The impact of mode on writing processes: A cognitive functional perspective on student writing

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Abstract

In this paper, we compare writing processes for twenty second year undergraduate students who participated in two different simulated, keyboard, writing tasks: a spontaneous writing task (FB, writing a Facebook message to a friend) and a planned writing task (ES, a short essay writing task). The main aim of this study is to determine to what extent these are truly different writing tasks as experienced by the students and whether there is any evidence that different writing processes are involved. We also consider keyboard efficiency as a factor in digital writing processes. Our findings suggest that there are major differences in how writers compose text that are at least to an extent reflected in their patterns of editing. Potential variables, in addition to text type, are automaticity in typing and whether they are able to track the text on screen.

Key words: digital writing; writing processes; mode of production

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1 Introduction

> "[T]he best way to model the writing process is to study a writer in action" (Flower and Hayes 1981: 368)

Writing activity among students is increasing due to the rise of Computer Mediated Communication (CMC) (e.g. texting, chatting, Facebook and Twitter) and yet teenagers do not perceive this CMC as writing (Lenhart, Smith, Rankin Macgill and Arafeh 2008). When the present authors were undergraduates, language production was typically achieved through speaking and handwriting, each involving different cognitive processes and different modes of production. In contrast, while students today still, of course, speak and handwrite, much communication is carried out on the computer (e.g. texting, chatting, Facebook and Twitter). It is of interest to us to establish whether this digital social communication entails the same cognitive processes as academic writing or whether the activities have different cognitive demands. Intuitions suggest that digital social interaction is not the same as academic writing. For example, Lenhart *et al.* (2008) state that, "[while] teens disassociate e-communication with 'writing'; they also strongly believe that good writing is a critical skill to achieving success" (2008: 1). Since students themselves perceive a difference, we must ask whether this increased frequency of CMC use has any impact on more traditional writing or what is 'good writing'. While it is clear that writing for educational purposes is not the same as writing for and with friends, whether it is perceived as writing or not, when using a computer keyboard, the physical and technical context of communicating does not change.

It may not be surprising that students do not think of all productive uses of CMC as writing. Although use of a computer keyboard to communicate is analogous with using a typewriter, the term *typing* has traditionally been reserved for *copy typing*, or what we might now refer to as *typing up*. The Cambridge English Dictionary defines 'typing' as 'the act of pressing a key', *writing*, on the other hand, is conceptually more creative, with definitions such as 'the act of producing words' (the Free Dictionary). Interestingly, *writing* does not readily distinguish between forming the characters by hand and selecting them on a keyboard. Yet they are different activities from a physical and cognitive perspective. Handwriting requires mastery of the letter forms, while typing requires the capacity to find the form from a predetermined set. Handwriting only involves one hand, while using the keyboard generally involves both hands in a co-ordinated and active way.

An informal survey of 60 of our undergraduate students that explored their understanding of *typing* and *writing* as terms for activities revealed that they only use the verb *type* for typing up something previously handwritten or making notes from a textbook. They use the verb *write* for composition on a computer such as an essay but never for an email or a Facebook message. For such messages they prefer verbal conversions based on the message form (e.g. *to message, to text, to email, to Facebook, to DM, to PM*). This apparent lexical choice is interesting because in all cases the physical activity is the same (they are using their hands on a keyboard) and yet the experience they choose to represent through language is that these are different activities.

Given these observations, it is highly relevant to study whether the differences they perceive are only superficial or reflect rather deeper contrasts in what they are doing. Relatively little is known about students' digital writing processes, despite their ubiquity. Research into student writing including writing development has generally relied on an analysis of handwritten texts (see Beard, Myhill, Riley and Nystrand 2009 for an overview). Keystroke logging is one approach to gaining insight into these practices and increasing our understanding of the linguistic and motor processes involved in digital writing, via "the opportunity to capture details of the activity of writing" (Spelman Miller and Sullivan 2006: 1) as it happens. The activity of writing as a process merits study because the written product does not tell the whole story. O'Donnell (2013: 248) explains that "the temporal sequences of choices made by a writer do not necessarily correspond to the linear sequence of words, or even sentences, within the final text. And where text is deleted, choices made in the writing of a text may not correspond to any text present in the final product".

In this paper, we use keystroke logging to look for evidence that different writing processes are involved when writing informal Facebook messages and more formal essay-type texts. In the next section we provide an overview of relevant literature on writing processes in a digital context, including what is known about computer-based writing and a brief introduction to keystroke logging methods. Section 3 describes the tasks we designed and the participants who took part, focusing specifically on how keyboard efficiency was established and how participants were grouped into high or low keyboard efficiency groups. Section four presents and briefly discusses the results from the comparison of the two tasks and the two keyboard efficiency groups. The discussion in Section five includes some examination of the writing behaviours of two participants in order to illustrate some of the differences we find in

our data. We end the paper with some considerations for language education and literacy development.

2 Writing processes in a digital context

Many discussions of Computer Mediated Communication begin with a comparison of speech and writing, asking whether the type of communication in question is more like speech or more like writing. This question conflates mode and tenor and misses out on two important clines affecting language production irrespective of the medium: spontaneous vs. planned and informal vs. formal (see Berry 1975, 2013 and below). Before considering how these differences in mode affect digital writing, we first provide an overview of the nature of computer-based writing generally and the use of keystroke logging software in writing research specifically.

Spelman Miller and Sullivan (2006: 1) define keystroke logging as "the computer recording of writing activity as writers compose on the computer." As Chukharev-Hudilainen (2014) states it is also useful for recording spontaneous internet-based writing activity such as chat and instant messaging. Informed by Latif's (2008) review of computer-aided writing study, the majority of writing studies using keystroke logging methods have focussed on "either writers' revisions or the temporal aspects of the composing" (Latif 2008: 44). Since many of these studies have, at their base, some version of the Flower and Hayes (1981) model of writing processes, we will very briefly present it here.

The original Flower and Hayes (1981) model provides a description of writing processes as non-linear; rejecting the idea that writing processes occur in stages. The model includes three major components: the task environment, the writer's long term memory, and the writing processes. The main writing processes, planning, translating and reviewing, are governed by what is called The Monitor (Flower and Hayes 1981: 367). The reviewing processes are of particular importance to this study. As Flower and Hayes themselves pointed out, reviewing does not take place in a linear fashion once a text has been written; "[t]he sub-processes of revising and evaluating, along with generating, share the special distinction of being able to interrupt any other process and occur at any time in the act of writing" (Flower and Hayes 1981: 374). Hayes (1996) updated the model by incorporating the individual and by revising the task environment so that it also accounted for the social environment (the audience and collaborators) and the physical environment, which includes the text so far and, importantly for this study, the composing

medium. Hayes (1996: 7) suggests that by studying the effect of the writing medium, we can develop a greater insight into the overall workings of the writing processes.

There are two main ways in which the computer has impacted on writing. First, the writing medium is obviously affected and we will come back to this when we consider register and mode in particular below. Secondly, according to Severinson Eklundh and Kollberg (1996), computers have significantly transformed the revision process for both writers and researchers. Writers become more flexible with their writing as they can "work recursively and explore their topic through reconsidering what has been written and they can start typing a sentence without knowing how it will end" (p. 163). In this sense, the writing process itself becomes a thinking tool. Van Waes and Schellens (2003: 848) summarise this as "word processing comfort" since documents can be changed at ease, avoiding an "illegible jumble of crossed out and inserted words"; in brief, revisions through computers "are simply easier" (Montague 1990: 39) and, as a consequence, computer texts are "more heavily revised" (cf. Hyland 2002; Severinson Eklundh and Sjöholm 1991; Cochran-Smith, Paris and Kahn 1991). These revisions tend to be at the lower end and revise form rather than content (cf. Hill, Wallace and Haas 1991; Joram, Woodruff, Lindsay and Bryson 1990; Collier 1983; Harris 1985) and Cochran-Smith *et al.* 1991) which distracts the writer's attention from the possibility of revision at higher levels (Van Waes and Schellens 2003: 833). This is a key point that we explore in this study.

We know relatively little about the role of the keyboard in digital writing contexts. Grabowski (2008) has noted that much work on typing behaviours has studied professional typists. It is likely that such typists can concentrate on text production without getting distracted looking for the keys (Leijten and Van Waes 2013, Andersson *et al.* 2005) but now that using a keyboard is a typical activity that most students undertake on a daily basis, we can no longer be sure that research findings are representative of how we, in this instance, students generally, use the keyboard when writing since "university students ... do not employ typing behaviours like professional typists who master a ten-finger touch-typing method with the highest perfection and without any need of visual keyboard control (Grabowski 2008: 49). While his study found considerable variation in terms of keyboard skill among students, he found that "typing speed turned out to be the most stable characteristic of a keyboard user" (p. 50), i.e. for a given student, typing speed is a relatively constant characteristic across different tasks.

It has been noted (Leijten and Van Waes 2013; Andersson *et al.* 2005) that some writers can spend a lot of time looking at the keyboard and can correct errors with parafoveal vision. This potentially allows the writer to focus on text production by not getting distracted by correcting the error.

However, if keyboard use is not automated, then the need to think about where to put your fingers is a distraction. This is the conclusion reached by Alves, Castro, de Sousa and Strömqvist (2007), who found that, when transcription is not automatized, its cognitive cost is high, resulting in working memory limitations. In the case of typists who have not automated keyboarding skills, the demands of execution are high and, as a result, they claim that "slow typists might be using a serial way of composing" (p. 63). They may be devoting pauses to high-level writing processes, and execution periods to typing. Being unable to-think and type at the same time; they might be alternating between execution, formulation, and monitoring" (Alves *et al.* 2007: 63).

Our own research on keyboard errors in writing tasks has shown that motor keyboard errors (e.g. typos such as *langiage* for *language*) constitute the vast majority (46.7%) of errors in students' Facebook messaging in naturally occurring settings (Fontaine and Aldridge 2014, p.47). Examples such as *I don't rela[BS][BS]ally* (where [BS]=backspace key and the target was *I don't really*) were common while 23.4%[1] were due to cognitive processing interference such as *Sun is finally suning on[BS8]hininh on[BS4]g* where the target was *Sun is finally shining*. Thus we can expect a high occurrence of motor errors as compared to processing interference and this is a point we return to later in the paper.

Several studies have looked at the effect of the writing mode (e.g. keyboard, handwriting) on the writing process. A generally well received model of mode within its account of register is found within the theory of Systemic Functional Linguistics (SFL), developed by Halliday (e.g. 1973) in the early 1960s. In SFL, language is seen as a realization of social context through a dynamic relationship between context and text (Martin and Plum 1996). The Hallidayan view of register sees it as 'variety according to use' (Halliday and Hasan 1985: 43) within three main elements, each glossed very generally here as field (the ongoing activity), tenor (the relationship between speaker and addressee) and mode (channel and medium).

As noted below, there is potentially more to 'mode' than just channel and medium but as space is limited, we will focus on those

[1] 29.9% were ambiguous and could not be classified

two elements of it, as they are of particular significance for digital language production. As O'Halloran (2004) points out these terms are problematic to some extent and are not used consistently in the literature. This is largely due to the concept of mode being developed to account for visual (image-based) communication as well as spoken communication and written communication. She adopts the view that mode includes medium and channel, although as she points out, mode generally has a meaning in the literature that is roughly equivalent to code (2004: 19-20). She defines mode, medium and genre as follows: "the term mode is used to refer to the channel (auditory, visual or tactile, for example) through which semiotic activity takes place, medium for the material resources of the channel, and genre for the text types" (p. 20). So in the case of digital writing, the channel is visual (although arguably electronic light on a screen could be seen as a different channel to physical print and indeed to sign language, and yet these all involve the visual sensory system) and the medium is the computer. However, Kress and van Leeuwen explain that "in the age of digitisation, different modes have technically become the same at some level of representation" (2001: 2). It is important to note here that Kress and van Leeuwen's use of mode differs from O'Halloran since they use it to refer to a semiotic resource whereas O'Halloran draws a distinction between mode as channel and as a semiotic resource. For our purposes here, however, we must be clear that we are dealing with mode as O'Halloran does. Understanding the effects of mode on digital writing processes is important. While it may seem that mode is held constant for all digital writing, in fact, there are important variables within mode that have an effect on the writing process as we will see below.

An important aspect to mode has been developed by Berry in her (1975, 2013) notion of "a cline of consciousness", which she explains as "ranging from fully subconscious to fully conscious" (2013: 368). This is a useful way to approach digital writing since the amount of conscious awareness in the writing process will have an effect on it. This cline also allows us to distinguish between, for example, Facebook messages or chatting, on the one hand, which would tend towards more subconscious writing activity (depending on other variables), and academic writing, on the other, which would tend towards more conscious activity. See Fontaine and Aldridge (2014) for how we equate this consciousness cline with the cline between spontaneous and planned.

Writing is necessarily mediated by mode. Sharples (1996: 127), for example, claims that "writing is primarily a cognitive activity, but it cannot be performed without physical tools and resources". He

explains that it is impossible to produce an entire text in one's head (except of course for very short texts), so, therefore, the writer needs a medium through which the text can be composed (Sharples 1996: 147). One particularly interesting feature about digital writing is that, unless it is printed out, the text is only available in memory, either the writer's memory or the computer's memory, or possibly also in the reader's memory if the text is sent or shared online.

3 Methodology

We recruited a total of 54 second year undergraduate university students who volunteered to take part in the study, although only 20 of these have been included in the results reported here for reasons outlined below. A written questionnaire enabled us to select participants who were L1 English speakers, had no known language disorder and had the same level of educational experience. None of the participants had been taught touch typing and all participants had been using a keyboard regularly for at least the last six years. Each of them gave consent for their participation and the use of the data. All data presented here are anonymous.

The research presented here is part of a larger project investigating digital language production (see e.g. Fontaine and Aldridge 2014 and Aldridge and Fontaine in press). In this paper we are considering differences in writing processes between two different writing contexts. The first task (FB) involved writing a personal Facebook message to a friend, the second (ES) asked participants to write a short academic essay.

Although typing ability, including typing speed[2], is variable among the participants, we set a time limit of seven minutes for each writing task. Participants sat in the same room at the same time and completed the tasks by typing onto a desktop computer. They were asked to follow the instructions without talking and without using any other materials such as mobile phones or notes. The first task entailed writing advice to a friend about her boyfriend problems, as if on Facebook. The second task was a simulated essay discussion answer. The instructions for each task are given in the appendix.

Unlike speech, where we assume most speakers have the same physical ability to speak and reasonably similar rates of production, keyboard writing differs considerably in terms of physical ability. Not

[2] The variability here is across participants, cf Grabowski, (2008), discussed above, and who found that typing speed is relatively constant for a given participant across a variety of tasks.

all digital writers interact with the keyboard in the same way, e.g. some use all ten fingers, others use two or four only. An untrained writer may reach speeds of up to 40 words per minute (wpm), while those with a higher skill level and perhaps some training can reach speeds over 60 wpm. As stated above, in previous research (Fontaine and Aldridge 2014) we have reported that almost 50% of all revisions in spontaneously produced writing are due to errors in pressing the intended key or what we might call clumsy keyboard behaviour, e.g. *langiage* instead of *language*, since [u] and [i] are adjacent on the keyboard. This finding was confirmed for non-spontaneous writing as well in Aldridge and Fontaine (in press) where we found that keyboard errors made up 42.61% of all revisions in copy tasks and 48.97% in essay writing tasks.

Following Alves *et al.* (2007), participants were divided into two groups based on their typing skill. The keyboard efficiency measure we used is very similar to Gabrowski (2008), which is a calculation of a ratio of the number of final characters (including spaces) produced during the process with the number of characters in the final product. *Inputlog* produces a Summary Logging Output report which provides a "produced ratio, including spaces" (PR). The PR score gives "a measure of an individual's habitual keyboard operation during writing" Gabrowski (2008: 40). To obtain this measure, we arranged for participants to complete a copy[3] task one week before the writing tasks. The copy task required students to read (to refresh memory & make sure they were all using the same exact wording) the first verse from the nursery rhyme, Jack and Jill[4], and then they were asked to type the text from memory. This method is adapted from Gabrowski (2008). Participants were ordered according to their PR score for this task. Those with a PR of 1.0 made no changes to what they had entered using the keyboard (see (1)) and the lower the PR ratio, the greater the difference between the process and the final product as shown in (2), where the participant pressed the comma key in error and then corrected it.

(1) Jill·came·tumbling·(excerpt from Participant 12, PR=1)

(2) jill·came·tum,bl (excerpt from Participant 22, PR=0.785)

Participants were then grouped into high keystroke efficiency (KE) group and a low KE group. Each group comprised ten participants.

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[3] We are following Gabrowski (2008:35) in using 'copy' here to mean copying from memory.

[4] Jack and Jill went up the hill to fetch a pail of water, Jack fell down and broke his crown and Jill came tumbling after.

The mean KE of the high KE group was 0.97 (Standard deviation 0.016) while the mean KE of the "low KE" group was 0.86 (Standard deviation 0.037).

Two things should be noted here. Firstly, the KE measure did not take into account typing errors, only corrections of them. Thus, if a participant made errors of content (e.g. Jack and Jane) or form (e.g. Jakc and JJill) but did not change them, the PR score would be 1 and that participant would be in the high KE group. There are other potential ways of measuring keyboard efficiency that would include attention to the accuracy of the product. However, they are not appropriate here for two reasons. Firstly, when collecting data from open composition tasks, as in this study, it is not possible to judge whether or not participants have written what they intended. Even typing errors could in fact be spelling mistakes (which the participant could not correct because of not realising they were wrong) and so imposing judgements about what was intended would be unreliable. Secondly, informal writing, as in our Facebook task, is tolerant of what in other contexts would be errors. Consequently, it is not possible to judge which 'errors', as viewed by an outsider, actually would be considered errors by the participant. For this reason, keyboard efficiency (KE) was based on the participant's own decisions about what should be corrected, rather than any external judgement. It follows that in the discussion later, it cannot be inferred that those in the high KE group are actually 'better' typists than those in the low KE group. Indeed, an inaccurate typist would fall into the high KE group if tolerant of, or oblivious to, errors, but would fall into the low KE group if aware of the need to correct errors. This becomes important later, when we consider the other reasons why changes might be made to a text—particularly content changes. Secondly, no account was taken of the time it took to complete the 'Jack and Jill' task. As a result, high KE could reflect fast and accurate typing, or slow and careful typing. This is an important distinction later, when we think about the amount of cognitive capacity available for the writing.

We used key logging software called *Inputlog* (Leijten and Van Waes 2006) to capture the writing process. This software runs in the background, invisible during writing and it records all keystrokes and mouse movements. Keystrokes include all keyboard activity (back space, space, delete, numbers, letters, caps lock, etc.). It also records time so that pauses can be determined and how long it takes the writer to key individual strokes as well as sequences (words). *Inputlog* generates statistical reports of the texts' production and pauses including time logs of the keys pressed.

4 Results

The results are in two parts. First we consider the comparison of the two tasks in terms of writing processes. We also consider to what extent keyboard efficiency affects writing processes by comparing the two KE groups within and across writing tasks. Then we provide a more detailed discussion of the results of the writing tasks for two participants, one from each KE group.

4.1 A comparison of the two writing tasks

As explained above, the Produced Ratio (PR) was used to identify the high and low KE groups. The PR indicates how edited the written product is. Since the 'Jack and Jill' task involved a preformulated text that the participants knew well, the PR value is a baseline for the amount of editing done when no planning was involved and they could focus all their attention on the keyboard and screen. This baseline is used to gauge how demanding each of the two writing tasks is, since the processes of thinking what to write would be anticipated to reduce attention to the typing process. Table 1 gives the product ratios for the copy task and two the writing tasks. A t-test for the copy task confirms that the two KE groups are significantly different in their PR scores, as intended. The t-tests comparing the groups' performances in the FB and ES tasks are thus one-tailed, since the prediction is that the high KE group will continue its PR score dominance across tasks. What we see in Table 1 is that even in the copy task, the vast majority of participants corrected some errors.

Table 1**:** Product Ratios in the copy task as compared to the two writing tasks

Task	Min.	Max.	Range	Mean	SD	p value for one-tailed T-test
Copy - high KE	0.96	1.00	0.04	0.98	0.02	difference is highly significant (P<0.0001)
Copy - low KE	0.79	0.92	0.13	0.87	0.04	
FB - high KE	0.87	0.98	0.11	0.94	0.04	difference approaches statistical significance (P=0.0554)
FB - low KE	0.82	0.96	0.14	0.91	0.04	
ES - high KE	0.71	0.96	0.25	0.88	0.08	difference is highly significant (P=0.00335)
ES - low KE	0.58	0.94	0.36	0.82	0.10	

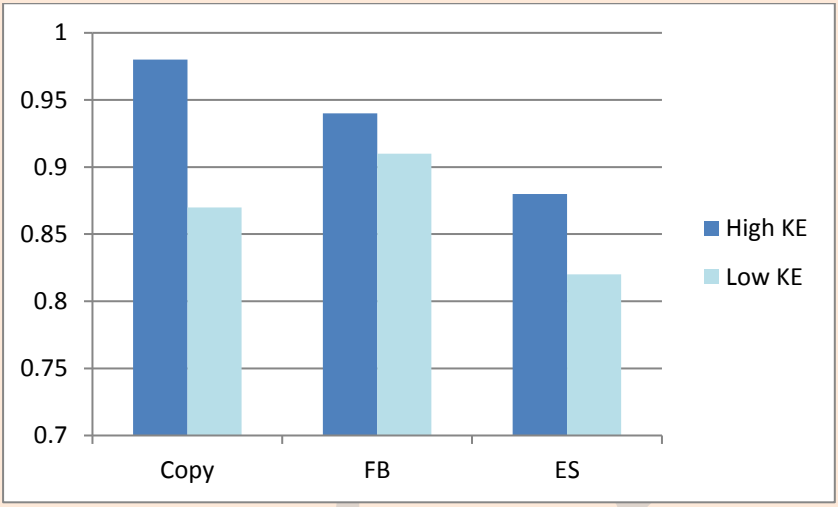

Figure 1: Mean Produced Ratios across tasks for the high and low Keyboard Efficiency groups

T-tests confirm that within each KE group, the two writing tasks generated significantly different PR values: High KE, $p = 0.024$ (one-tailed); Low KE, $p = 0.0533$ (one-tailed). When we compare the PR in the copy task with the writing tasks (Figure 1), we see that in the high KE group engages in an increasing amount of editing as the cognitive demands of the task increase. The low KE group, however, shows a different pattern. While they edit their essay text more than the copy text, they actually edit the Facebook text less.

To illustrate what the revisions look like, Figure 2 indicates the types of edits associated with the final text produced (example (3)) by participant P11 in the academic essay task. P11 had a PR score of 0.80, which is below the average for the low KE group. This text took 1 minute, 16 seconds to produce.

(3) The right hemisphere is used for linking objects and visual features with the word while the left hemisphere is used for processing language and so it links the lexical word with the phonemes for that word. [final product for the ES writing task]

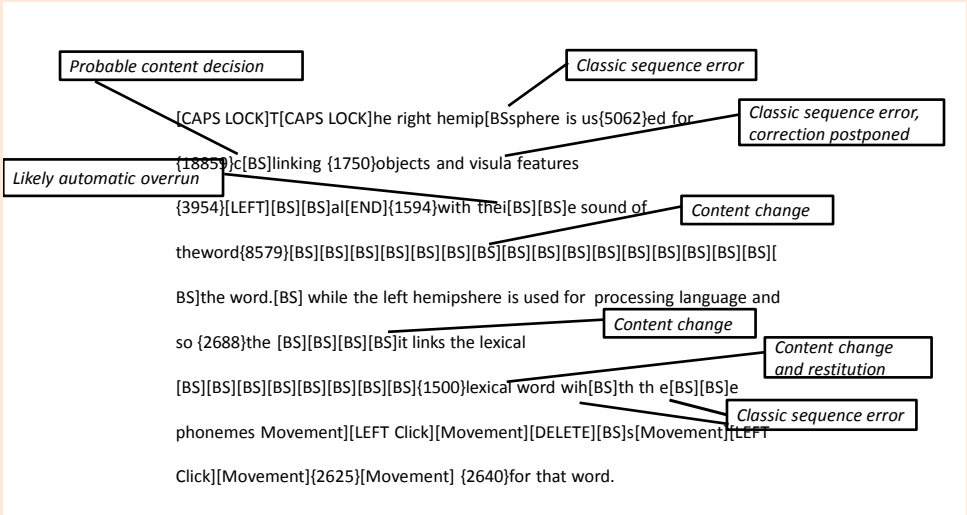

Figure 2: Keystroke report for the text in Example (3), indicating the likely types of edit.

This example of the actual process of writing one sentence allows us to see that the text was not planned before it was produced. For example, there are pauses, indicated in curly bracketing (e.g. {5062}), which suggest thought midway through the production and there are revisions to the content and grammar (e.g. 'sound of the word' is deleted entirely and returns in a different expression towards the end of the sentence). There are also immediate (e.g. hemip) and postponed (visula) corrections of keyboard errors. The writer is, in sum, attempting to balance motor control (keyboard accuracy), monitoring processes (both keyboard performance and language performance), and planning.

We cannot be sure that the failure to edit text during the task is the whole story, since the participants might have expected to, but not had time to, undertake a full read through and edit after drafting their text. The data collection period, lasting only seven minutes, may have prevented this latter part of the process.

5 Discussion

Several issues of importance arise from the results, and they will be considered in turn.

5.1 Why did the low KE group edit less in the FB task than the copy task?

The pattern in the low KE group in Figure 2 signals that it is important to take into account the reasons why someone might edit, or not edit, a text. By definition, the low KE group are the ones who edited more in the copy task, and since there was nothing to navigate there in terms of content choices, we can infer that their editing related to incorrect key choices. In the two main tasks, however, the participants had to compose text, which increases the amount of cognitive activity and, potentially, competition for attention. Unless the typing is highly automated, there will be a direct conflict between sustaining accuracy in typing and generating apposite content.

Insofar as the two writing tasks successfully simulated real writing behaviour, we would assume that writers are less careful about their Facebook output than essay output for two reasons. One is that the reader will be more tolerant of errors in typing. The other is that the Facebook text draws on the writer's own views, whereas the essay task entails laying out claims that someone else might consider more or less acceptable.

The progressively lower PR in the high HE group suggests that as the cognitive pressures increase, editing increases. We would expect this potentially to relate to both revisions of content and corrections of spelling. As the tasks get harder, cognitive competition increases the likelihood of keystroke errors, which then need fixing.

The fact that the low HE group does not do this suggests a different cognitive approach to the tasks. As noted earlier, the copying task is like the essay task in being subject to external scrutiny for its correctness. In contrast, the FB task can be more spontaneous. The concerns that generate a low PR score in the copy and essay tasks do not apply in the FB task. They can afford to monitor less.

In order to see if these inferences can be substantiated, the next sections examine in more depth a representative sample from each KE group.

5.2 What is a high KE writer actually doing?

Participant P12 belongs to the high KE group. That is, she made relatively few edits to her 'Jack and Jill' text. In her Facebook text, she also made almost no changes from what she originally keyed in. The

changes she did make related to accuracy in form (i.e. correcting typos) rather than content. Furthermore, the editing was done at the time of inscription rather than later. (However, note that with the seven minute limit for the task, we cannot rule out that she planned to read through and edit her text later). There is no evidence that she pauses to read over what has already been written. A sample of P12's writing in the essay task is given in example (4).

(4) This means that women are able to process new information more effieciently than men. [product]

T{266}his means that women{1328} {359}a{250}re {360}a{468}ble to {484} proc{266}e{297}ss{516} {1828}i{265}n{375}form{422} [BS][BS][BS][BS][BS]{359}[BS]{547}new in{266}forma{281}tion {281}more e{282}ffie{297}c{250}i{906}ently {406} that{297}n {594}[BS][BS][BS]{657}n men{391}. [process]

The regularity of curly brackets, giving the duration of pauses, shows that this participant (P12) pauses frequently and for relatively long periods of time. As noted by Alves, Castro, de Sousa and Strömqvist (2007) high accuracy or high attention to the keyboard comes at a cost and the frequent pausing to produce words may explain why the PR value is so high. What we can't immediately tell is whether she stops in order to plan or in order to locate the key she wants. However, we can gain some sense of whether there are some keys that she consistently struggles to find. Of the four instances of F, she pauses before three, and the fourth is a direct repeat of a previous one. She pauses before four of her 10 uses of N, two of her six uses of each of I and A, and two of her 11 uses of E. Other keys attract a pause only once (H, out of 3; R, out of 5; B, out of l; S, out of 4; T, out of 8; M, out of 6 and C, out of 2). The more times she types a key fluently, the less plausible it is that she has a specific problem with finding that key, though it could be that the previous key choice interferes.

5.3 What is a low KE writer actually doing?

Participant P22 belongs to the low KE group, meaning that she made a relatively high number of editorial changes in the baseline Jack and Jill task. The keystroke data reveals that in both the FB and the ES task she make extensive revisions—many more than P12 above. Keyboard errors were corrected, but this was not the only type of change in the developing document. This writer shows evidence of processing content rather than giving attention only to graphological

accuracy as illustrated in data extract (5), taken from the ES writing task. The linear log of the writing process is very difficult to follow. For ease of recognition, some of the text has been highlighted, and the actual series of revisions is given in Table 2.

(5) These differences may include changes in the use of language such as a more cognitive and imaginative usage, as the right hemisphere is predominantly used for thinking creatively. This means that women are more likely to use metaphors and use visuals in their thought processes. [product]

[CAPS LOCK]T[CAPS LOCK]hese diffences {2282}may include {4813}changes {297}in {390}the use of languia{485}[BS][BS]age {266}such as{2469}[Movement][LEFT Click][Movement] [Movement]{671}re[Movement][LEFT Click][Movement]{2468}[BS]{750} {6766} a more cognitive {312}and crea{265}t{375}ive {2578}u{359}s{422}a{250}ge{1391}, as the righthemis{360}phere is {1109}pre{328}domin{610}antl{1110}y {968}used{4797} for{5000} {5453}thinking {8438}c{250}reativ{359}ely{1187} {641}through{407} the use of metaphor{500}s and {453}visuals{2281} {312}play a fav{640}[BS]{625}ctor.{344}[BS] too. {453}[Movement] {1203}[Movement]{2828}[Movement] [LEFT Click][Movement] [Movement]{1141}{5031}[RIGHT][RIGHT][RIGHT][RIGHT][RIGHT]{625}[Movement]{485}[LEFT Click][Movement][LEFT Click]{250}[Movement]{578}[BS].{484}{281}[CAPS LOCK]T[CAPS LOCK]his·means·that·{609}women {391}{734}[RIGHT][RIGHT][RIGHT][RIGHT]{328}[BS]{500}[BS][BS][BS] [BS][BS][BS][BS]{328}[Movement][LEFT Click]{312}[Movement]{875}a{1079}re more likely to use {297}me{250}tap{250}hots {281}[BS][BS][BS]rs and{3422} use {500}visuals{344} in t{250}h{469}eir{406} thog{500}[BS]ught procc{360}[BS]ess{532}s{484}[BS]es.

Insert	This·means·that·women·
Delete	eht·hguthrouse·of·metaphors·and·visuals·play·a·factor·too.
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Table 2 - Revisions made in producing example (5)

Example 5 and Table 2 show recursive revisions which suggest that P22 is monitoring content at greater distances. Note for example, how the word 'creative' is revised to 'imaginative'. In contrast, we see that she is not closely monitoring her typing for accuracy. She does not notice the omission of 'er' in *differences* on the first line, which is corrected ten words later and is possibly only noticed due to another typing error in the word *language* as shown on the second line. The two sentences given in the final product are revised several times during the writing process.

This participant, then, is not following a linear writing process. She does notice and correct keyboard errors but not necessarily at the time. Rather, she seems to prefer to get her ideas out, and only sort out any typographical errors afterwards. We can suggested, then, that her preferred approach is one that tends to blot out the potential distraction of typing and spelling errors, in favour of focussing on the higher-order monitoring of the text.

5.4 Pinning down differences in text composition

The three tasks used to gauge the keyboard behaviour of the participants can be ordered in two different ways. Firstly, the copy task requires least cognitive engagement, being a simple production of an already known text, while the essay requires considerable academic engagement. The Facebook task falls between the two. Secondly, the copy task and both essay task generate products that are subject to judgement by an outsider for their accuracy, whereas

the Facebook task attracts a more spontaneous approach, in which the fictional reader (i.e. of the FB chat) would tolerate errors and the actual reader (i.e. of the experimental output) is not in a position to judge the quality of the content.

What we seem to see is that the high KE writers, the ones who change little in their text when copying, are sensitive to the increased cognitive demands of tasks, introducing more editing as the task becomes more demanding. P12's text showed that she pauses a lot and that she edits locally, usually immediately after keying the item.

Meanwhile, the low KE writers, who make more changes in their texts in editing across texts, seem more sensitive to the level of judgement of the output, easing up on editing when the stakes are lowered. This suggests they have greater control over the amount of editing they do, and what kind. In the high stakes context of the essay, P22 made substantial changes in the text, often sometime after the original keying of the text. Their less linear, more recursive writing process shows elements of Flower and Hayes' (1981) model (notably monitoring and revising).

5.5 Why is high KE associated with less recursive writing?

At first glance, writers who make fewer errors in their writing would seem to be the ones most likely to have cognitive capacity to put into their writing. Yet it seems that the writers who do more editing overall (low KE) are also the ones who change the text at the deeper level. We can consider several possible reasons for this.

(1) It could be that the high KE writers are not only satisfied with their typing accuracy but also their first draft of writing. They do not edit because they are satisfied that they have generated high quality text first time. From the present data we cannot judge whether the high KE writers were satisfied with the higher level coherence and content of their text, but it is plausible that they were deferring a content edit until later. If so, that strongly suggests that they were not able, within their style of writing, to engage with content editing to the extent that the low KE group could.

(2) There could be core differences in the automaticity of typing in the two groups. There are two reasons why someone might gain a high PR value, and thus fall into the high KE group. One is high automaticity in typing, and the other is very low automaticity, accompanied by pausing to select the right key. We saw the latter exemplified in the P12. A very competent typist would, then, be more likely to conform to proposal (1), needing so little concentration to type that there was plenty of scope for composition.

(3) There is a difference in how the two groups engage with the screen. One reason why the high KE group might undertake fewer local edits could be that they are looking at the keys and not the screen. In contrast, the low KE group might be screen readers. This would mean they were aware of when they made errors of form, and that would perhaps have encouraged a high level of correction in the copy task, where the purpose was to generate an accurate text. But once involved in the FB task, they might have accepted the key errors because of their focus on the content and relative tolerance of errors in a Facebook text. When it came to the essay, with high stakes on both text and content accuracy, they would have had to choose when to change what. P22's behaviour suggests that she preferred to edit for content, picking up keyboard errors in passing, rather than interrupting her flow. While it does not automatically follow that a typist who watches the screen is more tolerant of local errors, it is a reasonable hypothesis that someone who is primarily interested in the generation of content would learn to watch the screen and to downplay local errors in the short term. This would be in keeping with claims by Alves, Castro, de Sousa and Strömqvist (2007) and Lindgren and Sullivan (2006) in that less conscious attention to the keyboard facilitates monitoring and revision during the writing process.

6 Conclusion

Typing is special amongst media for text generation because it involves both hands simultaneously and equally. Even signed language favours a dominant hand (Vaid, Bellugi and Poizner 1989). We don't currently know what the impact of two-handed communication is, if any, on language production processes. Typing also calls on the individual fingers in a way that handwriting does not, and that requires a very different level of co-ordination. We know, of course, from the work of Hallowell (2007) and others that our brain is not wired to multitask well and thus, the divided attention needed to move our hands while producing language may be disruptive to general language production processes and place a relatively high cognitive demand on an already demanding task.

We have mentioned earlier that Facebook chat may tolerate a greater level of inaccuracy and spontaneity, and this is related in part to the way it mimics the synchronicity of speech. As Hasan (1998: 242-45) points out, "the value of dialogue in graphic channels is different from that of dialogue in the phonic channel where it [dialogic] is a genuine option". Like the phonic channel, the digital channel must also include dialogue as a 'genuine option'. Berry (2013) proposes a "cline of consciousness", on which we would situate FB

towards the 'fully subconscious' end and ES at the 'fully conscious' end. Chukharev-Hudilainen (2014) posits a similar distinction, although he uses the terms 'spontaneity' and 'preparedness'. We suggest that the more spontaneous and the more informal the language production context, the more likely we are to find a primarily linear writing process. This can be considered to hold true for both KE groups because, on account of the differences in approach to composition, for the low KE group, the copy task attracts greater attention to detail than the FB task, whereas for the high KE group it attracts less attention. It should be noted that we are not claiming that all FB messages are at the subconscious end of the cline, and this is important because a person may be using Facebook for very different social purposes. The point being made here is that the degree to which we give attention to what we are writing is an important factor in the writing process.

We set out to examine whether students approach essay writing with the same writing processes as when writing a Facebook message. Our results suggest that they do, but that there is more than one approach to text composition, which is reflected in the baseline level of editing. We have speculated that future research might find a difference between high and low KE groups with regard to their attention to the screen versus the keyboard. Since all typists look at the keys at first (and some continue to do so) there is scope, in principle, to track typists longitudinally, as they gain more and more facility with finding the keys. We would anticipate that greater confidence with key finding, and a consequent tendency to watch the screen more, actually results in more editing, not less, because the opportunity opens for more attention to the content. As Alves *et al.* (2007: 56) note,

> different writing components share a common pool of resources so that if a given component requires less capacity, others can make use of it. However, because writing is typically a demanding and effortful task, competition among writing processes is most often the case.

Certainly, caution is needed in any simple assumption that delivering a text without many edits is a sign of high level processing.

We expect essay writing to be a planned writing activity and we encourage this with our students, but it may be more or less planned during the actual act of writing, according to the language production style of the writer. This includes their conscious attention to the writing task (cf. Berry 2013 and Chukharev-Hudilainen 2014 as

discussed above) and their keyboard profile (degree of attention and automation at the keyboard). So it is not as simple as claiming that Facebook writing is different from essay writing but rather that individual writers vary in their capacity to adjust to the expectations associated with the text type and context.

It must be admitted that the tasks used in this study were artificially elicited and, thus, 'fictional'. This may have more impact on some participants than others, and we cannot be sure that they all behaved entirely naturally. In addition, we have not fully exploited the opportunities afforded by keystroke analysis in this paper, and more detail about individual styles and group patterns could be adduced by further analysis.

Finally, we would like to consider potential implications of this research for language and literacy development. There are two key areas of our results that relate to education. The first concerns keyboard management skills and the desirability of helping students develop automaticity in typing. While it would be difficult to argue that automaticity in typing is other than beneficial, since it undoubtedly frees up cognitive capacity for other things, the research reported here draws attention to some caveats. Firstly we should not assume that slow accuracy is better than fast inaccuracy, for the former may be more disruptive to the composition of a narrative than the latter. Another is that automaticity is enough. Rather, we should take into account the importance of watching the screen rather than the keyboard and of being tolerant to errors on the screen, unless the typing is so automatic that immediate corrections are not disruptive to thought. These considerations should be kept in mind when designing programmes for training school students in typing. A focus on content (as represented by the ES condition in this study) rather than on accuracy alone (as represented by the copy task) should be introduced as far as possible, along with consistent and ample time for post hoc correction, to encourage tolerance of errors at the time of typing. Finally, acknowledgement of the legitimacy of inaccuracy and spontaneity (as represented by the Facebook condition) will engender awareness and confidence in students about choice in how they deploy their cognitive focus.

The second area relates to understanding digital writing processes. We still do not know enough about what students are doing when they are writing. If we agree with the quote at the top of this paper which says that "the best way to model the writing process is to study a writer in action" (Flower and Hayes 1981: 368), then it follows that the best way to understand these processes is by capturing evidence of

these processes as they happen. We have noted above the potential for longitudinal studies that track changes in the composition of texts as typing dexterity increases. We are currently working with a local school on a digital writing project where students in secondary education have volunteered to take part in a blogging study. For details of this digital writing project, Literacy and Digital Writing, please visit our blog[5].

The National Curriculum in England and Wales shows that practices in schools must attend to the need to develop students' writing for a variety of purposes (e.g. reports, narratives etc.). However a lack of attention to mode will be a disservice to literacy development because it provides the basis for understanding the composing medium, which as Hayes (1996) makes clear, is an important aspect to models of writing processes and to our understanding of the related processes.

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Appendix

Below are the two writing tasks reported on in this paper.

Task 1 - Facebook Writing

One of your close friends has just sent you a Facebook message to ask your advice.

She says that her boyfriend won't commit to a long term relationship and she feels that after 18 months of going out, he should be able to say what his intentions are.

She feels he keeps brushing her off every time she brings it up.

She's crazy about this guy but she also doesn't want to be wasting her time on someone who isn't serious about her.

What do you tell her?

Task 3 - Academic Writing

It has been suggested that women use the right hemisphere of their brain to a greater degree than men. If this is true, what do you think it might tell us about women's (or men's) use of language? What would this predict about their language processing?

Write a response to this question.