Writing profiles: the effect of the writing mode on pausing and revision patterns of experienced writers

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Abstract

We investigated how writing processes are affected by physical aspects of the task environment, specifically the use of a word processor, with respect to patterns of pausing and revision. Consistent with the tradition of cognitive writing research, the writing processes of experienced writers were examined (60 involving the use of a word processor, 20 involving pen&paper). In comparison with writers using pen&paper, those using a word processor (i) spent more time on a first draft and less on finalizing a text, (ii) pursued a more fragmentary writing process, (iii) tended to revise more extensively at the beginning of the writing process, (iv) attended more to lower linguistic levels (letter, word) and formal properties of the text, and (v) did not normally undertake any systematic revision of their work before finishing. By clustering the various processes with respect to twelve relevant parameters, we developed a new typology of writing processes which distinguishes five writing profiles: the *initial planner*, the *fragmentary Stage I writer*, the *Stage II writer*, the *non-stop writer*, and the *average writer*. Our quantitative approach to describing the cognitive behavior of the different writers revealed that the profiles they adopt depend greatly on the constraints of the writing environment.

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1. Introduction

The agenda of writing researchers in the 1980s was dominated by a cognitive approach to writing processes. Especially the Flower and Hayes model (1981) generated many studies relevant to a better understanding of what happens in the writer's mind in the course of writing (cf. Nystrand et al., 1993).

About 15 years later, Hayes (1996) published a new framework for the study of writing. The major change in this model was that he added a more elaborated task component including the social (audience and collaborators) and physical environments (text produced so far and composing medium). This component interacts with the writer's individual cognitive processes at several levels: "Writing depends on an appropriate combination of cognitive, affective, social, and physical conditions if it is to happen at all. Writing is a communicative act that requires a social context and a medium. It is a generative activity requiring motivation, and it is an intellectual activity requiring cognitive processes and memory" (Hayes, 1996: 5).

By extending his writing model with these components, Hayes integrated the writing research of the 1990s, which focused mainly on the influence of social aspects on the writing process and the written product. However, this revised framework has not seemed as influential as the previous one. Writing research at the end of the 1990s was still polarized to a large extent. The description of cognitive processes was seldom studied in a wider perspective (cf. Kellogg, 1996) and the social perspective seemed to have dominated most writing research (Duin and Hansen, 1996). Only a few researchers went beyond this polarization and combined the social and cognitive perspectives in their studies (e.g. Pogner, 1997; Perrin, 1998).

It is implausible that one single writing process exists. Cognitive processes, and in particular their organization, are probably dependent on social and physical conditions and the writer's conception of his task. Consequently, we favor the idea of orienting writing research towards an integration of social, cognitive, and discourse studies. However, this is not to say that every individual study should focus equally on the different approaches, but rather that we should always take them into account in our research design. As it is, we need not only qualitative ethnographic studies of collaboration among non-academic writers, but also detailed quantitative analyses that focus on the various subprocesses of the writing process in different contexts and under different physical conditions. Both ethnographic and experimental research should remain on our agenda, but always from the perspective that the different components in the revised Hayes (1996) model play an important role in the design and analyses of the research.

In the present study,[1] we seek to address this point by providing a quantitative analysis of how writing processes are affected by the writing mode, in this case, by a word processor (or computer). The research we present in this paper can be understood as an example of a research project in which non-academic writing processes are studied in an experimental setting.

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[1] This research is described in greater detail in the first author's doctoral dissertation (Van Waes, 1991a), which was supervised by the second author.

Our approach has been to examine writing processes from two angles. First, the writing behavior of people using a word processor ('computer writers'/'computer mode') was compared with that of those using pen and paper ('pen&paper writers'/ 'pen&paper mode'). Focusing particularly on differences and similarities with respect to pausing and revising, we found that certain aspects of writing behavior were affected by the mode used. We then examined this writing behavior in greater detail and identified a number of basic patterns in the ways writers organize the writing process. These 'writing profiles', as we will call them, were defined as the combination of values given to a set of variables (e.g. time spent on initial planning, number of revisions made at a particular stage of the writing process, etc.).

Before describing the study in more detail, we will provide a short overview of related research into the effect of the computer on the writing process and into the nature of writing profiles.

2. Related research

In one of their earliest articles on the writing process, Hayes and Flower (1980) developed an interesting starting point for further research on writing profiles. They elaborated on the distinction between 'Mozartians' and 'Beethovians'. 'Mozartians' are extensive planners who formulate and revise their texts sentence by sentence, whereas 'Beethovians' write a first draft of their text rather quickly with minimal revision, postponing the main revision until a later stage.[2]

Hayes and Flower (1980) based their writing typology on think-aloud protocols obtained from college students writing in the pen&paper mode. They distinguished four writing profiles:

1. *Depth first*, in which the writer tries to produce a perfect first sentence, then a perfect second sentence, and so on. That is, the writer completes the work of planning, implementing and reviewing each sentence before starting to work on the next.
2. *Postponed review*, in which the writer writes down his/her thoughts as they occur and reviews them later.
3. *Perfect first draft*, in which the writer tries to generate a perfect first draft. Planning is very explicit and directed towards the text as a whole.
4. *Breadth first*, in which a draft is planned and then written out in full before any revision is contemplated.

These writing profiles are described in very general terms. The difference between the first and third type, for instance, is not made very explicit. As far as we know, this typology has never been revised, applied, or developed further, either by the authors themselves or by anyone else.

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[2] Musicologists, it must be said, do not completely agree with these characterizations.

Schwartz (1983a,b) described another typology that showed some resemblance to that of Hayes and Flower (1980). On the basis of 200 portfolios produced by college writers, Schwartz established nine profiles. These profiles show how content and form are generated, organized, and reassessed, from ideation to revision. They are grouped into three types:

1. *Language production and regeneration profiles*, in which the writer either writes down more than is needed and then reduces it later (the 'overwriter'); or economizes on the initial text and then adds more later (the 'underwriter').
2. *Structural reformulation profiles*, in which the writer rejects the text and starts again (the 'restarter'); or rejects it, making only a few changes (the 'recopier'); or pieces together old sections into a new structure (the 're-arranger'); or builds on the original structure (the 'remodeler').
3. *Content reassessment profiles*, in which the writer is concerned with the propriety of the text (the 'censor'); or with its accuracy (the 'refiner'); or with the correctness of its form (the 'copy-editor').

This typology of profiles no doubt constitutes a useful starting point for further research into writing curricula, but it does not form an appropriate basis for describing the writing process in general. The problem is that the various categories are not mutually exclusive. For instance, a writer may be a 'restarter' when revising one paragraph but a 'rearranger' when revising another.[3]

Severinson Eklundh (1994) studied the effect that type of writing task undertaken had on writing strategies, particularly its effect on the linearity[4] of text production with a word processor. Her study suggests that writers change their writing profiles depending on the tasks they are engaged in (reporting, structuring, comparing, arguing, etc.): "Subjects who use a strictly linear style in a simple, reporting task used a more nonlinear strategy when the task required increased amounts of planning and recursivity" (Severinson Eklundh, 1994: 215). However, in an experimental study, Levy and Ransdell found that writing profiles remained highly consistent both within individual writing sessions and across writing sessions, even when the subject matter of the texts was very different: "These patterns seem so characteristic of individuals that we have termed them 'writing signatures'. Like cursive signatures, they are distinctively different between individuals. And like cursive signatures, they exhibit small and unsystematic differences within individuals across time" (1996: 158).

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[3] Schwartz (1983a) describes various approaches to writing in a teaching environment. Her writing strategies bear a close resemblance to Flower's (1981) writing heuristics described in her handbook for writers, and to the 'composing patterns' of Williamson and Pence (1989), who distinguish among linear revisers, intermittent revisers, and recursive revisers.

[4] By linearity, Severinson Eklundh was not referring to the composition of text, word by word, sentence by sentence, until completed. Rather, she saw linearity as a continuum along which writing sessions might be located. She provided a negative definition: "nonlinear writing means that high-level text-editing operations — insertions and substitutions of large text passages — are regularly made at a distance from the current point of insertion" (1994: 204).

The present study extends previous lines of research in two ways. First, it shows how writing profiles are affected by the writing mode being used. Second, in contrast to the qualitative nature of earlier studies,[5] it adopts a quantitative approach to the definition of writing profiles. To reach these objectives, it is important to select the relevant variables that characterize the writing process in both the pen&paper and the computer modes.

Research into the effect of the computer on the writing process has focused largely on the revision process. The hypothesis that computer writers *revise more* than pen&paper writers is confirmed in most studies (cf. Arms, 1983; Bridwell et al., 1987; Case, 1985; Collier, 1983; Gould, 1981; Lutz, 1987). Researchers who did not register a noticeable difference (e.g. Hawisher, 1987, 1989; Kurth, 1986), or who occasionally even observed a decrease in the number of revisions by computer writers (e.g. Harris, 1985; Schriner, 1988), limited their investigation to 'between-draft' and 'after-draft' revisions, a limitation which makes comparison very difficult.

A more important question is whether the computer mode influences the 'level' at which revision takes place. Previous research is not unanimous on this point. Daiute's hypothesis (1985: 137) that the word processor encourages the writer to experiment more with textual changes at a higher level is confirmed by only a few studies (e.g. Fitch, 1985; Hawisher, 1987; Schriner, 1988). Most studies, however, show that use of a word processor tends rather to encourage revision of formal aspects (spelling, punctuation, etc.) and revisions below the level of the sentence (cf. Balkena, 1984; Bridwell and Duin, 1985; Bridwell et al., 1985; Collier, 1983; Daiute, 1986; Deming, 1987; Joram et al., 1990; Lutz, 1987). The risk-taking behavior expected because of the ease with which the text on-screen can be manipulated does not, according to those studies, lead to a greater number of revisions at a higher level (revision of meaning). On the contrary, the greater attention paid to revision at lower levels (revision of form) apparently distracts the writer's attention from the possibility of revision at higher levels.

Several studies report that texts written in the computer mode tend to have fewer spelling and punctuation errors than texts written in the pen&paper mode (Collier and Werier, 1995; Daiute, 1985, 1986; Duling, 1985; Kurth, 1986; Womble, 1985). This result is not surprising if we take into account that computer writers tend to pay more attention to the formal aspects of the text than pen&paper writers.

Computer writers also tend to write *longer texts* than pen&paper writers. This is one of the few results common to most of the studies that have been carried out in this field. Following on from the related research presented and the objectives described, we now describe the design of our research study.

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[5] Wyllie (1993) constructed a typology of writing strategies on the basis of a survey of academic writers and student writers. She found five types of writers, giving them the evocative names of watercolorist, architect, bricklayer, sketcher, and oil painter. Other researchers have taken quite a different approach to this topic, basing their studies not on the writing process itself but on certain elements that affect the writing process, such as the personality of the writer (e.g. Jensen and Di Tiberio, 1984) or the characteristics of the thinking process (e.g. Harris and Wachs, 1986).

3. Present research

The present study compared writing produced in two primary modes, the pen&paper mode and the computer mode, with the latter being further subdivided into a mode involving use of a normal screen (25 lines of text) and another involving use of a DIN A4 format screen (66 lines of text), making a total of three modes.

To allow us to compare writing performance in the three modes, two experiments were set up in which participants were asked to write two texts, each in a different mode. A total of 40 participants took part, 20 in each experiment. In the first experiment, the participants were asked to write one text on a computer with a 25-line screen and the other on a computer with a 66-line screen. In the second experiment, the other 20 participants wrote one text in the pen&paper mode and another on a computer with a 25-line screen. These experiments generated a total of 80 separate writing processes and about 200 h of writing.

3.1. Participants

The participants were 27 male and 13 female university faculty and graduate students. All used the computer for word processing (*WordPerfect*) on an almost daily basis and had had at least 2 years' experience in doing so. All wrote a great deal: writing comprised 15% or more of their total work load. They all wrote the texts in the experiments in their native language, which was Dutch.

3.2. Writing tasks

Participants were given two tasks, each of which involved writing a report. In one case, they had to write a report about the introduction of a new system of bank charges; in the other, they had to write a report about company regulations for in-service training. The resulting texts had to be two to three pages of typescript.

Two days before they were required to do each task, participants were provided with an outline of the communicative context of the report on the topic in question, plus certain data relating to the contents of the report.

In each experiment, the participants were divided into four groups of five, and the tasks were offered sequentially crosswise, spread over the two writing conditions (Latin square design). This was in order to eliminate any effect of the order in which participants used the modes or performed the tasks.

Under experimental conditions, participants were then allowed between 2 and 3 hours to complete the task. Participants writing in the pen&paper mode were asked to produce a text that could immediately be typed out by a secretary without the need for further instruction. Participants writing in the computer mode had to print out their final text. These participants were also free to print their text out at any intermediate stage of the writing process and were also free to make notes with pen and paper at any time.

3.3. Observations

The method used to observe the writing processes had to meet three principal requirements:

- it had to yield as detailed a picture of the writing process as possible
- its results had to be quantitatively comparable
- it could not affect the writing process itself.

Accordingly, the performance of each participant writing in the pen&paper mode was recorded on video whereas that of each participant writing in the computer mode was recorded using automatic keyboard registration linked to a resident computer program (*Keytrap*).[6] This program registered every keystroke as well as the time lapse between strokes (1/18 s), and allowed the exact reconstruction of the on-screen writing process and automatic analysis of certain data. These observations were supplemented by interviews held before and after the experiment.

In order to create a basis upon which the data thus obtained could be easily compared and analyzed, the pen&paper performance was transferred letter by letter from the video recording to a process log file in *WordPerfect* macro format. The pauses were subsequently inserted manually by the researchers into the linear data storage.

Fig. 1 shows a fragment of the log file of a reconstructed writing process. This fragment starts with the correction of a typing mistake: the letter *E* was written in uppercase instead of lowercase. The second revision is a revision of a preposition: the preposition *va(n)* [of] was replaced by *in* [in]. At the end of the first period of 30 seconds, the writer paused 3 seconds before typing the verb *is* [is], for 6 seconds afterwards, and so on.

These methods of observation allowed full and exact reconstruction of the writing process (from the first letter to the final revision) pursued by each participant during each task and in each mode.

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[6] The basis of *Keytrap* was developed by IBM, Brussels. H. Pauwels (University of Antwerp, UFSIA) updated the program and wrote the necessary application software. For a detailed description of the program, see Van Waes (1991a), Van Waes and Van Herreweghe (1994), and Janssen et al. (1996). At the Royal Institute of Technology (IPLab) another keystroke recording program was developed for the *Mac* environment that integrates a basic word processor and a key-logging device (*JEdit*). In conjunction with this, *Trace-It* is was developed. This is a powerful software program that facilitates the analysis of writing patterns with S-notation. It has functions for navigating among the revisions, playing back the writing session, and obtaining lists with different kinds of information about the revisions. For a detailed description see Severinson et al. (1996) and Kollberg (1997).

<1950>
DE{Backspace}e·netto·rendabiliteit·va{2x Backspace}in·de· banksector·[3]is·[6]

<1980>
sinds·begin·jaren·'60[5]{2x Left}{9x Word Left}{4x Right}{Del} {24x Right}vertoon

<2010>
t{2x Del}{7x Right}het·{Down}{Left}{3x Word Left}{6x Right} van·de· {Backspace}·{9x Right}·een·dalende·trend.[14]

<2040>
[3]Waar·in·de·periode·1960-19{2x Backspace}'64·nog·sprake· was·van·

<2070>
0.66[7]·Bf·winst·per·[3]100·Bf·ingezettte{3x Backspace}e{2x Backspace} tte·werkmidde

<2100>
len,·is·dit·nu·geslonken·tot·0.22·Bf.

Legend

<00>	time indication (seconds), time slots of 30 seconds used to identify the writing fragment in the writing process
[00]	duration of pauses (seconds, in rounded figures; only pauses longer than 3 seconds are included in this example)
{xx}	*WordPerfect* functions
·	space

Fig. 1. Example of a writing process reconstruction on paper (format: *WordPerfect* Macro Language— text written in Dutch).

3.4. Analysis

The analysis of the data focused on variables relating to three aspects of the writing process. These variables were later used to construct writing profiles. The three aspects and their associated variables are listed below.

Time taken and final product
  Total duration of the writing process
  Duration of each stage of the process

A distinction was made between Stage I (from initiation to the completion of the first draft) and Stage II (from the completion of the first draft to the completion of the final version).

Ratio of time spent pausing to time spent actively writing

Number of words in final text

Pausing behavior

Duration of pauses

Number of pauses

Type of pause

A distinction was made between pauses followed by the formulation of new text ('formulation pauses') and those followed by the revision of existing text ('revision pauses', cf. Matsuhashi, 1987: 208).

Linguistic location of pauses

Three locations were selected as relevant: within the sentence, at sentence boundaries, and at paragraph boundaries.

Temporal location of pauses (Rijlaarsdam and Van den Bergh, 1996)

The total time spent on the task was divided up as follows: functionally, into Stage I and Stage II (see variable 1, above); absolutely, into 10-minute segments; and relatively, into ten equal units, whereby units 1–5 and units 6–10 are also referred to as Part 1 and Part 2, respectively.

Revision behavior

Number of revisions

Type of revision (Witte and Cherry, 1986)

Addition, deletion, substitution, reordering

Level of revision

Letter, word, phrase, sentence, paragraph; layout, punctuation

Purpose of revision

Correction of typing errors, revision of form, revision of content

Location of revision

Title, first paragraph, first sentence of paragraph, elsewhere

Remoteness of the revision

Measured in terms of the number of lines above or below the point of inscription

Temporal location of revision

Stage, segment, unit (see variable 2, above)

The result of the observation and analysis described above was a highly detailed account of the differences in writing behavior between the modes investigated, and for the participants as individuals and as a group. The method was shown to be

reliable by a comparison of two experiments whose participants were from two corresponding subgroups ($n = 20$).

3.5. Writing characteristics and the computer mode

The principal results of the analysis of the variables (combining the results of both experiments) are given below, grouped in accordance with the threefold division made above.[7]

3.5.1. Time taken and final product

The 24-line computer mode and the pen&paper mode did not differ significantly with respect to the duration of the writing process as a whole (see Table 1). However, there was a significant difference with respect to the time spent on each stage. The time spent on Stage I by computer writers was half of that spent on the same stage by pen&paper writers. Texts written in the computer mode were also approximately 20% longer than those written in the pen&paper mode.

3.5.2. Pausing behavior

Analysis of pauses longer than 3 seconds revealed a clear difference between the modes with respect to pausing behavior. The results are shown in Table 2. Computer writers paused approximately 70% more often than pen&paper writers. This suggests that use of a word processor tends to result in a more fragmented writing process.

Revision pauses constituted 45–50% of all pauses. However, the distribution of formulation and revision pauses over the two modes differed. In the pen&paper mode, the proportion of formulation pauses to revision pauses in Stage I was 70:30,

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[7] The differences between the writing processes of writers using 24- or 66-line screens will not be dealt with at length here: see Van Waes (1991b) for a detailed analysis. Briefly, this analysis shows that, in certain respects, the 66-line computer mode occupies an intermediate position between the 24-line computer mode and the pen&paper mode. This mainly applies to the level at which revisions are made. Writers working on the larger screen seem to pay more attention to revisions at the levels of words, sentences, and paragraphs, similar to pen&paper writers, but unlike computer writers using the traditional 24-line screen, who tend to revise at the level of the letter. This is particularly true in the later stage of the writing process (the proofreading phase), when the size of the screen may play an important role.

On the other hand, writing in both computer modes is characterized by relatively little initial planning and little proofreading effort. In contrast, in the pen&paper mode, both planning and proofreading are given considerable attention. This suggests that the size of the screen and the amount of text visible on it do not completely explain the difference observed in pausing and revising behavior between computer and pen&paper writers. We believe that, ultimately, a number of differences in the organization of the writing process have their origin in the characteristics of the computer itself.On the other hand, writing in both computer modes is characterized by relatively little initial planning and little proofreading effort. In contrast, in the pen&paper mode, both planning and proofreading are given considerable attention. This suggests that the size of the screen and the amount of text visible on it do not completely explain the difference observed in pausing and revising behavior between computer and pen&paper writers. We believe that, ultimately, a number of differences in the organization of the writing process have their origin in the characteristics of the computer itself.

Table 1
Writing time and mean number of words in final text (computer vs. pen&paper)

	Average duration (min)		Column%		Sign[a]
	Computer	P&P	Computer	P&P	
Stage I	102.05	74.45	84.9	65.7	*
Stage II	18.20	38.95	15.1	34.3	*
Total duration	120.25	113.40			n.s.
Number of words	843	695			*

* $p < 0.05$.
[a] p-value calculated with the Wilcoxon matched-pairs signed-rank test based on average values per participant.

Table 2
Number of pauses (computer vs. pen&paper)

	Average		Column%		Sign[a]
	Computer	P&P	Computer	P&P	
Type of pause					
Formulation pause	171.5	90.3	54.7	50.1	n.s.
Revision pause	142.2	89.9	45.3	49.9	n.s.
Linguistic location of pause					
Within sentence	245.9	108.6	78.4	60.2	*
At sentence boundary	41.8	41.1	13.3	22.8	*
At paragraph boundary	25.9	30.5	8.3	16.9	*
Total	313.7	180.2			*[b]

*$p < 0.05$.
[a] p-value calculated with the Wilcoxon matched-pairs signed-ranks test based on column percentages per participant.
[b] p-value calculated with the Wilcoxon matched-pairs signed-ranks test based on mean values per participant.

compared to 60:40 in the computer mode. In Stage II, the proportion of the two types of pauses in each mode was more or less reversed.

The two modes also differed clearly with respect to the location of pauses. Computer writers tended to pause more within the sentence than pen&paper writers. Pen&paper writers paused at sentence and paragraph boundaries twice as often as computer writers, with approximately 40% of their total number of pauses occurring there, compared to 20% for computer writers.

The two modes differed even more strikingly with respect to the average length of the pauses made. The results of the analysis are given in Table 3. Pen&paper writers, as already noted above, tended not to pause as often as computer writers did. However, when they paused they tended to pause longer. In fact, as can be seen in Table 3, pauses made by pen&paper writers were up to twice as long as those made by computer writers.

Table 3 shows that, with respect to both pause type and linguistic location, pause length differed significantly between the two modes. In all categories except one (within sentence), pauses made in the pen&paper mode were significantly longer than those made in the computer mode. Formulation pauses made by pen&paper writers, for example, were on average twice as long as those made by computer writers, and their pauses at paragraph boundaries were also much longer. Taking these data together with the higher percentage of pauses at paragraph boundaries exhibited by pen&paper writers, it becomes apparent that almost half (45%) of the total time spent pausing in the pen&paper mode was spent at paragraph boundaries. In contrast, computer writers paused there only 20% of the time.

3.5.3. Revision behavior

A total of 6434 revisions were recorded. Approximately 30% of these were typing errors. Since this sort of error naturally only appears in computer mode, it was excluded from further analysis. The results of the analysis of revision behavior are given in Table 4. In general, they show that computer writers did not revise significantly more often than pen&paper writers. However, analysis of the sub-categories revealed the existence of more clear-cut differences between the two modes.

Table 3
Duration of pause (computer vs. pen&paper)

	Duration (s)		Sign[a]
	Computer	P&P	
Type of pause			
Formulation pause	12.48	25.59	*
Revision pause	11.36	16.71	*
Linguistic location of pause			
Within sentence	9.59	11.40	n.s.
At sentence boundary	16.19	20.85	*
At paragraph boundary	27.78	56.28	*
Total	11.97	21.16	*

* $p < 0.05$.
  [a] p-value calculated with the Wilcoxon matched-pairs signed-ranks test based on average length per participant.

Table 4
Number of revisions per writing process according to level, purpose, remoteness, and distribution (computer vs. pen&paper, excluding typing errors)

	Average		Column%		Sign[a]
	Comp	P&P	Comp	P&P	
Level					
Letter	14.1	2.5	11.4	2.6	*
Word	46.6	41.9	37.7	44.1	*
Phrase	36.7	37.6	29.7	39.5	n.s.
Sentence	6.3	5.5	5.1	5.8	n.s.
Paragraph	2.5	2.3	2.0	2.4	–
Lay-out	10.5	2.4	8.5	2.5	*
Punctuation	6.7	2.9	5.4	3.1	*
Purpose					
Content	94.8	81.0	76.8	85.1	*
Formal	28.7	14.1	23.2	14.9	*
Remoteness					
Within the line	75.0	58.6	60.8	61.0	n.s.
2–10 lines	36.4	30.6	29.5	31.8	n.s.
11–24 lines	5.3	3.6	4.2	3.7	n.s.
25+ lines	6.8	3.4	5.5	3.5	n.s.
Distribution					
Stage I	101.7	47.9	82.4	50.3	*
Stage II	21.7	47.2	17.6	49.7	*
Part 1 (Units 1—5)	57.3	34.7	46.4	36.3	*
Part 2 (Units 6—10)	66.1	60.4	53.6	63.7	*
TOTAL	123.4	95.1	56.5	43.5	n.s.[b]

*p < 0.05.

[a] p-value calculated with the Wilcoxon matched-pairs signed-ranks test based on column percentages per participant.

[b] p-value calculated with the Wilcoxon matched-pairs signed-ranks test based on the average number of revisions per participant.

The following account is restricted to those findings which indicate significant differences between the two modes.

- *Level of revisions*: The two modes differed clearly with respect to the preferred level of revision. Computer writers tended to revise more at the level of the letter, whereas pen&paper writers tended to revise more at the level of the word. With respect to revisions made above the word level, the two modes differed clearly in proportional terms, although in absolute terms they were

similar. In the computer mode, revisions at the higher levels constituted 42.8% of the total, compared with 50.6% in the pen&paper mode, suggesting that pen&paper writers tend to revise at a higher level than computer writers.

- *Purpose of revisions*: In analyzing the purpose of the revisions, a distinction was drawn between revisions which were directed toward changing content, and those which were directed toward changing form (spelling, lay-out, concord, etc.). A comparison of the modes with respect to this aspect revealed that almost one in four revisions made by computer writers was form-oriented, compared with only one in seven in the case of pen&paper writers. This greater attention paid to formal revision by computer writers turned out to be essentially cosmetic, in effect, as it did not result in any reduction in the amount of revision at the level of content.

- *Remoteness of revisions*: The remoteness of a revision was measured in terms of the number of lines intervening between the point of inscription and the point of revision. A distinction was made in the vertical dimension of the complete revision operation between upward (+) and downward (−) movement.

  Analysis showed that, in both modes, revisions were distributed evenly over the various categories: approximately 60% of the revisions took place within the line being composed and could therefore be classified as 'immediate' or 'non-remote' revisions. However, some 10% of the revisions were made more than 10 lines away from the point of inscription.

  The even distribution noted above implies that computer writers tend to revise more across the whole range of distances: they revise more within the line, and more at greater distances. In our data, for instance, they made twice as many revisions in the most remote category (a distance of 25 lines or more) as pen&paper writers did.

  Further analysis taking the vertical dimension of the revision operation into account reinforces this conclusion. Pen&paper writers, especially at Stage II, were inclined to read and revise their text systematically, starting at the beginning and working through to the end. This systematic, sequential revision process is reflected in the fact that the downward movement proceeded through the text in relatively small steps.

  With respect to the vertical dimension of revision, pen&paper writers had a clear preference in Stage II for revisions within the line and revisions involving downward movement of less than 5 lines. Computer writers also performed this type of revision but, unlike the pen&paper writers, they tended to do it evenly throughout the writing process.

- *Distribution of revisions*: The modes also differed with respect to the distribution of the revisions over the two stages. Pen&paper writers, for instance, made approximately 50% of their revisions during Stage II, compared with 17% for computer writers. This clearly confirms the impression gained from the analysis of temporal considerations and pausing behavior. Pen&paper writers reserved plenty of time for a second stage, during which they subjected their text to quite elaborate revision.

3.6. Writing profiles[8]

The quantitative analysis of the writing processes described above was then taken as the basis for developing a typology of writing profiles, in which the interplay of planning and revision behavior was central. Variables were selected from the above analysis and supplemented by others taken from the typology of Hayes and Flower (1980, see above).

The resulting typology is described below, preceded by an account of the statistical methods used to construct it and followed by a discussion of how the profiles were affected by the use of a word processor.

3.6.1. Method

The first step in developing the typology was to perform a cluster analysis.[9] Cluster analysis, although a useful tool for detecting structure in data, does not itself determine structure, and the method used here should therefore be seen as providing no more than a possible guideline for developing writing typologies.

The construction of the typology proceeded according to the following steps:

1. selection of the variables for cluster analysis
2. cluster analysis
3. discriminant analysis.

A detailed account of the process cannot be given here due to space restrictions, but the various steps may be described briefly as follows. We started with as many variables as possible and then eliminated those that showed a high correlation, since such variables, being linked in the same dimension, might skew the clustering. This process led to the selection of a total of twelve variables that were deemed to characterize relevant aspects of the writing process. These variables are listed in Table 5.

With these 12 variables, the cluster analysis was then performed on the writing processes recorded for each of the 40 participants in each of the two modes (12×80). All variables for the cluster analysis were recalculated to the Z-value so that the variables all had the same weight, since the average of the Z-scores for all variables is always 0 and the standard deviation 1. Finally, a discriminant analysis was performed on the results of the cluster analysis. This clarified the number of groups and offered insight into the discriminatory value of each variable (Wilks' step-by-step input).

Cluster analysis on the basis of the complete linkage method yielded the purest classification, which was a classification into five groups. The discriminant function assigned about 90% of cases to the correct cluster. Furthermore, discriminant analysis with step-by-step input showed that eleven of the 12 variables contributed to the classification. Only the variable 'total duration of the process' failed to be discriminatory and is therefore left out of the following account.

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[8] This section is based on Van Waes (1992).

[9] See Aldenderfer and Blashfield (1984) for a very accessible account of the procedures used in cluster analysis.

Table 5
Variables used in the cluster analysis to characterize certain aspects of the writing processes

Revisions	• Proportion of revisions in Stage I as compared to Stage II
	• Total number of revisions in Stage II
	• Total number of revisions in Part 2
	• Proportion of revisions above word level
	• Total number of revisions (excluding typing errors)
	• Ratio of number of words to number of revisions
Pauses	• Duration of initial planning (in seconds)
	• Total number of pauses
	• Average duration of pauses (in seconds)
	• Average total time spent pausing (in minutes)
	• Degree of recursion (the number of times that a formulation pause was followed by a revision pause)
Total duration of the writing process	

3.6.2. Typology of writing profiles

As noted above, cluster and discriminant analysis of the data of the 80 writing processes yielded five different clusters. These clusters effectively form quantitative descriptions of writing profile types (or writing profiles, for short). Table 6 shows the results of the analysis, based on eleven discriminatory variables.

The profile types thus established cannot be located along the continuum of a single variable. Each profile consists of a well-defined combination of variables. For convenience and clarity, each profile has been given a characteristic name. Although this name is (for the most part) based on the most discriminatory variable in the profile, it should be taken to represent all values of the variables in that profile.

Table 6
Quantitative descriptions of writing profile types

Types	1	2	3	4	5	*Average*
Revisions						
Stage I (%)	81	76	89	34	82	*77*
Stage II (total)	16	28	17	88	10	*26*
Part 2	54	64	82	93	30	*61*
Above word level (%)	35	38	38	54	28	*37*
Total number	87	119	151	133	55	*108*
Number of words / number of revisions	10	7	7	6	15	*9*
Pauses						
Initial planning (total, in seconds)	1310	332	235	824	319	*448*
Total number	229	283	364	201	173	*259*
Average duration (seconds)	21	12	12	20	15	*14*
Average time spent pausing (minutes)	76	57	70	67	40	*59*
Recursion	62	79	105	33	42	*68*
Number of participants[a]	7	24	19	9	20	

[a] One extreme outlier was excluded, reducing the total number of participants to 79.

- Profile 1: *Initial planners*

Initial planners tended to make relatively few revisions, especially during Stage II. They paused a great deal during initial planning. Their pauses tended to be relatively long and the total time spent pausing was significantly above average.

- Profile 2: *Average writers*

The profile of *average writers* shows a value for each variable which is closest to the average value for that variable over all the profiles. *Average writers* occupy a medial position with regard to users of other profiles.

- Profile 3: *Fragmentary Stage I writers*

Fragmentary Stage I writers tended to make most of their revisions during Stage I of the writing process. Although they made more total revisions than writers of other profiles, they made few revisions during Stage II. They devoted little time to initial planning. They paused often during writing, but their pauses were of relatively short duration. *Fragmentary Stage I writers* therefore followed a writing process which was highly fragmented and characterized by a high degree of recursion.

- Profile 4: *Stage II writers*

Stage II writers made most of their revisions during Stage II of the writing process. Many of these revisions were made at a level above the word, and the number of revisions was high in relation to the total number of words in the final text. *Stage II writers* spent time on initial planning, but once they started writing, they paused relatively infrequently. However, any pauses they did make were relatively long. There was only a slight degree of recursion.

- Profile 5: *Non-stop writers*

Non-stop writers showed relatively low values for most of the variables. They revised less often than the other writers. The proportion of words to number of revisions was correspondingly high in the final text. In percentage terms, they made fewer revisions during Stage II and Part 2. They also made relatively few revisions above the level of the word. *Non-stop writers* paused less often than all other writers: their total time spent pausing is clearly below average. Additional analysis showed that *non-stop writers* tended to spend little time on initial planning and tended to complete the writing task more quickly than others.

3.6.3. Writing profile and writing mode

Writers do not always adhere to the same profile. Fig. 2 shows the relationship between writing profile and writing mode. The matrix on the left of the figure shows the shifts in writing profile made by participants during the first experiment (25-line
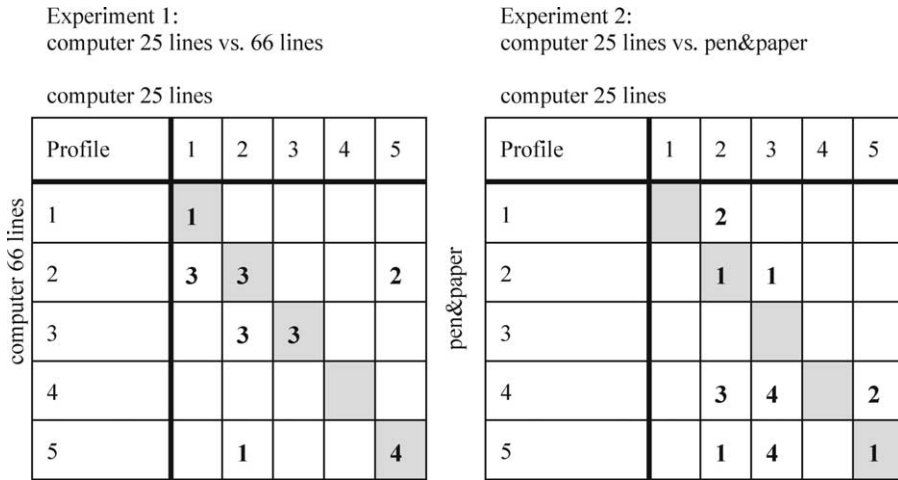
Experiment 1:
computer 25 lines vs. 66 lines

Experiment 2:
computer 25 lines vs. pen&paper

computer 25 lines

Profile	1	2	3	4	5
1	1				
2	3	3			2
3		3	3		
4					
5		1			4

(left matrix: rows labelled "computer 66 lines" 1–5)

computer 25 lines

Profile	1	2	3	4	5
1		2			
2		1	1		
3					
4		3	4		2
5		1	4		1

(right matrix: rows labelled "pen&paper" 1–5)

Fig. 2. Relationship between writing profile and writing mode. Distribution and shifts of writing profiles.

screen vs. 66-line screen), and the matrix on the right shows the shifts made during the second experiment (computer vs. pen&paper). The matrices should be read as follows. Two writing profiles can be determined for each participant. For example, in the left-hand matrix, the 2 in Column 5, Row 2 shows that two participants in the first experiment adopted Profile 2 when using the 66-line screen. The same two participants adopted Profile 5 when using the 25-line screen. The digits along the diagonal dimension of the matrix show the number of participants who did not change their writing profiles when changing writing mode. Two facts emerge clearly from the matrices in Fig. 2: no pen&paper writer adopted Profile 3, and no computer writer adopted Profile 4.

Clearly, the preferred profile of pen&paper writers was Profile 4: it was adopted in 9 of the 19 cases in which writing was performed in the pen&paper mode. The relatively large difference between Profiles 3 and 4 corresponds to a great extent with the difference that emerged from the analysis of pausing and revision behavior in the two modes. In both absolute and relative terms, the revision behavior of writers adopting Profile 4 was strongly concentrated in Stage II of the writing process; they also made more revisions above the word level. On average, Profile 4 writers spent three times as much time on initial planning as Profile 3 writers. They paused much less often throughout the entire process, but the average length of pause was longer. The degree of recursion in Profile 4 was much lower than that in Profile 3.

Fig. 2 also shows that there was a strong tendency for writers to change their profile when they changed writing mode (in the second experiment). Such shifts seemed to occur less frequently during the first experiment, when writers used 25-line and 66-line computer screens. Fig. 2 shows clearly that writing profiles are less affected by a change in screen size than by a shift from the computer mode to the pen&paper mode. More than half the writers in the first experiment (11 out of 20 participants) adopted the same writing profile with each screen size. Only a few

shifts occurred, and these were in the direction of a closely related cluster. For example, as can be seen from the figure, three *average writers* (Profile 2) became *initial planners* (Profile 1) when they changed from the 66-line screen to the 25-line screen. Both the cluster and discriminant analyses show Profiles 1 and 2 to be the two clusters most closely related to each other.

The matrix in Fig. 2 for the second experiment shows a completely different picture. Only two writers retained the same profile when using the two different modes. This suggests that writers do not necessarily transfer their pen&paper profile to computer mode. The extent to which they adapt their way of writing varies depending on their preferred writing behavior. Moreover, different writers adapt their writing in different ways.

Writers who used Profile 4 (*Stage II writers*) in the pen&paper mode shifted to Profiles 2, 3, or 5 when writing in the computer mode. Each of these shifts entailed certain divergences from the typical pattern of writing behavior associated with Profile 4. In general, the impact was greatest for those variables related to Stage II revision: level of revision, degree of recursion, and amount of initial planning.

Even most of the pen&paper writers who were using a profile that was transferable to the computer mode (Profiles 1, 2 and 5) tended to modify their profiles. Fig. 2 shows that four out of six Profile 5 writers (*non-stop writers*) shifted to Profile 3 (*fragmentary writers*) when they changed to the computer mode. These were mainly writers who revised and paused less often, especially during Stage II. When they shifted to the computer mode, they adopted a profile which involved more pauses and revisions. The total amount of time spent pausing increased greatly and the amount of recursion doubled. The ratio of the number of revisions to the total number of words in the text increased by 50%.

4. Discussion and conclusion

Writing profiles seem to be clearly influenced by the writing mode. The differences between the profiles adopted by computer writers and those adopted by pen&paper writers lie mainly in the following areas:

- the level at which revisions are made
- the way the revisions are distributed throughout the writing process
- the degree of fragmentation of the writing process.

4.1. Level of revisions

The percentage of revisions made above word level in the profile predominantly used by writers in the pen&paper mode (Profile 4: *Stage II writers*) is at least 1.5 times that found in the other profiles. It was noted above that computer writers tended to revise more at the level of the letter than pen&paper writers. This may be explained by the fact that, at this low level, computer writers tended not to delete the part of the word that did not need to be changed, even if it consisted of only a few

letters, and we observed that they often deleted a word before it had completely appeared on the screen. Such strategies are hardly ever efficient for writers using pen&paper. Pen&paper writers were more inclined to cross out a whole word, probably in order to maintain the readability of the text. To a great extent, the large number of low-level revisions made in the computer mode were the result of 'mechanical' considerations, and often served the same purpose as revisions made at, and above, the word level in the pen&paper mode.

4.2. Distribution of revisions

Another notable characteristic of the profiles predominantly used by computer writers is the high percentage of revisions made during Stage I of the writing process. It was noted that pen&paper writers had a tendency to reread and revise the text systematically, working from beginning to end. The result was a downward, step-by-step revision, moving relatively small distances at a time through the text. Computer writers, on the other hand, seemed to revise in smaller units throughout the writing process.

4.3. The process of fragmentation

Finally, another distinctive difference that emerged between the profiles preferred in each mode was the degree of fragmentation. The large number of short pauses within the sentence which occurred in rapid succession in the writing of computer writers resulted in a writing process in which planning, formulation, and revision were strongly focused on relatively small units of text. Computer writers were found to switch very often between formulation pauses and revision pauses, indicating a high degree of recursion. For pen&paper writers, however, the writing process took place in longer episodes and their pausing behavior seemed to be less locally-oriented. The degree of recursion was also lower.

One explanation for the greater degree of fragmentation and recursion in computer mode is the awareness of what we may call 'word processing comfort'. During the writing process, writers are aware of the fact that, at any moment during writing, they can alter their text without creating an illegible jumble of crossed out and inserted words. This means that writers can start typing a sentence without knowing how it will end. They ask themselves questions such as "Does this sentence (or part of a sentence) mean what I meant it to mean?" immediately after they finish writing the sentence, and, indeed, sometimes even before they have finished. The result is short pauses, often within the sentence.

Pen&paper writers paused longer, mostly at sentence or paragraph boundaries. This suggests that pen&paper writers tend to plan their sentences and paragraphs mentally, evaluating and revising them in advance, and only proceeding to write them down after these phases have been completed. Writing with pen&paper is usually slower, and revision on paper often results in the text having a messy appearance.

An additional explanation for the greater degree of fragmentation and recursion in the computer mode is the limited initial planning typical of this mode. The average

time spent on initial planning in the dominant pen&paper profile (Profile 4) was more than twice that found in the dominant computer writing profiles (Profiles 2 and 3). Computer writers apparently started writing sooner than pen&paper writers. The presence of the computer itself, with its flashing cursor, seemed to be an invitation to start text production immediately (cf. the concept of 'the seductive screen' in Bridwell et al., 1987; Daiute, 1985, 1986; Dyson and Haselgrove, 2000; Haas, 1989a,b, 1996).

This relative lack of initial planning undoubtedly affects the rest of the writing process. In the absence of any real, explicit text structure, the writing process is naturally more fragmented and shows a higher degree of recursion. Such an ad hoc way of working leads to many more conceptual modifications during the writing process, and these may entail a fundamental change in the degree of recursion.

Less initial planning seems to affect the distribution of the longer pauses in the writing process. Analysis of the distribution of pauses in terms of time segments showed that more than half the longer pauses in the pen&paper mode occurred at the beginning of the writing process. There was a second concentration of longer pauses at the start of Stage II (the proofreading phase). Precisely these pauses were responsible for the longer average length of pauses in the pen&paper mode.

In the computer mode, on the other hand, longer pauses were much more evenly distributed throughout the writing process. Here, too, a similar concentration of longer pauses at the beginning of Stage II could be seen, although it was much less well-defined.

These findings suggest that writing with the computer calls for a different distribution of conceptual planning effort in the writing process: rather than being concentrated at the beginning, it is spread more evenly over the writing process as a whole.

From the research of Haas (1989b) and Matsuhashi (1987), it may be concluded that rhetorical and conceptual planning and revision lead to relatively long pauses, whereas sequential planning and revision entail much shorter pauses. In our data, this can be clearly seen in the fact that the average duration of a pause varied depending on its location: pauses at paragraph boundaries, for instance, which may be assumed to be largely conceptual or rhetorical in nature, were on average 2.5 times longer than pauses within the sentence. In other words, the broad spread of longer pauses throughout the writing process in the computer mode may be interpreted as a strategic extension of the initial planning phase over the entire writing process.

We have presented here a typology of writing profiles based on cluster and discriminant analyses of writing processes. A set of variables derived from the writing process itself was used as input to the analyses. Unlike earlier typologies, which often relied on vaguely formulated writing variables, our typology has the advantage that it is quantitatively defined and susceptible to quantitative interpretation.

The writing profiles that emerged from this study clearly show that writers organize their writing in several different ways. Specifically, it appears that the writing process is strongly affected by the mode in which writing is performed: certain profiles are predominant in the computer mode, while others prevail in the pen&paper mode.

Our findings also show that, when writers who have been using the pen&paper mode change to the computer mode, they also change their writing profile. The extent to which the writing process is affected by this change of mode varies from person to person. However, it may be said that those pen&paper writers whose writing profiles are similar to profiles more frequently encountered in the computer mode tend to alter their writing profiles less substantially when changing to the computer mode. Conversely, writers who exhibit typical pen&paper characteristics (such as more elaborate initial planning and a preference for revision in the later stage of the writing process) tend to modify their writing process much more radically when changing modes.

Severinson Eklundh's findings (1994) clearly showed that the writing task affected the linear cognitive organization of the writing process. Other researchers (e.g. Pogner, 1997; Perrin, 1998) added elements that described the importance of the social environment in the task environment when studying writing processes. Our research demonstrates not only that individual characteristics of writers determine the cognitive organization of writing processes (cf. Levy and Ransdell, 1996), but also that the physical environment—or more specifically the composing medium used (here, the word processor)—affects writing processes and writing profiles.

Today's professional writing environments are changing rapidly. Non-linear text production in internet and intranet environments, multi-author systems with different collaboration concepts, and speech-recognition input replacing keyboards and traditional dictation devices are just a few examples of changes in the social and physical writing environment that need further research. We are convinced that the observational methods and research approach developed in this study can be very useful in future writing studies focusing on these changes.

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