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Contributions of Online Studies to Understanding Translation from Ideas to Written Text

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The ultimate goal of written composition research is to understand how we normally compose texts and the mental processes that are involved in such a complex task. A cognitive perspective has the goal of determining the what, when, and where for different kinds of thoughts related to the text as they become available and can be transcribed. A developmental perspective introduces the necessity to study the evolution of the different dimensions involved in composing, from idea generation to graphic transcription. An educational perspective adds to the two previous research on what dimensions can be modified, and to what extent, by direct or indirect interventions.

There are two avenues toward understanding processes of text production, its development and its modification through education. The first one is to use corpus analyses of texts composed in natural situations: A number of texts are collected, some key dimensions are carefully studied through linguistic analysis that can be supplemented by using more sophisticated tools (e.g., pause and writing rate [WR] recording) and through correlational and regression analyses in order to bring to the fore the main determinants of written composition performance. Until recently, linguistic analyses have been extensively used with adults, often combined with verbal protocols of people having to comment on what they were thinking about when they prepared to write. By contrast, the recording of pauses and WRs was rarely used until recently, mainly because technical devices were lacking or very difficult to use. Such devices are now available and offer new perspectives to study written composition in real time (Alamargot & Chanquoy, 2001; Alamargot, Chesnet, Dansac, & Ros, 2006).

The second avenue is to design experimental studies by carefully controlling for some aspects of the situations, material, and instructions. Of course,

experimental research is a better source of data if the goal is to make inferences
AQ1 about cause and effect to understand causal mechanisms. However, experiments often lead to elaborate, artificial situations and thus introduce difficulties in the interpretation of data or in the generation of results with ecological validity. As a consequence, the best way may be to combine correlational and experimental approaches and thus benefit from both the authenticity (generalization to the real world) of corpus analyses of written production *and* the careful design of experiments and manipulation of variables to evaluate cause–effect relationships. That is what we tried to do in a series of studies from 1990 to 2010 that combined writing protocol analyses and controlled experiments to study correlational and causal relationships.

FIRST STEP: ANALYZING ONLINE PROCESSING IN WRITTEN COMPOSITION

Combining Developmental and Experimental Research Methods

Two research programs were initiated at the end of the 1980s. The first one aimed at studying the development of written composition in real time in second and third graders, when handwriting is known to be not fully mastered and still difficult for some students (Berninger & Swanson, 1994; Fayol, 1991c; Simon, 1973). The second one used experimental design to determine the impact of different variables on the online management of written composition of short text endings (Chanquoy, Foulin, & Fayol, 1990). In the two studies, the main dependent variables were the variations of pause durations (or latencies) and, to a lesser extent, the variations of WR (or writing duration).

From a descriptive point of view, pauses as well as WRs imply a deviation from a continuous and entirely linear process of written transcription unfolding in real time (Schilperoord, 2002): Pauses correspond to moments of scribal inactivity (Matsuhashi, 1981, 1982; Piolat, 1983); WR changes correspond to variations in the speed of transcription. A number of correlations have been reported regarding variations in pauses in speech as well as in written composition and several other vari-
AQ2 ables (Espéret & Piolat, 1991): (a) Butterworth (1980) observed that pauses occur at important discourse breaks and separate idea units; (b) Cooper, Soares, and Reagan
AQ3 (1985), Danks (1977), Ford (1984), Ford and Holmes (1978), and Kaufer, Hayes, and Flower (1986) described regular associations between pauses and syntactic structures that followed; and (c) Daiute (1981, 1984) reported that pauses were linked to the previous part of the text. Fewer data were available regarding variations in WR. In any case, the main question had to do with the interpretation of the variations.

Composing in the Framework of Limited Capacity Theories

There is general agreement that text production draws on at least four types of cognitive processes: (a) retrieving and organizing information from memory, that is, planning text content; (b) formulating information that is retrieved; (c) monitoring the text produced so far; and (d) rereading and repairing already produced text (Flower & Hayes, 1980; Hayes & Flower, 1980). Researchers dealing with study of speech production or written composition tried to relate variations in pause duration and production rates with these processes.

On the one hand, composing is a complex task, which requires the efficient online coordination of both lower-level processes, such as graphic transcription, lexical access, syntactic frame construction (Bock & Levelt, 1994; Levelt, 1989), and higher-level processes, such as elaborating ideas and conceptual relations, thematic processing, maintaining coherence and cohesion, and respecting text-type constraint processes (Berninger & Swanson, 1994; Fayol, 1991a, 1991b, 1997a). Researchers assume that all these processes have a cognitive cost, even very slight.

On the other hand, human beings have a limited pool of general cognitive resources (including attention and working memory) that must be flexibly allocated to accommodate the real-time needs of the processing system (Fayol, 1999; McCutchen, 2006). Using auditory probes and verbal categorizations to examine how college students allocated their time while composing texts, Kellogg (1987b) reported that one-half of their time was devoted to *translating*, and the rest to *planning* and *reviewing*. The time required for planning decreased over the composition session while the time spent reviewing increased. Translating remained approximately constant throughout composition and required less cognitive effort than planning or reviewing.

To better assess the cognitive effort involved in the different cognitive processes described in the Hayes and Flower's model, Kellogg measured interference between composition and a secondary task. College students were asked to detect randomly presented tones (the secondary task) while they were composing a text (the main task). Kellogg assumed that attentional resources not dedicated to the primary task would remain available to writers who could use them to process the secondary task: The more time it took to identify the tones, the more demanding the composition task was. The cognitive processes of planning, translating into text, and reviewing required more cognitive effort than many other human tasks, for example, playing chess or reading simple and complex texts. Kellogg (2001a) compared the cognitive effort expended while composing narratives, expository, and argumentative texts. By measuring RTs on secondary tasks and examining verbal retrospections, he concluded that planning, translating, and reviewing competed for common memory resources. He also noted that the cognitive effort was larger when producing expository and argumentative texts than when composing narratives. Finally, Kellogg (2001b) showed that RTs on secondary tasks were reliably lower for high domain-knowledge writers compared to those with low domain knowledge (Kellogg, 1987a, 1987b). High domain knowledge reduced the transient effort required for planning, translating, and reviewing. Moreover, variations in writers' domain knowledge and verbal ability independently affected students' performance.

Pause and Writing Rate Variations in a Capacity Theory of Composing

Composing is thus both a multicomponent activity, involving several costly cognitive processes that operate at different levels of representation, and an integrative activity. It is necessary not only to describe and study the processes involved in written composition and analyze the shiftings between these processes, but also to explain how they are orchestrated in the limited-capacity cognitive system (Levy & Ransdell, 1995). One objective of written composition research is thus to analyze the online management of written composition (Fayol, 1999), that is, to determine how the different processes are activated, and how they succeed or not without exceeding the limits of capacity. In this perspective, variations in pauses and WRs (or writing durations) are worth studying because they provide objective cues to follow the online management of written composition. The main assumption is that variations in pause durations (or latencies) and in WRs (or writing durations) may be interpreted in terms of differences in processing load: The longer the pause, the slower the WR, the heavier the load (Schilperoord, 1996, 2002).

At any moment during composing, people have to deal with the management of several subcomponent skills. Improvement of this management can be obtained by automating some skills (graphic transcription, spelling, lexical access), by increasing the knowledge and processing of some highly stereotyped situations (story schema, chains of anaphoric references; Fayol, 1991b; Fayol & Lemaire, 1993), and by having a well-structured knowledge base about the topic dealt with in the text (Kellogg, 2001a). When dimensions of written composition can be more or less automated, such automation reduces capacity demands, and thus increases the ability to carry out concurrent tasks. In contrast, some other dimensions persist as problem-solving tasks. AQ5 For example, in accessing and organizing ideas, as one must do during translation, the writers must exert a conscious and careful control over what they are doing. The cost of such higher-order activities can only be slightly reduced through practice. To cope with such costly situations, writers have to develop adaptive strategy choices (Siegler, 2005), that is, vary their choices of procedures in response to problem difficulties (Are they highly knowledgeable about the topic?) or evaluate their own competencies (How costly are transcription and spelling?) or task instructions (Is it important to focus on spelling?) and so on. Studying the modifications of the online management of written text production in children—how they modulate their pause durations and WR and whether they simultaneously write and plan ahead part of what they have to report—provides insights about the way automation and strategies help improve text production.

First Study

Employing such a perspective, Foulin and Fayol (1988) compared the production of two types of texts—a narrative and a report—in second and third graders. Children were video recorded when they were composing their two texts (the order was counterbalanced) and the production process was analyzed through computing the frequency and duration of pauses between and within main linguistic units (sentences and clauses) and the WR (including the within-clause [WC] pauses) of the same linguistic units. As expected, the authors observed that from the second to the third grade, the texts became longer, the mean pause duration decreased (but the frequency of pauses remained stable), and the WR increased. Third graders composed longer texts by writing faster and pausing less time than second graders. At each school level, the between-clause (BC) pauses were significantly longer than the WC pauses. Pauses were longer following punctuation marks and preceding connectives, giving some indications regarding the way successive clauses are related to each other.

In a later study, Foulin (1998) analyzed the distribution and duration of the initial pauses as a function of syntactic units (paragraph, sentence, clause, and phrase) in second and third graders and adult students composing a report about a personal tour (which enabled to control for the knowledge of the topic). At each level, in adults as well as in children, initial pause duration was consistently longer than intra-unit pauses. Moreover, the pause duration varied as a function of the level of language of the pause location: The higher the language unit of the pause location, the longer the pause. These results are in compliance with previous data regarding both speech production (Goldman-Eisler, 1972; Holmes, 1995; Piolat, 1983) and written composition (Matsuhashi, 1981, 1982; Nottbusch, 2010; Schilperoord, 1996, 2002). However, these results neither permit disentanglement of the roles of conceptual complexity or lexical selection from that of syntactic complexity (Grosjean & Dommergues, 1983) nor take into account processes of revision and control: Only latencies supposed to be related to planning were considered. Moreover, only pause durations were analyzed, and no attempt was made to study their relation to WR and to determine whether participants were able to conduct several activities (e.g., transcribing and accessing the lexicon) in parallel.

NEXT STEP FURTHER: EXPERIMENTING WITH WRITTEN COMPOSITION

At the end of the 1980s, it was clear that the familiarity with the content (i.e., the knowledge base of the writer), the type of text (narrative versus expository versus argumentative, Fayol, 1991b), and less clearly the complexity of syntactic structures have an impact on the quality and quantity of texts produced by adults (or adolescents). Far less was known about the processing in real time of the cognitive operations leading to such differences. Almost unexplored also were the evolution of text production and the online involvement of the cognitive operations. One way to deal with these questions was to plan an experiment using a simplified composing situation enabling better control for the different variables assumed to impact written composition. For that, we adapted the Holmes' (1984) paradigm of text completion (Chanquoy et al., 1990).

Experiments with Composing Text Endings

Adults, third graders, and fifth graders were asked to compose written endings from oral text beginnings, which were either narrative (e.g., Mary goes to the restaurant. She reads the menu. She goes in) or expository (e.g., It's a car. It is parked in the car park. It's shining). All participants were required and trained to produce endings that were either highly predictable (script-like endings) or unpredictable. The endings had to consist of three (for the adults) or two (for the children) events (in the narratives) or states (in the expository texts). The adults had to formulate the endings in either one or three sentences, whereas the children had to use either one or two sentences. To adapt the difficulty and duration of the task to the participants, the children produced eight endings (four narrative and four expository; one- or two-sentence long; four predictable or four unpredictable), whereas the adults produced 16 endings (eight for each condition). All the participants, but especially the children, were trained before performing the task.

The participants were video recorded when composing and their production behavior was analyzed using a videotape recorder. Three dependent variables were analyzed:

1. The time lapse between the end of the instructions and the beginning of transcription (i.e., the prewriting [PW] duration)
2. The time lapse between the end of the *n*th clause and the beginning of the (*n*+1)th clause; that is, the BC pause duration: BC—the adults had two BC pauses (between clause 1 and clause 2, and between clause 2 and clause 3), whereas the children had only one BC pause (between clause 1 and clause 2)
3. The mean duration for the transcription of one character between the beginning and the end of the same clause, that is, the WC WR (in seconds per character). This WR includes both the writing duration and the duration of the WC pauses

Three findings are of interest. First, there was a significant increase in WR and a significant decrease in BC pause duration as a function of age and/or school level. Moreover, the PW latency was significantly longer in the adults than the children. Second, familiarity with the content impacted the PW pause duration in the three groups, as well as the BC pause duration and the WR in adults and fifth graders but not in the third graders. The text type (narrative versus expository) had no effect on pauses or WR. Third, the WR of the adults and fifth graders increased in the last clause (i.e., the third or the second, respectively), thus suggesting that its management imposed a lower load on the participants. Overall, these results show that the speed and the flexibility of composing increase as a function of age or school level: The oldest participants made shorter pauses, wrote more quickly, and modulated more the speed of processing of the different dimensions of composing (familiarity with the content and syntactic complexity). The same trends have been reported elsewhere using slightly different methodologies (Van Dell, Verhoeven, & Van Beijsterveldt, 2008; Verhoeven & Van Hell, 2008). This finding suggests that, with increasing age and experience, people become both more skilled at dealing with the low-level components of writing and more able to distribute strategically the management of the other components of composing. However, no precise data are available regarding the processing of the low-level dimensions of composing: The WR provided only a rough indicator of the processing of transcription.

To summarize, using a text-ending paradigm, we were able to provide evidence of some online production effects in adults as well as in fifth graders: The more predictable the endings are, the shorter the initial and the BC latencies and the faster the WR. These effects did not appear in third graders, maybe because children mainly devote their attention to the management of transcription and therefore have fewer resources available for dealing with the higher dimensions of text production (Bourdin & Fayol, 1994, 1996, 2002). To test this hypothesis, another experiment was planned.

Comparing Composing and Recalling Text Endings

What emerged from the previous study is that the temporal parameters of composing became more differentiated between the age of 8 years and adulthood. However, the data remained difficult to interpret, especially regarding the third graders. As written composition involves many components, variations in pause duration and WR cannot be attributed to one process only. Moreover, these variations are themselves dependent on age or school level. Berninger (Berninger & Swanson, 1994; Berninger et al., 1997, 1998) and Graham (Graham, Berninger, Abbott, Abbott, & Whitaker, 1997) have shown that spelling and handwriting skills are important determinants of composition performance and that their cognitive cost decreases with age. One possibility would be that the cost of handwriting is so high and writing so slow in young children that it is only during pauses they are able to deal with other dimensions.

To test this hypothesis, we compared the written composition and the written recall of the same text endings in the same children and adults. The written recall of a linguistic text fragment is a much simpler task than composition because the content, the syntactic frames, and the lexical items have already been selected. The task merely consisted of writing down a series of strings of linguistic elements from working memory. As a consequence, the cognitive load associated with conceptual and linguistic processing could be measured by comparing the pauses and WR associated with each linguistic segment in written composition and transcription after rote learning.

A new population of children and adults listened to the beginning of stories and were asked to compose a two-action ending for each beginning. The endings had to be either predictable or highly unpredictable, and the two actions had to be inserted in either one or two separate sentences. After training, each of the participants (third graders and adults) produced four endings each. After composing, participants had to read every ending and memorize it thoroughly until they could write it down again by rote. The participants were video recorded while composing and recalling the text endings. The same temporal parameters as in the previous experiment were analyzed relating to both composition and recall: initial PW pause duration (in composition only), BC pause duration, WC pause duration, and WR.

We provide an overview of the main results. As in the previous experiment, the PW latency was significantly longer with unpredictable than with predictable endings in adults (9.27 versus 4.86 s, respectively) but not in children

(8.36 versus 8.34 s, respectively). Recalling the text endings was always faster than composing the same texts, in both adults and children. There were dramatic decreases between the composition and the recall durations and rates: in BC pause duration −5.55 s (−69%) in children and −1.76 s (−72%) in adults; in WC pause duration −0.56 s in children (−39%) and −0.15 s in adults (−33%); and in WR −0.13 s/car in children (−14%) and −0.04 s/car in adults (−10%). The decrease was approximately of the same magnitude in children and in adults. This unexpected result suggests that the *relative* cost of graphic transcription is approximately the same in children and adults and cannot therefore explain the differences in composition patterns between children and adults. However, the pause durations and word transcription times were far higher in children than in adults. It is possible that the length of the pauses and the time required for transcription prevent children from retaining and/or from retrieving from memory the information that they need in order to generate and organize ideas.

Another important result emerged from the two previous experiments. In the first one (Chanquoy et al., 1990), the WR of the last clause of narratives relating unexpected endings (but not any aforementioned endings) was faster than the WR of other previous clauses (note that adults had to produce three-clause endings). The second one (Fayol & Stephant, 1991) confirmed this result—the last clause of such endings was composed as fast as it was recalled in the second part of the experiment, which means only that remained to manage the cost of graphic transcription. Moreover, the WC pause duration when recalling (1.28 s) was shorter than when composing (1.7 s), and the difference was more important with the first (0.58 s) than the second (0.26 s) clause. These two observations suggest that, in the next to last clause of narratives, the WC pause duration was lengthened and the WR was slowed down by the preparation and/or the maintenance of information regarding the next (and last) clause. By contrast, the semantic content and most aspects of the linguistic dimension of the last clause had been selected before the production onset of this clause. This result suggested that writers, at least adults, manage several activities in parallel when composing. As already reported by Ford and Holmes (1978) regarding the production of oral discourse, planning processes may occur outside of pauses, that is, along with speaking or writing. The main question is to try to determine what representations and what procedures can be activated in such cases.

LEVELS OF LANGUAGE: FROM TEXT PRODUCTION TO WORD PRODUCTION

From Oral to Written Production During Translating

Online studies of written text composition have used two main paradigms: verbal protocols associated with secondary tasks and analyses of temporal parameters, especially pause durations, assuming that pause durations reflect the cost of planning the next segments (but see Daiute, 1981, 1984; Kaufer, Hayes, & Flower, 1986). In all cases, WRs have rarely been taken into account, as if no modulation occurred of this dimension. This lack of analyses of WRs is probably due to the fact that models on composing texts focused on high-level dimensions, especially planning and revising and did not deal with the translation process and the written output processes of writing (Fayol, 1991a; but see Berninger & Swanson, 1994). At best grammatical encoding was studied, especially clauses, because clauses are the interface between conceptual and linguistic processes (Schilperoord, 1996, p. 115). Words were almost systematically ignored in text production models despite their fundamental role in language production model and their extensive study by psycholinguists. The results from a number of experiments dealing with the oral production of single-word or multiword utterances have been collected since the end of the 1980s (Levelt, 1989, 1999). They provide theoretical frames, empirical data, and clever methodologies to investigate word production; they might also provide guidelines to study the written composition processes and representations.

Producing Single Oral Words

Over the last 10 years, researchers have focused their work on investigating the production of single words, mainly nouns. Most of the theories of speech production distinguish four main levels of processing: conceptual preparation, formulation (i.e., grammatical encoding and phonological encoding), and articulation. There is also general agreement that lexical access in speaking can be subdivided into a phase that is concerned with the retrieval of semantic and syntactic characteristics (i.e., lemma) and a phase that involves access to the phonological properties of the intended word (i.e., lexemes) (Garrett, 1982; Levelt, Roelofs, & Meyer, 1999; AQ6 Schriefers, Meyer, & Levelt, 1990). Evidence from speech errors (Astell & Harley, 1998; Harley, 1993; Levelt, 1989), neuropsychology (Kinsbourne & Warrington, 1964), and experimental studies on normals (Schriefers, 1990, 1992) suggest that semantic representations related to the concept-to-be-named are first activated. Experimental evidence comes mainly from the picture–word interference paradigm, in which participants have to name a picture target (generally eliciting the production of nouns, e.g., *a cat*) while ignoring distractors related or not to the target (e.g., *a dog*, presented in the oral or in the written modality). Semantic distractors presented auditorily (or visually) at 150 ms (but not later) before picture onset (i.e., –150 ms stimulus onset asynchrony [SOA]) delay spoken picture naming compared to unrelated controls (Schriefers et al.). A picture of a *cat* is named more slowly when accompanied by the related word *dog* than by the unrelated word *nut*. This inhibition effect from semantic distractors occurs also with visual distractors.

The situation is less clear concerning phonological (or orthographic) encoding, especially regarding how the lemma level and the lexeme level relate to each other. Discrete two-step models assume that speaking proceeds in a serial manner (Schriefers et al., 1990); cascaded models propose that speaking proceeds from one to the other level in a gradual fashion such that semantic retrieval need not to be entirely finished before the beginning of phonological access (Dell, 1986). Again, using a distractor while naming a target noun enabled inferences about the representation(s) activated: For instance, the target was *cat* and the phonologically related distractor was *cap*, a phonological neighbor that could be presented at different SOA (–150, 0, and +150 ms). The naming of *cat* was facilitated (speeded up) when *cap* was presented either simultaneously (0 ms) or shortly after (+150 ms) the picture onset. The interpretation of this result was subject to numerous criticisms AQ7 that are not relevant for the current chapter (see Bonin & Fayol, 2002a, 2002b for an extensive discussion).

AQ8 The results from most studies thus confirm the relevance of distinguishing in spoken production between a semantic and syntactic lemma level and between a phonological morphemic and lexical level. The lexeme is the locus of the classical word frequency effect (WFE). Naming objects takes more time when the lexical labels are rare than when these labels are frequent (Levelt, 1989). Jescheniak and Levelt (1994) provided the first clear evidence supporting the lexeme locus of the WFE in speech production. This very robust WFE explains at least part of the variation in between-word pauses and hesitations in oral production.

Several problems are related to the previous result. The first one is that the latencies in picture naming do not provide definite evidence that the WFE alone does affect spoken or written responses. WFE is strongly correlated with age of acquisition (AoA): Frequent words are learned earlier in life than rare ones. WFE is also correlated with length (the word length effect [WLE]): Short words tend to occur more often than longer ones and to be learned earlier than long ones. In most previous studies, AoA was not controlled for, but when AoA was controlled for, the WFE did not emerge easily as a significant predictor of word naming latencies AQ9 (Bonin, Chalard, & Fayol, 2001; Bonin, Chalard, Meot, & Fayol, 2002).

Another problem concerns the WLE: Longer words should take longer to prepare. Regarding speech production, this question concerns the degree to which speakers plan ahead at the phonological level (i.e., the number of syllables) before they initiate a response. Theories and data differ about the role and span of phonological planning. The empirical results are mixed. In a majority of studies, the WLE is not a significant predictor of the latencies in picture naming: Only the first syllable would be prepared before the word onset whatever the length of the word. Using a picture-naming task associated with a priming of the second syllable of the target words, Damian, Bowers, Stadthagen-Gonzalez, and Spalek (2010) reported a faster production of the words, attesting that the entire word was planned at the phonological level despite the absence of the WLE. Speakers could plan long phonological chunks (one utterance at least) but the (oral) response could be initiated as soon as the first syllable is placed into the articulatory buffer.

The last problem concerns the articulatory duration. Most of the time, researchers have only taken into account latencies in picture naming, that is, the time between the picture presentation and speech onset. Thus they implicitly assumed that the whole phonological information was available from the response onset and that no retrieval occurred during articulation. As an articulatory response unfolds over time, its duration (the time interval between onset and offset of an utterance) could vary as a function of the processing of the previous cognitive operations, for example, lemma selection or lexeme retrieval. Only Kello, Plaut, and MacWhinney (2000) found that when task demand increased in a Stroop naming task, lengthening occurred in both naming latencies and response duration. However, Meyer (1990), Schriefers and Teruel (1999), and Damian (2003) could not replicate this finding. All reported effects on response latencies, but response duration was never affected by the experimental manipulations of semantic and phonological relatedness. However, all these experiments dealt with isolated words and not more or less long utterances. By contrast, Ford and Holmes (1978), using a detection task along with an oral monologue production, observed that reaction times increased significantly toward the end of clauses. They interpreted this increase as an index that some planning concerning a next clause might take place before the current clause had been completed. Planning processes might thus occur along with speaking.

In spoken word production, a word is selected from among all of the words in the mental lexicon to express a particular concept. This representation is mapped onto the sound shape of the word. Current models of word production assume that there is automatic activation of the target word but also partial activation of other related representations that share properties with the word candidate (Dell, 1986). These representations compete with each other and the best fitting candidate is ultimately selected from the set of activated representations. The selection of the phonological representation of a word is modulated by the number of words in the lexicon that share sound properties with it (Dell & Gordon, 2003), resulting in a cascaded effect on its articulatory implementation. Reaction time latencies for naming pictures of words, which have many phonological neighbors, are faster than that for naming words, which have few phonological neighbors (Vitevitch, 2002).

To summarize, the study of oral word production led to observing several signatures of the processes involved in such production: the relevance of the distinction between a semantic and syntactic lemma level and between a phonological morphemic and lexical level; the occurrence of a frequency effect (WFE) difficult to disentangle from the AoA and the length effect (WLE); a robust neighborhood effect; and the absence of two expected effects—the length effect and the impact of all the variables previously evoked onto the articulatory duration. From the end of the 1990s, several researchers began to determine whether these effects would appear when word production is conceived as part of utterance production involving at least two words.

Producing Multiword Spoken Utterances

When turning thought into oral language during translation, speakers need to convert a preverbal message into a linear sequence of words. Key questions are how far ahead speakers do plan in this process and whether advance planning differs at different representational levels. These questions can be raised as concerns for both each word of a clause or a sentence *and* the whole clause or sentence. For example, in referring to the lemma/lexeme distinction it is worth considering whether all lemmas and lexemes from the same utterance are activated before the onset of articulation or whether only some of them are activated and thus how and when the others are planned and articulated. Questions about latencies (i.e., pauses between words) and articulatory durations must be considered in this new perspective.

At first evidence with respect to phonological advance planning in multiword utterances came from the analysis of speech errors. Garrett (1980) contrasted word-exchange errors and sound-exchange errors. In word exchanges, words from the same syntactic categories exchanged places and spanned over different syntactic phrases; this observation suggests a relatively large degree of advance planning (Fromkin, 1971). Sound exchanges occurred over short distances, generally within a phrase. Because speech errors obey different constraints, they are thought to arise at different levels of encoding and different representational levels, respectively, grammatical encoding and phonological encoding.

More recently, advance planning was addressed by applying the picture–word interference task: Participants produce utterances in response to picture(s) while ignoring distractor words. Meyer (1996) was the first to study experimentally the oral production of multiword utterances. The participants named two simultaneously presented objects (pictures of, e.g., the bag/the arrow) either by noun–phrase coordination (the bag and the arrow) or by a simple sentence (the bag is next to the arrow). Semantically related distractors to the first as well as to the second noun slowed down naming speed (inhibition effect), providing evidence that both lemmas have been selected before the speech onset. Phonologically related distractors to the first noun had facilitation effects (the latencies were shorter); those related to the second noun showed a small inhibition effect: The phonological form of the second noun became a competitor for the phonological form of the first noun (see also Smith & Wheeldon, 1999).

Several studies have been conducted to understand better the extent, the levels of representation, and the processes of advance planning in dealing with sentences but not texts. They concentrated on phonological advance planning. The results seemed to converge toward a unified conception strongly related to the picture–name interference paradigm. For example, Jescheniak and Schriefers (2001) asked German speakers to produce bare nouns or noun phrases (Det + noun) while phonological distractors were presented related to or not related to the noun. They found substantial facilitation with bare nouns, but reduced facilitation with noun phrases. In Italian speakers, Miozzo and Caramazza (1999) found similar facilitation for bare nouns and for determiner plus noun phrases. In English and in Spanish, Costa and Caramazza (2002) reported facilitation on the noun describing colored objects by using determiner plus adjective plus noun, suggesting that speakers had encoded the phrase up to its final element before the articulation onset. Damian and Dumay (2007) replicated these results even when a deadline response was used to increase the demand of the production task (but see Schriefers & Teruel, 1999). Schnur, Costa, and Caramazza (2006) observed faster latencies when their participants produced intransitive sentences such as *the girl jumps* and *the orange girl jumps* with a distractor phonologically related to the verb.

Jescheniak (Jescheniak, Schriefers, & Hantsch, 2003; Oppermann, Jescheniak, & Schriefers, in press) proposed a theory able to accommodate most of the previous empirical results. The assumption is that the phonological forms of the successive words receive a graded pattern of activation before articulation is initiated. The subsequent words differ with respect to their activation level, decreasing from left to right, such that activation strength varies as a function of their position (i.e., rank) in the utterance. Elements outside the phonological advance planning scope have an activation of zero. Any distortion of this graded activation pattern leads to interference during phonological encoding. As a consequence, primes that enhance the activation of the utterance-initial element speed the encoding process without cost. By contrast, primes that enhance the activation of noninitial elements disturb the graded activation pattern such that the primed element moves to a wrong (i.e., too early) position, hence production errors such as those described by Fromkin or Garrett. Oppermann et al.'s (in press) results are in line with this conception. The participants viewed pictures of simple scenes involving an agent performing a simple action on a patient (e.g., a mouse eating cheese) along with sentences describing these scenes (e.g., the mouse eats the cheese). During the test, only the picture of the agent was presented (mouse) and participants were asked to describe what the agent has been doing using SVO or SOV sentences elicited by sentence fragments. Distractors phonologically related or not to the subject or to the object of the sentence were presented at three SOA (0, 150, and 300 ms). There was facilitation from distractors related to the noun in the initial utterance position and interference from distractors related to the object appearing in the second phrase in SOV and to the subject in the second phrase in VSO production (i.e., in noninitial position). However, when sentences used a nondominant word order, the increased processing demands led to smaller grammatical planning.

At the moment, most results having to do with the oral production of multiword utterances bear on short phrases or clauses. An integrative model suggests that in such cases all lemmas are selected before speech onset but only the initial lexeme of the utterance is activated. This conclusion cannot be extended without caution to sentences and (small) texts. Moreover, no data are available regarding the online processing of lexemes in the course of the utterance articulation: When are the successive words retrieved? Is the corresponding process cost free or does it require variable latencies to reactivate the target words? Are all lexemes activated after the previous one has been articulated or are some of them retrieved in parallel with articulation to ensure the fluency of production? At the moment none of these questions is answered, and most of them are not approached or tackled.

Producing Written Utterances

The study of written composition benefits from the previous studies, results, and theories from oral production, which may draw on common as well as unique processes during translation of ideas into language that can be produced orally through mouth or graphically through hand. In a number of cases, researchers tried to use the paradigms and replicate the results in the written modality that have been used and reported in the oral modality. Most of the time, the researchers were successful.

To begin with, it is useful to transfer the question approached in the oral production to the written production of utterances. In written word production, a word is selected from among all of the words in the mental lexicon to express a particular concept. This representation is then mapped onto the phonological and orthographic form of the word, and these abstract representations are in turn mapped onto articulatory implementation of oral or written processes that provide information to the articulators of mouth or finger movements of hand about the ultimate realization of the word. Most theories assume that there would be an automatic activation of the target word but also a partial activation of other related representations (Dell, 1986), leading to a competition until the selection of the target word. This competition leads to interferences in some cases (with increasing processing difficulties entailing increases in latencies) and to facilitation in other cases (enhanced processing leading to decreased processing time).

As the selection of the phonological representation of a word, that of the orthographic representation is expected to be modulated by the frequency, the AoA, and the number of words in the lexicon that share form properties with it. This modulation would have a cascaded effect on the articulatory implementation, in the written modality as well as in the oral modality. Reaction time latencies for words, which have many phonological and/or orthographic neighbors, would be faster than that for words that have few neighbors (Vitevitch, 2002). The influence of lexical neighbors on articulatory processes would reflect the cascading effects of lexical activation and selection processes on articulation. The main difference has to do with the articulation phase, that is, how abstract cognitive representations coming from phonological–orthographical encoding are transformed into articulatory motor program (Damian, 2003). One important question concerns the possibility of an impact of this cascaded effect onto the modulation of written rate, that is, the duration of transcription. Indeed, handwriting is far slower than speaking, leaving potential room for modulations of the production rhythm, and making it possible to control for through reading the forms already produced.

Research devoted to writing isolated words provided evidence that there are no fundamental differences between oral and written word production regarding the different levels of representations and the time course of their activation: The lemma level is common to both modalities, whereas in writing, the lexeme level includes both phonological and orthographic information (Bonin & Fayol, 2000). The same semantic interference effect showed up in the written production of isolated words with the same SOA (–150 ms), suggesting that the same representation level (lemma) and the same time course in written picture naming as in oral picture naming (Bonin & Fayol). Extending the picture–word interference paradigm to the production of written words, Bonin and Fayol used a factorial combination of semantic and phonological relatedness and two SOAs (0 and –150 ms). Phonologically related distractors facilitated written production (latencies decreased) as compared to phonologically unrelated distractors. However, semantic and phonological relatedness interacted: Semantic interference was observed with phonologically unrelated distractors, but disappeared with phonologically related distractors. The latencies observed with the semantic interference and that observed with the phonological interference were not additive, as expected by the strict serial conception. These results replicated the interaction between semantic and orthographical/phonological relatedness reported by Starreveld and La Heij (1995).

Comparing the oral and written naming of frequent and rare nouns on the basis of pictures depicting well-known objects, Bonin, Fayol, and Gombert (1997, 1998) observed significant frequency effects in both writing and speaking from pictures. Using an homophonic picture-naming task in which participants had to speak aloud or write down homophonic words (e.g., *verre* = glass, high frequent word, versus *ver* = worm, low frequent word, the common pronunciation of which is /vEr/), Bonin and Fayol (2002) reported that written latencies were longer than spoken latencies, but less time was necessary to produce high than low frequency words under both modalities. This result confirmed that the differences in naming time were related to lexical properties, here frequency. However, as in the oral modality, the latencies in picture naming do not provide definite evidence that the WFE alone does affect spoken or written responses: Again, WFE correlated with AoA and length (WLE). When AoA was controlled for, the WFE did not emerge easily as a significant predictor of word naming latencies (Bonin, Fayol, & Chalard, 2001; Bonin et al., 2002). However, WF remains one of the main and most robust variables in studies of written language, in reading as well as in writing.

Things are clearer regarding the neighborhood effect. Roux and Bonin (2009) have studied the impact of orthographic neighborhood on spelling. Adult participants were required to spell orally words with dense or sparse orthographic neighborhood. The dependent variables were oral spelling latencies and error rates. As expected, oral spelling latencies were shorter with words having a dense orthographic neighborhood and longer with words having a sparse orthographic neighborhood. The authors interpret the facilitatory effects (60 ms) of dense neighborhood by considering that words with such neighborhoods receive activation from many similar words.

Moving from orthography (spelling) to handwriting production necessitates programming of the number of letters, their sizes, and directions (Van Galen, 1991). Van der Plaats and van Galen (1990) provided evidence that the longer the word to write (i.e., the number of letters), the higher the latency. However, the increase as a function of the number of letters was slight, which led the authors to conclude that a large part of the letters was programmed online. Because processing capacities are limited, handwriting proficiency requires that letters are grouped into chunks in order to facilitate motor programming. As a consequence, people use syllables and graphosyllables as units for chunking information on the letter string to write words and pseudowords. Interestingly, this chunking process leads to an increase of pause duration at the syllable boundaries (Kandel, Alvarez, & Vallée, 2006). Copy tasks have shown that the number of syllables affected latencies for pseudowords, but not words when items were copied once. However, when the same items were copied several times, the number of syllables impacted on latencies of both words and pseudowords from the second copy onward. It is as if the participants stored the items in a phonological buffer that delivered information to the articulatory program sequentially, syllable by syllable (Lambert, Kandel, Fayol, & Esperet, 2008).

In addition, handwriting proficiency was optimized through grouping letters into chunks in order to program efficiently the motor outputs. In French, these chunks integrate both phonological and orthographical information: Orthographic syllables (similar to the graphosyllables of Caramazza & Miceli, 1990) and bigram frequencies are used as processing units separated by boundaries

(Kandel, Grosjacques, Peereman, & Fayol, submitted; Kandel, Hérault, Grosjacques, Lambert, & Fayol, 2009). Results are thus mixed regarding the phonological WLE, and are few in number concerning the graphemic dimension (i.e., number of letters). Nevertheless, it is impossible to disregard the number of letters as a potential variable impacting on latencies and on writing duration (or WR).

The possibility of parallel processing, for example, planning occurring while articulating, seems more likely in written composition because writing is slower than speaking. Few data are available. Chanquoy et al. (1990) observed that the WR of adults and fifth graders increased in the last clauses of narratives, and Fayol and Stephant (1991) showed that the pause before and the WR of these last clauses were, respectively, as short and as fast as when people were recalling them, suggesting that their management imposed a lower load on the participants than when they are producing the clauses. Unfortunately, the collection of data did not allow the authors to determine whether the variations affected the pauses within clauses and within words or the speed of transcribing words and letters. Another set of data was clearer regarding this last question.

Delattre, Bonin, and Barry (2006) used a spelling-to-dictation task to compare the written production of regular (consistent) versus irregular (non-consistent) French words matched on a number of dimensions (word frequency, bigram frequency, etc.). They replicated Bonin, Peereman, and Fayol's (2001) finding that latencies in the initiation of written production were reliably longer for irregular than for regular words matched for frequency and several other variables. More importantly, the writing duration was also significantly longer for irregular than for regular words matched for length and bigram frequency. The authors interpreted these results within a cascaded model of written word production: Spelling irregular words should trigger some central conflict between sublexical processing (i.e., using phoneme–grapheme associations) and lexical processing (i.e., access to the word-specific orthographic form). Resolving this conflict would both delay the latency and slow down the writing duration of the words, thus suggesting that the conflict is still not resolved when writing begins. The results obtained by Bonin et al. (1997, 2001) and Delattre et al. (2006) clearly show that the written production of isolated words is sensitive to both the frequency and consistency of these words and that these dimensions impact on both latencies (pause duration) and writing duration (WR) in isolated word production. Unfortunately, the authors did not report the value of the correlations between these two variables.

AQ10 Regarding the production of written multiword utterances, Bonin, Fayol, and Malardier (2000) replicated Meyer's (1996) results (see above) using the same paradigm with the written modality. Both lemmas were activated. Both activated their lexical and sublexical units but the first one activated its units more strongly than the second. Latencies were shorter when the distractors were related to the first noun (facilitation effect) and longer when the distractors were related to the second noun (inhibitory effect). Subsequent studies showed that the variables that contribute to the naming latencies were similar in the two production modes, oral and written (Bonin, Malardier, Méot, &
AQ11 Fayol, 2005). The processes involved in the written production of two nouns

from pictures are thus coordinated in the same way as in speaking despite that written latencies were longer than speaking latencies.

To the best of our knowledge, none of the experiments devoted to the study of clause or sentence production have been replicated in the written modality. However, there is no theoretical reason to consider that the representations involved and the time course of their activation would differ from that of the oral modality. The main differences between the oral and the written modalities have to do with (a) the slowness of graphic production, which could facilitate both planning and reviewing of what has been already produced and (b) the difficulties related to spelling: Word writing demands spelling processing, the difficulty of which differs between spelling systems, depending on the consistency of the phoneme-to-grapheme correspondences (Lété, Peereman, & Fayol, 2008). Phonology-to-orthography consistency refers to the level of variability in the orthographic codes that can be assigned to a particular phonological unit. For example, phoneme-to-grapheme consistency is lower when a number of different graphemes can be mapped to a particular phoneme (e.g., /o/ in French is spelled o in "mot" (word), au in "saut" (jump), and eau in "oiseau" (bird)) than when a single grapheme is always associated with a particular phoneme (e.g., again in French, /u/ is always spelled "ou" as in the words "fou," "cou," and "bijou"). Bonin et al. (2001) found longer latencies for irregular than for regular French words, providing evidence that consistency has an impact on the online management of isolated written word production. In a spelling-from-dictation task, Lété et al. (2008) found that phoneme-to-grapheme consistency and word frequency had independent effects on spelling accuracy scores in the primary grades of learning to read.

Whereas the consistency contribution (indicating a sublexical procedure to spell words) remained high across grades, the impact of word frequency (indicating a lexical lookup procedure) exhibited a massive jump between first and second grades. People producing written sentences or texts have thus to manage the specific difficulties related to spelling. One important question concerns when such difficulties are managed. Two possibilities are worth considering. First, spelling difficulties can be perceived and solved before the writing onset, words being directly retrieved and transcribed from memory. Second, as suggested by Delattre et al.'s (2006) results, some difficulties could remain unresolved when transcription begins. In such cases, these difficulties could be tackled either when pausing within word, for example, before an earlier part of the word, or when writing through parallel processing of transcribing and planning the sublexical part of the current or the next word.

As previously noted, studies dealing with the oral production of isolated words have reported that no variable impacted the articulatory dimension. The situation is quite different regarding sentence or clause production. To repeat, at least two observations suggest that adults and children at the end of elementary school can both transcribe sentence fragments and prepare or review other parts of their writing (Chanquoy et al., 1990; Fayol & Stephant, 1991). The remaining question is to determine when and how they proceed to conduct these different activities.

SUMMARY AND CONCLUSION: FROM TEXT PRODUCTION TO WORD PRODUCTION AND BACK TO INTEGRATE BOTH

The previous review makes clear that we have two current trends in written production research. The first one deals with texts as wholes and analyzes the management of the higher-level components through verbal protocols, linguistic analyses, secondary tasks experiments, and global studies of pauses and (rarely) WRs. The corresponding results attested that the knowledge of the content evoked within the texts, the rhetoric organization (e.g., narrative, expository), and the phase of the composition process (e.g., planning before onset, translating, reviewing) impact on the online management of written composition. In addition, the strategies of the writers change as a function of age or schooling: Elementary school children tend to produce according to a knowledge-telling strategy (Bereiter, Burtis, & Scardamalia, 1988); they formulate their utterances as the corresponding knowledge is accessed. By contrast, older writers compose their texts using a knowledge-transforming strategy (Bereiter et al.). Researchers adopting that perspective rarely take into account the role of lower-level variables such as the complexity of handwriting, the orthographic form of words, or the syntactic structure of sentences (but see Berninger, Fuller, & Whitaker, 1996; Berninger & Swanson, 1994; Graham et al., 1997).

The second trend focuses on lower-level processes, most of the time the production of isolated words generally in the oral modality (Levelt, 1989). However, more recently, the research paradigms used to study oral production have been extended to the study of oral phrases, clauses, and even sentences, and to that of written word and multiword utterances, making clear that the first steps of the production process (i.e., conceptual and the lemma) are the same whatever the modality. Regarding the following steps, even if the word forms differ (phonological versus orthographic), the same variables impact on latencies: frequency, AoA, and neighborhood. Some differences appear with the impact of spelling and with the mapping of the lexeme representation onto the articulation process. Contrary to what has been reported with the oral modality, in the written modality, the impact of frequency, neighborhood, and consistency could have cascaded effects on the articulatory implementation, leading to variations in both latencies and handwriting durations.

For some time, the focus of study was how written word production unfolds when words are included in texts. Until recently, the production of words has mainly been studied using isolated words or, at best, pairs of words as if producing isolated words was enough to understand how words are processed in larger context, that is, texts. Moreover, the main chronometric measure was latencies, implicitly assuming that pauses are devoted to planning the next word and that writing duration (or rate) is not relevant.

Following researchers working on the study of reading in real time (Kliegl, Nuthmann, & Engbert, 2006), we envision the question of word production within texts through new glasses. First, as we are studying written composition, we propose considering both latencies (i.e., pause lapses) before words and within words.

Indeed, online analyses reported in the section "First Step: Analyzing Online Processing in Written Composition" showed that adults and children often stop writing within words for a while. We also suggest taking into account the WR (or duration) of written words. At the moment, it is impossible to disregard the possibility that handwriting speed can be modulated by variables such as frequency, neighborhood, and consistency. As a heuristic approach, it could be worth studying the correlations among these three dependent variables. Previous results attest that latencies (at least before isolated words) are sensitive to the previously mentioned variables. If there is no variation in writing duration, no correlation will appear. By contrast, if some variations occur, it will be relevant to determine whether they are highly or slightly, positively or negatively, correlated with latencies (a high correlation would mean that the two variables index the same processes). Previous data regarding the production of text endings (Chanquoy et al., 1990; Fayol, Foulin, Maggio, & Lété, in press) showed that the correlations were weak (−0.10), justifying that latencies and WR are treated as independent indexes in separate analyses. The reasoning is thus that each of the three dependent variables is worth studying because each of them provides information about specific aspects of word production.

Second, until now, the implicit assumption regarding the relationship between latencies and word production was that the pause before any word was indexing processes related to this word, or at most, to the two or three following words. We refer to that conception as the *immediacy* assumption. It can be extended to within-word pauses and to writing duration or rate: The variations affecting these variables should be exclusively related to the processing of the current word at time *n*. However, another conception is worth considering. As evidenced by researchers working on the dynamics of reading, we hypothesize that some words are not totally processed when they have been transcribed (Daiute, 1981). As a consequence, some cognitive operations would still be devoted to their processing (n−1) when the next word is being processed, a matter of *delayed effect*, the impact of which could affect the following pause (i.e., the latency relative to the next word) or the written duration of the next word. Reciprocally, a writer engaged in the transcription of a current word *n* could begin processing the next word (n+1) (e.g., computing its consistency), either when pausing within the word *n* or when transcribing it: an *anticipatory effect*.

To summarize, we suggest studying the online written word production in the context of text production through the use of chronometric measures, taking into account three dependent variables and three moments of production: the current word *n*, its predecessor (n−1), and its successor (n+1). We are expecting both *immediacy effects* (e.g., the impact of consistency), *delayed effects* (e.g., frequency), and *anticipatory effects* (e.g., neighborhood). Such research is currently in progress (Maggio, Lété, Chenu, Jisa, & Fayol, in preparation). The most salient results to date include the following: First, as reported in previous attempts to take into account both latencies and writing duration, the correlation between these variables (and the within-word pause duration) was significant but weak, suggesting that the variations were relatively independent. As a consequence, each of them was indexing some specific aspects of the dynamics of written composition.

Second, a brand new result was that the rank of the words in the text exerted a systematic facilitatory effect upon the three dependent variables: The further the word in the text, the faster the WR, and the shorter the before and the within pauses. Third and contrary to the general assumption, the pause preceding word *n* was only sensitive to delayed effects from some characteristics of the previous words (*n*–1). Fourth, the WR variations were associated with immediacy (e.g., consistency of the spelling of *n*) and anticipatory (e.g., the frequency of (*n*+1)) effects. Fifth, the within-pause durations were mainly sensitive to immediacy effects (e.g., syllable frequency).

Overall, analyzing the processing of words in the context of written text composition brings to the fore the dynamics of production. Obviously, things appear far more complex than has been previously expected. When composing, people are concurrently writing down parts of their texts, finishing the processing of data from already transcribed words (delayed processing), solving current problems about some specific difficulties (e.g., spelling), and thinking ahead about other aspects related to the characteristics of the next word(s) (anticipatory processing). This dynamic management of composing is not yet completely understood, but it is worth studying because it opens new avenues in understanding why written composition is so complex and why it is so hard to learn and manage.

The next step in this line of research will undoubtedly make the writing process appear to be still more complex because it will be necessary to integrate in a unique model components from higher and lower levels involved in written composition online in time.

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AQ15 Montluçon (France) December, 2010

AUTHOR QUERIES

[AQ1] Please check if edit to the sentence starting "However, experiments…." is ok.
[AQ2] Please note that the year in Butterworth (1975) is changed as per list.
[AQ3] Please provide complete details for Ford (1984) in list.
[AQ4] Please check the running head is edited from the chapter title.
[AQ5] Please check if edits to the sentence starting "For example, in accessing…" and a similar occurrence are ok.
[AQ6] Please note that the year in Garrett (1975) is changed as per list.
[AQ7] Please note that the year in Fayol (2002) is given as 2002a and 2002b.
[AQ8] Please check if edit to the sentence starting "The results…" is ok.
[AQ9] Please provide complete details for Bonin et al. (2001), Meyer (1990), Bonin et al. (1998), and Caramazza and Miceli (1990) in list.
[AQ10] Please specify the section heading instead of "see above" in the sentence starting "Regarding….".
[AQ11] Please note that the year in Bonin et al. (2006) is changed as per list.
[AQ12] Please provide in-text citation to the following references Alamargot and Fayol (2009), Bonin et al. (2008), Burtis et al. (1983), Fayol (1991a, 1997b, 1995), Fayol et al. (1994), Flower and Hayes (1981), Foulin (1995), Goldman-Eisler (1968), Hawkins (1971), Holmes (1988), Just and Carpenter (1980), Kowal and O'Connell (1987), Martlew (1983, 1992), McCutchen et al. (1994), Scardamalia and Bereiter (1986, 1987), Thomassen and Teuling (1983), and Van den Berg and Rijlaarsdam (1996, 2001).
[AQ13] Please provide volume number for the reference Fayol (1991a).
[AQ14] Please update Kandel et al. (submitted), Oppermann et al. (in press), and Fayol et al. (in press).
[AQ15] Please clarify whether "Montluçon (France) December, 2010" denotes reference. If so, please provide complete details and citation for the same.