begin to develop when we are very young that comes from our mastering, first, the grapheme shapes of a language, and second, the motor skills to form them (75). However, Swann feels that teaching the visual, graphical importance of a written/printed message should be done beyond the rudimentary mastery of orthographic skills. Our schools separate aesthetic judgment of written/printed discourse into “art teaching” and “English” as separated subject areas (75). Rather than striking a balance between the two types of literacy, aural literacy, which is focused on training people to read, write, and speak a common language competently, is favored largely over visual literacy, which involves skills that are typically reserved for training specialists in design. To illustrate this point, Swann presents five examples of variously effective signs created by people with varying levels of skill and competence in rendering graphic communication. He analyzes them for both their linguistic and their visual effectiveness as they relate their content and form to the context of the situation in which they are read.

Swann concludes the fifth chapter and his book by philosophizing about how visible language can best be analyzed. He suggests a scheme for analysis that requires making specific assessments about five successive categories or aspects of “visible language.” It is comprised of “a first-stage ‘overview’ to describe the item and a final stage for conclusions [about its effectiveness], [between which] there are three main areas concerned with the physical structure [or, the visual and textual elements of a written/printed form], the sociological context [or, the cultural, subcultural, stereotypical, and ideological contexts of the form], and the psychological states of the sender and receiver”(89). Swann then applies this scheme by analyzing an advertisement.

Clearly, Swann’s book is a treatise on the visual presentation of language using typographic elements. The design of the book itself, one would presume, is meant to illustrate the concepts he addresses, to present pertinent examples and to counsel us about creating visible messages. It is ironic, however, that his book has some important design problems. Although the page design is at first glance attractive, it is difficult to use. The page layout typically reserves the top portion of the pages (each measuring 11 3/4 inches by 8 1/4 inches) for text, which is placed in two columns on the right half of each page, and the lower portion of the pages for illustrations. This layout

in itself is not problematic, but the poor judgment to place the text very close to the right edge of the page results in it running into the gutter on all even-numbered, left-hand pages. I found it inconvenient to have to bend the book abnormally open to see the text that is hidden in the gutter. Furthermore, since all pages have the text placed on the right half of the upper portion of the pages, the running heads are difficult to find (if, for example, you flip through the pages to find specific topics), because they are essentially placed around the top-center of the pages. I also found that the visual breaks between chapters were poor. Because each chapter begins immediately after one concludes, this problem is linked to, I believe, an ineffective use of typographic emphasis for the chapter titles and subsequent headings to signal the beginning of each chapter. Even though Swann uses space around these titles and headings, the weight of their typefaces is identical to the weight of the text type. Chapter titles, headings, and sub-headings would be more effective if he used boldfaced and enlarged typefaces.

On a scholarly level, I found that Swann does a poor job documenting his sources. There are instances when he quotes or otherwise paraphrases other scholars and does not give complete citations elsewhere in the book (neither in his “Recommended Reading” sections that follow each chapter, nor in his “Bibliography” at the end of his book). So his bibliography does not reflect all the sources he used in the text or in his recommended reading lists. Perhaps he should have used two separate lists to better manage his references at the end of the book—one as an annotated list for recommended reading and another for the works cited. These problems may not be easily overlooked by more experienced and demanding readers. Perhaps Swann felt that they may not be important in an introduction of typography to beginning, less experienced, and less demanding students of the subject. Yet there is no substitute for good scholarship and good document design for any reader regardless of their level of familiarity with the subject.

As you read Swann’s book, you will see that he teases you with complex issues like discourse communities, reception theory, schema theory and intertextuality in very simple deconstructionist terms. He also skims the surface of semiotics and rhetoric as they apply to typographic design and visible language. His linguistic approach toward analyzing visible language almost seems related to the general semantics movement championed by the likes

of Alfred Korzybski and S.I. Hayakawa. If you are a willing reader who would forgive the design and scholarly flaws of this book, you will certainly come away with interesting and somewhat innovative ways to look at the visible language that bombards us daily. If you or anyone you know design documents, especially if a novice in this field, Swann's book would be a very useful and succinct thought-starter for creating visible language.

Reviewed by Peter M. Smudde, a Ph.D. candidate in Communication at Wayne State University. He was formerly a technical editor for training materials at AT&T and is currently a developer of owner use and care information for General Motors Corporation.

BOOKS RECEIVED

Andrew Carstairs-McCarthy
Current Morphology
 London and New York: Routledge, 1992
 290 pages, paper, \$22.50; cloth, \$77.50
 ISBN 0-415-07118-6

Influential developments in theoretical linguistic approaches to morphology during the past twenty years are the focus of this survey. The book addresses questions relating to morphology and the shape of universal grammar as well as morphological issues as distinguished from lexical, phonological and syntactic issues. The audience for this volume is not the novice or those interested primarily in generative work.

Giorgio Fano
The Origins and Nature of Language
 (Translated by Susan Petrilli)
 Bloomington: Indiana University Press, 1992
 333 pages, cloth, \$57.50
 ISBN 0-253-32121-2

This is the first English translation of Fano's *Saggio sulle origini del linguaggio*. His goal in this book is to outline a general theory of expressive signs by examining research that explores the relationship between semantics, aesthetics and logic. While language origins remain a realm of speculation, this author advances the theory that the basis of verbal language is mimetic/gestural. It is characterized by structure, indexicality (the gesture) and iconicity (mimicry, similarity, images). The author brings together many theoretical and evidentiary threads among which

are: child language invention, mimetic languages created by uneducated deaf-mutes, observation of anthropoid apes' expressive capacity, conclusions from analyses of diverse writing systems, reviews of various language theories from the Greeks to artificial intelligence and problems of spirituality and expression in language.

Bob Gill

Graphic Design Made Difficult

New York: Van Nostrand Reinhold, 1992

160 pages, illustrated, paper, \$29.95

ISBN 0-442-01098-2

The author/designer presents his design process in which he underscores the need to *communicate* with clarity and vitality. The primary idea is to redefine the communication problem in order to release its creative and/or communicative potential. This is a book for looking rather than reading as Gill gives verbal and visual examples for his redefined one-liners.

Philip B. Gough, Linnea C. Ehri and Rebecca Treiman

Reading Acquisition

Hillsdale, New Jersey: Lawrence Erlbaum, 1992

384 pages, cloth, \$69.95

ISBN 0-8058-0113-8

Twelve international papers from the English-speaking world are presented. The authors are psychologists involved in basic research in learning to read. They cover such topics as: learning the alphabetic cipher, phonological awareness, syntactic awareness, comprehension and metalinguistic awareness. Other discussion within this volume includes constructions of the research/testing configuration and examination of the pros and cons of teaching reading with the whole language approach or the code emphasis approach.

Victor Margolin

Design Discourse, History Theory Criticism

Chicago: University of Chicago Press, 1989

292 pages, cloth, \$55.00; paper, \$17.95

ISBN 0-226-50514-6

Victor Margolin is one of the founding editors of the journal *Design Discourse*. In this book he collects twenty essays from the journal, organizing them under three frameworks: examination of design in relation to critical strategies; investigation of new methods to interpret and

analyze design; and design in relation to history. The middle section, *Interpretation of Design*, contains articles of interest to readers of *Visible Language*. Articles such as Abraham Moles' "The Legibility of the World: A Project of Graphic Design"; Ellen Lupton's "Reading Isotype"; Jack Williamson's "The Grid: History, Use and Meaning"; and Robin Kinross' "The Rhetoric of Neutrality" indicate the nature of this section.

W. Barnett Pearce

Communication and the Human Condition

Carbondale: Southern Illinois University Press, 1989

220 pages, cloth, \$16.95; paper, \$10.95

ISBN 0-8093-1412-6

The author defends the thesis that communication is not only central to the human condition, but that the specific forms of communication used, based on culture or historic period, alter their user's way of being human. Alternate forms of communication are not benign, but comprise various approaches to specifically defining humanity. Pearce goes beneath the surface of communication to explore the values and controls which underpin the social exchange. His discussion of "modern" and "cosmopolitan" communication deserves particular attention.

Marie-Laure Ryan

Possible Worlds, Artificial Intelligence, and Narrative Theory

Bloomington: Indiana University Press, 1991

291 pages, cloth, \$35.00

ISBN 0-253-35004-2

Textual semiotics from an interdisciplinary standpoint is at the core of this book. Its conceptual framework consists of the theory of possible worlds (a formal model developed by logicians) and artificial intelligence. Within this framework, the first section defines fictionality and the second investigates the semantics of narrativity. Ryan explores the heuristics of automatic story generation. Tree-structures and flow-charts deliver structural clarity in her description of mystery narratives with their alternative outcomes.

Christopher Seeley
A History of Writing in Japan
Leiden, Holland: E.J. Brill, 1991
254 pages, illustrated, cloth, \$85.00
ISBN 90-04-09081-9

The beauty and complexity of written Japanese have fascinated many. *A History of Writing in Japan* examines nearly two thousand years of writing development with its movement toward simplified visual form and orthography. While this book is directed to readers with some familiarity with Japanese or Chinese language, readers lacking such a background, while at a disadvantage, will not be lost. The author moves out from his primary topic to touch upon other aspects of Japanese culture—its history, literature, religion and institutions.

Claudia Thompson
Recycled Papers, The Essential Guide
Cambridge: The MIT Press, 1992
200 pages, illustrated, cloth, \$40.00; paper, \$25.00
ISBN 0-262-20089-9

The paperless office has not materialized—paper consumption continues to grow—and in recent years a print aesthetic has developed which holds in high regard super-coated, bright white papers which ultimately are densely coated with ink. The author presents all the facts: a brief history of paper, diagrams, statistics, definitions and standards, and in the appendix, a list of paper mills with recycled products. This is the book for which many ecologically concerned designers and publishers have been waiting.

- We have different opinions about typography. A scientific journal like *Visible Language* should not be used as a playground for funny typographic ideas. Typography—and type design for text faces—has a utilitarian function.

I have nothing against new solutions or experimental design, but the layout of volume 24:3/4 of *Visible Language* is badly done. The handling of the oversized headlines is not in a balanced relationship with the small text type and extremely tiny size of the type for the notes. The letterfit is too tight, reducing legibility. There is a lot of white space on the page, which could have been used to produce a more readable layout.

Take a look, for example, at the folios or the handling of the initials on page 242 or 247 in Albert Kapr's excellent article on Gutenberg. Typographers should not push themselves into the foreground by using a text to show off through the use of gimmicky effects, ignoring the basic rules of legibility and functional typography.

Hermann Zapf, Darmstadt, Germany

Before addressing the specific comments in your letter, I would like to put this journal into its pragmatic context, although not as a way of displacing your criticism or of side-stepping my own final responsibility for its publication. The journal has a history (25 years) of exploring the concepts of visible language both in its content and in its form. Exploration of typographic configurations and alternative ways to structure information is an important attribute of the journal. Most issues are designed by one or two students at the Rhode Island School of Design. While they are paid for this work, the journal cannot pay them sufficiently. As a result, the educational nature of the activity becomes important.

Design education tends to focus on either a master/apprentice relationship or on a more open-ended process of discovery. The students who work on the design of the journal operate from the second point of view. For the journal to be published, they must hit a threshold in their performance. Some, of course, far exceed this level (see, for example, volume 24:2 or volume 23:4), and some simply cross this threshold. This is not ideal, but it is practical and optimistic with regard to student performance.

The real point of departure in our views is philosophical. You believe typography has a serving function. I agree with this, but the difference lies in our definitions of what constitutes a serving function. It is necessary to put this within the context of contemporary readers. People read less, they obtain more of their information from other media, and even people who read a journal such as this are struggling with a deluge of print, i.e., they read many journals and they process much information. This context seems to demand more interesting, more responsive typography. Typography in the classic crystal goblet mode may not be the best solution for contemporary readers who are distracted by more dynamic modes of presentation.

The typographer as reader may be able to interpret through structure and emphasis the importance of the author's manuscript. I am also seeing more authors who are beginning to think typographically: they are beginning to think more fluidly about structure; they are going beyond the confines of dumping their particular information into a set of standard conventions. Both the typographer as reader/interpreter and the author as designer/typographer have limitations. This suggests to me the need for better crossover knowledge between the verbal and visual disciplines.

Another aspect of what we might call content-responsive typography is stimulation. This is the attribute on which the designer of volume 24:3/4 focused. Since it was a general issue, he wanted to develop a magazine format to present each article in a distinctive way. In retrospect, he may have tried too many things—some worked well, some not so well. Perhaps I should have reined him in. As you can see, my roles as teacher and as publisher are sometimes in conflict. The point at which these two perspectives meet is at the threshold of student typographic performance.

The editor

- I should like to make two observations [with regard to *Visible Language* 24:1, the special issue *The Origin of Visible Language in the New World*]:
 - 1) Assuming that this journal is intended for an international audience and, in this case, also for scholars in Latin America, close attention should be given to the correct

usage of accent marks in Spanish words. These are missing altogether except for the brief bibliography for Beatriz de la Fuente (not Funtenta!),

2) Occasionally, writers have deplored that European publications on Mesoamerican subjects are frequently ignored in the United States, even if they appear in English. A case in point is Brian Stross' iconographic essay on Stela 1, La Mojarra (cover illustration and pp. 46-56), which completely overlooks the 30-page article "Some Observations of Stela 1, La Mojarra, Veracruz," by Thomas Barthel and H. von Winning, in *Tribus* no. 38, December 1989, Linden Museum, Stuttgart, Germany, pp. 91-120. Hence an opportunity for discussion of some divergent viewpoints has been missed.

Hans von Winning, Hollywood, California

Dr. von Winning's second point is well taken. When writing the essay on the La Mojarra Stela, I was quite unaware of his excellent collaboration with Thomas Barthel that appeared in Tribus in 1989. I would have greatly appreciated the opportunity to discuss some of the divergent viewpoints that it contains. The fact that the library at my university had cut the journal Tribus from its subscription list because of the budget crunch affecting libraries everywhere in the United States may help to explain why I unintentionally overlooked it, and in turn we can see one of the potential losses to scholarship in this country that may be exacerbated in the future because of dwindling library resources.

Brian Stross, Austin, Texas

- It's time to say adieu—I'm not renewing my subscription as I am now a senior citizen. I've taken the publication since the very start and I've given the whole collection to the Design Archive at the University of Illinois/Chicago Library—Special Collections.

I do want to add that I think the articles are a lot more readable and interesting in the past few years. With all respect to Merald Wrolstad, in the beginning he must have had difficulties in getting a variety of articles, and from my viewpoint, the majority of them ended up focusing on different ways to measure reading ability, including all the statistics. Since I was designing materials for elementary education, I tried very hard to understand it all. I did mention the esoteric language to Merald. Nevertheless, his

journal was probably the first in the design community to deal with all aspects of language.

Muriel Underwood, Chicago, Illinois

Merald had, what surprisingly continues to be, a unique vision: communication between the humanities and sciences in a genuine interdisciplinary spirit of discovery. His particular mission, bringing good research information to the design/communication practitioner with the goal of improving both the focus of research and the intelligence of practice, continues to be explored by the journal.

The editor

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- Bear**, Donald R. *Copying Fluency and Orthographic Development*, 40-53.
- Benson**, Philippa Jane. *Leading-edge Research or Lost cause?: The Search for Interscriptural Stroop Effects*, 4-17.
- Bever**, Thomas G. et al. *Spacing Printed Text to Isolate Major Phrases Improves Readability*, 74-87.
- Brown**, R.A. *Literacy Assessment in Polyscriptal Societies: Chinese Character Literacy in Korea and Japan*, 18-39.
- Burwell**, Rebecca et al. *Spacing Printed Text to Isolate Major Phrases Improves Readability*, 74-87.
- Copans**, Ruth and John Anzalone. *Covering the Text: The Object of Bookbinding*, 257-269.
- Cruttenden**, Alan. *Intonation and the Comma*, 54-73.
- DeKay**, Michael and Jennifer J. Freyd. *The Effects of Drawing Method on the Discriminability of Characters*, 377-414.
- Deguy**, Michel. *Deguy | Dorny, Dorny | Deguy*, 193-196.
- Drucker**, Johanna. *Typographic Manipulation of the Poetic Text in the Early Twentieth Century Avant-Garde*, 231-256.
- Freyd**, Jennifer J. and Michael DeKay. *The Effects of Drawing Method on the Discriminability of Characters*, 377-414.
- Hartley**, James. *Psychology, Writing and Computers: A Review of Research*, 339-375.
- Haskell**, Eric T. *Reading the Multimedia Book: The Case of *Les Fleurs du mal**, 271-282.
- Hoyem**, Andrew. *Working Together: Collaboration in the Book Arts*, 197-215.
- Hubert**, Renée Riese, guest editor. *The Artist's Book: The Text and Its Rivals*, volume 25:2/3.
- . *An Introduction to the Artist's Book: The Text and Its Rivals*, 117-137.
- Jandreau**, Steven et al. *Spacing the Printed Text to Isolate Major Phrases Improves Readability*, 74-87.
- Kaplan**, Ron et al. *Spacing the Printed Text to Isolate Major Phrases Improves Readability*, 74-87.
- Lydon**, Mary. *The Book as the Trojan Horse of Art: Walter Hamady, The Perishable Press Limited and *Gabberjabbs 1-6**, 151-172.
- Perloff**, Marjorie. "Inner Tension/In Attention": Steve McCaffery's Book Art, 173-191.
- Polkinhorn**, Harry. *Bastard in the Family—The Impact of Cubo-Futurist Book Art on Structural Linguistics*, 88-109.
- . *From Book to Anti-Book*, 139-147.
- Prinz**, Jessica. *The "Non-Book": New Dimensions in the Contemporary Artist's Book*, 283-302.

- Saillard**, Martine. A Book Exhibit at the Musée Pompidou, 317-326.
- Sayre**, Henry. *Ida Applebroog and the Book as Performance*, 303-315.
- Shipe**, Timothy. *The Librarian and the Artist's Book: Notes on the Subversive Art of Cataloging*, 327-333.
- Zaenen**, Annie et al. *Spacing Printed Text to Isolate Major Phrases Improves Readability*, 74-87.
- Zelevansky**, Paul. *The Computer Made Me Do It: Computers and books*, 217-230.

By Title

- The Artist's Book: The Text and Its Rivals*. Renée Riese Hubert, guest editor, volume 25: 2/3.
- Bastard in the Family—The Impact of Cubo-Futurist Book Art on Structural Linguistics*. Harry Polkinhorn, 88-109.
- The Book as the Trojan Horse of Art: Walter Hamady, The Perishable Press Limited and Gabberjabbs 1-6*. Mary Lydon, 151-172.
- From Book to Anti-Book*. Harry Polkinhorn, 139-147.
- A Book Exhibit at the Musée Pompidou*. Martine Saillard, 317-326.
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- Copying Fluency and Orthographic Development*. Donald R. Bear, 40-53.
- Covering the Text: The Object of Bookbinding*. John Anzalone and Ruth Copans, 257-269.
- Deguy|Dorny, Dorny|Deguy*. Michel Deguy, 193-196.
- The Effects of Drawing Method on the Discriminability of Characters*. Michael DeKay and Jennifer J. Freyd, 377-414.
- Ida Applebroog and the Book as Performance*. Henry Sayre, 303-315.
- "Inner Tension/In Attention": Steve McCaffery's Book Art*. Marjorie Perloff, 173-191.
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- An Introduction to the Artist's Book: The Text and Its Rivals*. Renée Riese Hubert, 117-137.
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- Literacy Assessments in Polyscriptal Societies: Chinese Character Literacy in Korea and Japan*. R.A. Brown, 18-39.
- The "Non-Book": New Dimensions in the Contemporary Artist's Book*. Jessica Prinz, 283-302.
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