INSTANT MESSAGING: A THREAT FOR POOR SPELLERS WHOSE SPELLING IS IN THE PROCESS OF BEING CONSOLIDATED

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Abstract

It is hard to make a clear status about the link between instant messaging and spelling. We dug into 2 areas that found no clear answer in the literature. In a first study, we compared the amount of modified words produced in instant messaging by French and American adolescents (both orthographies are opaque but cultural and economic aspects differ). Results showed the first produced more modified words than the latter. These aspects would matter to explain the amount of modified words. In a second study, we compared the amount of misspellings on paper and modified pseudo-words in instant messaging. There were 3 groups (made of good and poor French spellers) for 3 exposure phases (12 weeks): not exposed to instant messaging; exposed during 6 weeks; exposed during 12 weeks. Results showed poor spellers produced more misspellings than good spellers – only for the second group. There would be a risk for poor spellers whose spelling is being consolidated.

Keywords: Spelling; Adolescent; Texting; Instant Messaging.

Resumo

É difícil estabelecer um status claro sobre o link entre mensagens instantâneas e ortografia. Nós cavamos em 2 áreas que não encontraram nenhuma resposta clara na literatura. Em um primeiro estudo, comparamos a quantidade de palavras modificadas produzidas em mensagens instantâneas por adolescentes franceses e americanos (as duas ortografias são opacas, mas os aspectos culturais e econômicos são diferentes). Os resultados mostraram que o primeiro produziu mais palavras modificadas que o segundo. Esses aspectos seriam importantes para explicar a quantidade de palavras modificadas. Em um segundo estudo, comparamos a quantidade de erros ortográficos no papel e modificamos pseudo-palavras em mensagens instantâneas. Havia 3 grupos (compostos de bons e maus spellers franceses) por 3 fases de exposição (12 semanas): não expostos a mensagens instantâneas; exposto durante 6 semanas; expostos durante 12 semanas. Os resultados mostraram que os soletradores fracos produziram mais erros ortográficos do que bons soletradores - apenas para o segundo grupo. Haveria um risco para os soletradores pobres, cuja ortografia está sendo consolidada.

Palavras-chave: Ortografia; Adolescente; Mensagens de texto; Mensagens instantâneas.

Introduction

Defining digital writing in instant messaging

According to Varnhagen, McFall, Pugh, Routledge, Sumida-MacDonald, and Kwong (2010), Digital Writing (DW) can be compared to an interactive type of communication similar to normal conversation. In contrast to conversation, however, it involves distance, as parties communicating do not physically share the same space in general) and a time lapse (communication is either synchronous or asynchronous). Joshi (2014) describes this type of writing as a set of figures, signs, words, and symbols, for which the “technical” rules of a given language are not followed to the letter (e.g., spelling rules). Defining DW is equivalent to evaluating what happens from a linguistic standpoint on the basis of rules that defines Standard Writing (SW),

making it *the* reference (Crystal, 2011; Ong'onda, Matu, & Oloo, 2011). Many authors chose the corpus-collection method to form typologies to define DW (Anis, 2003; Dresner & Heering, 2010; Fairon, Klein, & Paumier, 2006; Kobus, Yvon, & Damnati, 2008; Liénard, 2008; Ong'onda et al., 2011; Panckhurst, 2009a; Simoës-Perlant et al., 2012; Véronis & Guimier de Neef, 2006; Yvon, 1998[1]). Whatever the study, some characteristics seem to be specific to DW (when compared to SW)[2]:

- At the syntactic level, punctuation is not frequently used (e.g., capital letters at the beginning of sentences) (e.g., Panckhurst, 2009a);
- At the lexical level, truncations (e.g., "ciné" instead of "cinéma" in French; "Tues" instead of "Tuesday" in English) and Anglicism (e.g., "bye" instead of "au revoir" in French) are used more often (Anis, 2003);
- At the semantic level, "consonantal skeletons" shorten messages (e.g., "slt" instead of "salut " in French; "tmw" instead of "tomorrow" in English) (Anis, 2003);
- At the grammatical level, sentences are constructed based on a verb, as in speech (as opposed to written sentences, which are constructed based on the common noun). Even if DW is – as the name suggests – written, its structure is closer to the oral code than to the written code (Lanchantin, Simoës-Perlant, & Largy, 2012);
- At the spelling level, there is a high occurrence of "phonetic written forms" (e.g., "kom" instead of "comme" in French, "u" instead of "you" in English) (Anis, 2003).

With a view to analyzing DW production, Ong'onda et al. (2011) mentioned a number of factors to explain the roots of DW, such as (a) the technical characteristics of cellphones, computer tablets, and computers or (b) the fact that people share the same environment, related to a situation known to the parties communicating. Defining DW therefore actually involves considering the role of the medium used to communicate, as it seems to result in a difference in use. The term SW or DW "medium" refers to a way of sending written information to someone. This medium

[1] Concerning typologies, most of them concern corpuses written by adults, who did not develop their abilities in reading and writing in close contact with SW and DW, except for Simoës-Perlant et al. (2012), who asked adolescents (with and without reading or writing disorder) to form a corpus.
[2] N.B.: Some categories also belong to SW (e.g., truncations), but they are produced more frequently in DW (e.g., Panckhurst, 2009a). Consequently, they have become even more specific to DW.

can either be traditional (e.g., paper) or digital and paper-free (e.g., the screen of a computer, of a cellphone, or of a tablet computer). It is also important to distinguish between the type of medium and the type of writing (standard vs. digital), as it is possible to produce SW by using a digital medium and DW on paper (N.B.: DW also includes words that are spelled correctly – in other words, it includes SW, see Lanchantin, Simoës-Perlant, & Largy, 2014). Consequently, it has to be understood that DW is complicated to define as it has many different characteristics that are hard to identify.

Lately, studies have been designed to know whether orthographic depth has something to do with modification production and to analyze the link between the use of DW and the quality of spelling.

About the role of orthographic depth, Panckhurst (2009b) and Plester Lerkkanen, Linjama, Rasku-Puttonen, and Littleton (2011) showed the more the opaque spelling, the more modification produced in DW. But other aspects come to mind when talking about writing (i.e., cultural and economic). Concerning the cultural aspect, Grace, Kemp, Martin, and Parrila (2012) showed no significant differences in terms of text-messaging habits between a sample of Australian and Canadian modifiers (all English-speakers). Concerning the economic aspect, Lee (2002) showed getting access to DW was more complicated for American than European adolescents, because of more restrictive and expensive phone contracts (which include now instant-messaging features). As we may see, comparing participants' performance according to their nationality (or to the language they speak) allows taking the cultural and economic aspects into account that we refer to as being the "context of production".

The link between the use of digital writing and the quality of spelling

About the link between the use of DW and the quality of spelling, studies contrast skills required to modify[3] words used for DW (mainly in text messaging) and literacy skills used in SW. By literacy, we are referring to the amount of knowledge a child acquires, which allows him/her to become a full-fledged member of a particular

[3] We prefer using the terms "to modify" rather than to "oralize" (Bouillaud, Chanquoy, & Gombert, 2007), "to use textism" (Plester, Wood, & Joshi, 2009), or "to use SMismes" (Macedo-Rouet, 2010), as these terms only reflect one aspect of DW (i.e., only texting and not instant messaging, emails, messages on social-network walls, etc.).

community. This is usually done through reading and writing, and more specifically through spelling or grammar (Burns, Espinosa, & Snow, 2003; Tran, Trancart, & Servent, 2008). Comparing these skills may help to determine the nature of the link between the use of DW and skills in literacy, but this task proves to be highly complex. Designing a protocol that responds to this need is likely to be laborious. For instance, comparing two types of production by asking participants to write two dictation tests on SW and DW medium during one hour is really interesting. But at the end, it does not allow determining whether there is a link between the use of DW and the quality of spelling. Designing longitudinal experiments over one/several year/s may then be the answer, but here again: does the spelling level really decrease/ increase/ remain the same/ because of this use, or is it due to other non-identified factors? Many authors have tried to find a solution to these issues, which have produced many different results – many of which are contradictory. To answer the question we just mentioned, Verheijen (2013) summarized most of these findings by concluding that the use of DW decreases, increases, or has no link with the quality of knowledge related to literacy. According to Verheijen (2013), the explanation for this wide range of results could be (a) the conditions under which the author of the text modifies words while producing DW; (b) the modifier's abilities; and (c) the type of link that the authors underline. Consequently, the results would vary:

- In the first case, because of the frequency of modification in DW, the situation in which the modifier finds him/herself (i.e., of DW comprehension or of production), or the desire to use modifications or not to use them;
- In the second case, because of the level of knowledge (or expertise) regarding modification production or the level of knowledge related to literacy;
- In the third case, because of the nature of the link (which is considered as depending on the type of literacy knowledge – sometimes related to SW comprehension through reading abilities, sometimes to its production through writing and/ or spelling abilities).

These 3 types of findings show how important the need is for designing a protocol that takes into account all the work that has been done so far. That is why an exhaustive review of the scientific literature that focuses on the analysis of the link between the use of DW and the quality of spelling has to be undertaken.

Over the past ten years, numerous studies using a wide range of methods have

been published. The very fact that so many methods have been used could explain the contrasting results that have been highlighted above. If we take the modifier's profile into account, it is important not only to determine the type of contact s/he has had with DW (by gathering data on the frequency of modification), but also and especially to assess his/her contact with SW (in terms of habits in standard reading and writing). It is with this in mind that Gann, Bartoszuk, and Anderson (2010) compared the performance of 62 students to that of 44 people from the same area (all English-speakers) to determine – after having assessed their spelling level and identified their profile (text users vs. non-text users) – that there was no significant difference between the two groups.

Results showing no link between the use of DW and the quality of spelling are found in De Jonge and Kemp (2012) and Gonthier and Leblanc (2012). Bernicot, Goumi, Bert-Erboul, and Volckaert-Legrier (2014) started from a natural corpus of texts written by French-speaking pre-adolescents to show the same findings. Partially confirming these results, Wood, Kemp, Waldron, and Hart (2014a) showed no link at all about the use of modification and grammatical and spelling levels for children, but a negative correlation among adult students. This would mean that population specifics are key, as writers' spelling levels seem to be highly important. For example, Plester, Wood, and Bell (2008) mention in the conclusion of their study that there may be no deleterious effect for good spellers (after having analyzed performance in a translation exercise, from sentences to texts and vice versa). These results have to be completed with studies showing that the use of modification is positively correlated to high skills in literacy (e.g., Drouin & Davis, 2009; Kemp, 2010; Plester et al. 2009; Wood, Jackson, Plester, & Wilde, 2009; Wood et al., 2014a; Wood, Kemp, & Waldron, 2014b) or that the higher the literacy level, the more modification produced in DW (Drouin, 2011; Kemp & Bushnell, 2011; Plester & Wood, 2009; Wood, Jackson, Hart, Plester, & Wilde 2011b; Wood et al., 2011).

Another difference is relevant to the question at hand. To better define the nature of the link (between the use of DW and the quality of spelling) from the cognitive-psychology standpoint, we chose to focus on instant messaging for a specific reason. The majority of studies on the topic focused on text-messaging production, which is closer to making sentences than to standard text production (N.B.: the word (standard) "text" here does not refers to "texting"), as is the case with instant messaging. But when it comes to cognitive psychology, the reference models are based on standard text production and not on sentence production (e.g., see

Hayes, 2012), which is the reason instant-messages corpus study is more relevant here. Considering SW production, Hayes (2012) identified resources involved in text production (including attention, working memory, long-term memory, and reading). Considering instant-messaging production, two of the resources described by Hayes (2012) get special attention: working memory (see Baddeley, 2000) (we will come back to this later) and long-term memory. Long-term memory indeed includes (a) declarative knowledge (which allows us to know we have to put in French an “m” before a “b” to create the digraph “em” pronounced /ã/), (b) procedural knowledge (which allows us to use grammatical rules, for example), and (c) conditional knowledge (which allows us to know when and how to use declarative and procedural knowledge) (Baker, 1989; Glaser & Chi, 1988; Garner, 1990). Regarding all the studies that aimed at defining DW production, knowledge used to produce instant messages is mainly related to spelling knowledge stored into long-term memory. Then, three aspects – related to long-term memory when using DW – come to mind: (a) the modifier’s spelling level (that was already mentioned supra); (b) the use of one specific kind of modification that impact spelling knowledge in the long term; and (c) the orthographic depth hypothesis (Besner & Smith, 1992; Katz & Frost, 1992). Analyzing specific modifications is of prime importance as it cannot be determined whether or not they were produced intentionally. Indeed, modifications that can be confused with misspellings – which are therefore at risk – can pose a threat to poor spellers. For example, if a modifier writes “Je suis allé à Paris” in French or “me to” instead of “me too” in English on DW medium, did s/he [in French] omit the accent on the preposition on purpose, confused this preposition with the auxiliary verb; [in English] omit to write the second “o” on purpose or not; or is it all about “instances recall” (which consists in recalling written instances stored as such in the mind’s orthographic lexicon stored itself inside long-term memory, see Gunnarsson & Largy, 2010 for further details)?

The frequency of word use having a high impact on data storage in the mind’s spelling lexicon (e.g., Cassar & Treiman, 1997; Deacon, Conrad & Pacton, 2008; Gombert, 2006; Largy, Cousin, Bryant & Fayol, 2007; Lété, 2006; Nigro, Jiménez-Fernandez, Simpson & Defior, 2015; Pacton, Fayol, Lonjarret, & Dieudonné, 1999; Pacton, Fayol & Perruchet, 2002; Perruchet & Pacton, 2004; Share, 2005), the effect of frequently using these specific modifications in DW has to be considered. Some results show that the phonological aspect is very influential when it comes to the process of producing DW (see Anis, 2003, knowing that Gunarsson & Largy, 2010,

showed this aspect also oversteps the orthographic aspect when producing SW). And this is why there is a higher risk – that the use of DW in instant messaging has a negative effect on spelling. Indeed, when the orthography of a particular language is transparent, written words simply encode speech; when it is opaque, the process becomes more complex and the more the phonological element may be ignored (Besner & Smith, 1992; Katz & Frost, 1992; Seymour, Aro, & Erskine, 2003). In opaque orthographies, there are words that are pronounced the same but spelled differently. In such cases, the speller has no other choice but to rely on his/her literacy skills and on the environment if s/he wants to spell them correctly. Literacy awareness is therefore even more under threat for spellers who use opaque orthographies because of the frequency of use of modifications that can be confused with misspellings. The risk of the aforementioned becoming a reality therefore increases if the modifier produces DW (which is even truer if his/her spelling level is poor). Increasing the production of modifications is tantamount to increasing the production of instances that may harm spelling knowledge, considered in SW to be misspellings (see Powell & Dixon, 2011 and Anderson & Elsner, 2014 who showed that participants who are more exposed to misspelled words produce more misspellings than participants who are not exposed).

Starting from this literature review, it is highly important to take the adolescent population into account – and not adults as it has been done in previous studies – given the popularity of DW amongst the younger generations, who are inclined to favor this less rigid form of communication (Bryant, Sanders-Jackson, & Smallwood, 2006). Furthermore, two main questions raised from this literature review that still need a clear answer. In addition to Panckhurst (2009b) and Plester et al.'s (2011) findings (who showed the more opaque the spelling, the more modifications produced), does the context of production (which includes cultural and economic aspects) also linked to the amount of modifications produced (see Grace et al., 2012; Lee, 2002)? Concerning the link between the use of DW and the quality of spelling, does multiplying situations of instant-messaging production equals to multiplying the production of modifications at risk? As a consequence, using instant messaging should have a negative influence on spelling production (see Powell & Dixon, 2011 and Anderson & Elsner, 2014). Furthermore, the way cognitive resources are involved in DW production also have to be clearly identified, as very few information is available on the subject. We mentioned we chose instant messaging over text messaging because of Hayes' (2012) model based on standard text production in

SW. As mentioned supra for DW in instant messaging, working memory and long-term memory seem to be particularly involved. That is why the way resources are allocated inside working memory and the kind of knowledge behind DW production have to be further identified and analyzed.

Method

Experiment 1

Objective

This first experiment aims at determining whether the context of instant-messaging production has an influence on the rate of modifications produced when it comes to the use of two opaque spellings. This will also allow better identifying the central-executive monitoring activity in working memory for instant-messaging production. Our hypothesis is as follows: French French-speaking adolescents would modify more than American English-speaking adolescents, because of the context of production that refers to economic and cultural differences.

Participants

Forty adolescents voluntarily participated to the study: 20 French participants were enrolled in "Quatrième" (Group 1) and 20 American participants enrolled in 8th grade (Group 2). To be able to compare their performances, we relied on the "Program for International Student Assessment" results (OECD, 2012), which showed equivalent performances between 15 to 16-year-old French and American adolescents in terms of written comprehension. If for the French sample, selecting participants in the same school was not an issue (since there is one standardized curriculum for all the country, as opposed to what it is in the United States[4]), for the American sample, this task was harder. The American scholar system is indeed known as being strongly decentralized; that is why we invited participants from different American schools and areas. We also ensured all the participants had (a) the required spelling level by asking participants to take the Doutriaux and Lepez' Spelling Level Test (1994) to assess their lexical and grammatical spelling knowledge

[4] See Kaspi, Durpaire, Harter, and Lherm (2006) for a full description.

(see Table 1 for results)[5]; and (b) the required reading and writing habits in SW and DW by using a questionnaire (see Annex A.1). This questionnaire is developed in four axes, which are "the use of computers, blogs and MSN®; general use of mobile phones; reading habits; writing habits" (Febvrel & Hureau, 2008). No significant difference was found between the two groups regarding the use or access to information and communication technologies, of which instant messaging is a part (*Fs*<1, ns.).

Table 1 – Gender, average age and its standard deviation, average score to the Spelling Level Test and its standard deviation for Group 1 (French) and Group 2 (American)

Information	Group 1 (French)	Group 2 (American)
Gender	10 boys/ 10 girls	10 boys/ 10 girls
Average age	13.05	13
Standard deviation (age)	0.39	0.65
Average score (Spelling Level Test)	38.85	38.7
Standard deviation (Spelling Level Test)	3.6	3.51

Ethical clearance and conflict-of-interest disclosure

Every adolescent who participated to these two studies gave their free and informed consent, with their parent/s' agreement. They were informed that they could leave the scientific process at any time. Their anonymity has been fully respected and protected. The methods have been peer reviewed to manage conflict of interest and to guarantee that ethical basic principles were scrupulously followed. The objective of each study has been clearly defined to participants. Students were invited to participate to the study during two hours (per study). Our material (for both studies) was built in such a way as to leave no misunderstanding or uncertainty on any matter at all.

[5] N.B.: For Experiment 1 and 2, the adolescents with a diagnosed language disorder took part in the study, but their results were not taken into account. Gender data provided in Table 1

The French adolescents did not receive any financial contribution for their participation. However, for recruiting the American adolescents, we received financial support for conducting this study from the "Language Learning" Journal. This experiment has been submitted and approved by the Institutional Review Board (i.e., the American research ethics committee).

Material and procedure

Two dictation tests were made from the same text, which has been taken from a website and which corresponds to the spelling level of all the participants: the first to be dictated on paper (SW); the second on an instant-messaging website (DW) (see Annex A.2). Both dictation tests are different, but include the same amount of keywords that have been selected according to (1) characteristics related to the orthographic opacity of each language, (2) to the frequency of use (that has been identified as having effects on orthographic memory, see Cassar & Treiman, 1997; Gunnarsson & Largy, 2010), and (3) to usual modifications produced when sending instant messages (see Table 2 for examples).

Table 2 – Examples (right spelling)

N°	Characteristics	In French	In English
1	Non homographic homophones Grammatical Lexical	 et chair	 to veil
	Words with double consonant	embrassa	wedding
2	Words with an opaque spelling and a low frequency of use	rentes	fowl
	Words with an opaque spelling and a high frequency of use	ensuite	brought
3	Words with an ending that can be easily modified	mariage	organized
	Capital letter	La	Drawing

A first dictation test was to be written on paper, the instructions being that they had to correctly spell each word; the second was written on an instant-messaging

website. The instructions given were that the participants were to write in the way they were accustomed to writing instant messages. The spellcheck tool was deactivated throughout the experiment. The dictation tests were offset from one participant to the next to avoid an effect order. First, the dictation were read and then dictated (the spelling of proper nouns was provided). Then, only the dictation written on paper was read again; for the other dictation, participants were invited to read it again, but only if they were used to do it in real life when producing DW. The dictation test on SW medium only allowed checking whether modifications in DW (e.g., “to” in SW was written “2” in instant messaging) were real modifications or if they were misspellings that were reproduced in DW (e.g., “embrassa” was written “embrasa” both in SW and DW).

Findings

To process data, we analyzed the corpuses with a typology that includes 3 categories of modifications (see Lanchantin, Simoës-Perlant, and Largy, 2014; kappa coefficient: 0.89). These 3 categories are as follows: additions (e.g., “Hellooooo”), substitutions (e.g. “2” instead of “to”), and reductions/ alterations (e.g., “tmw” instead of “tomorrow”).

A t test was performed, with 2 (Context of production: French vs. American). The dependent variable (DV) was equal to the rate of modifications produced in DW in instant messaging (N.B.: modifications that cannot be confused with misspellings). In other words, we only took into account the modifications that did not appear on paper. For instance, if one participant produced 6 modifications in instant messaging, but produced 2 misspellings that s/he already wrote on paper, we only counted 4 modifications.

The Context of production effect is significant, since French French-speaking adolescents produced more modifications (25.67% [7.26]) than American English-speaking adolescents (5.67% [19.97]), $t(38) = 4.208$, $p < .001$. Other t-tests were performed, with 2 (Context of production: French vs. American). The dependent variable (DV) was equal to the (a) rate of substitutions and of (b) reductions/ alterations produced in DW in instant messaging (N.B.: substitutions and reductions/ alterations that cannot be confused with misspellings). No addition was produced; that is why we did not take this category into account. The Context of production effect is significant, since French French-speaking adolescents produced more

reductions/ alterations (19.34% [13.32]) than American English-speaking adolescents (4.67% [5.76]), $t(38) = 4.520$, $p < .001$. The Context of production effect is also significant, since French French-speaking adolescents produced more reductions/ alterations (6.33% [10.02]) than American English-speaking adolescents (1% [2.44]), $t(38) = 2.312$, $p < .03$.

Discussion

For this first study, we wanted to determine whether the context of instant-messaging production has an influence on the rate of modifications produced when it comes to the use of two opaque spellings. Despite the fact that there is no difference in terms of use and access to mobile technology between French and American adolescents according to the questionnaire responses on the topic (see Annex A), there is a significant difference in terms of context of production highlighted through the amount of modifications produced by each group. This study enables to complete Panckhurst (2009b) and Plester et al.'s (2011) findings, which showed the more the opaque spelling, the more modifications produced. By only taking their findings in to account, we may conclude people who use an opaque spelling would then be more likely to use modifications. There should have been no significant differences between these two groups who use an opaque spelling for modifying words (see also Grace et al., 2012).

Our findings go further and confirm our hypothesis regarding the amount of modifications that differs according to the context of production, as French French-speaking adolescents produced more misspellings that cannot be confused with misspellings than American English-speaking adolescents. We conclude that the context of production is as important as the orthographic opacity or as device technical features (Ong'onda et al. 2011) when it comes to explaining the amount of modifications produced (whatever the category of modification, at least for substitutions and reductions/ alterations, since no data is available for additions). At the cognitive level, these findings showed the central-executive monitoring activity, which is more restrictive for American English-speaking adolescents than for French French-speaking adolescents (we will further analyze the topic infra).

Now we have tried to answer to one of the main interrogations that rose from the literature review, we will try to answer to the other one, which is at the heart of the matter: does using instant messaging have a negative influence on spelling

production?

Experiment 2

Objective

This second experiment aims at determining whether using instant messaging in DW has a negative effect on spelling production, especially for adolescents with a low spelling level. This will allow better identifying how this use may affect spelling knowledge stored in long-term memory.

Participants

Ninety French French-speaking 9th grade secondary student volunteers were asked to produce SW and DW in instant messaging during pre- and post-test phases. Between the two test phases, the participants were/were not exposed to DW in instant messaging (see Annex B.1 for illustration). This exposure phase lasted 12 weeks and was divided into 3 types of exposure: (a) No Exposure (i.e., participants only produced SW for 3 months); (b) Mid-experiment Exposure (i.e., participants produced only SW for 1 ½ months and then SW and DW in instant messaging for 1 ½ months); and (c) Full Exposure (i.e., participants produced SW and DW in instant messaging for 3 months) (see Annex B.2 for illustration). These exposure were set up to determine whether or not using DW in instant messaging has an effect on spelling performance, by taking into account the regularity of the learning phase, which can impact the knowledge or awareness consolidation.

In order to control the variables (related to reading and writing habits in SW and DW and spelling level) so that 3 homogeneous groups be set up (one per exposure phase), every adolescent answered the same questionnaire as the one used for Experiment 1 (see Annex A.1). This questionnaire made it clear that all the participants had the required level of knowledge about the use of information and communication technologies, of which instant messaging is a part.

They were also asked to take the Doutriaux and Lepez Spelling Level Test (SLT) (1994) to assess their lexical and grammatical spelling knowledge, as was done for Experiment 1. This test made it possible for us to check the spelling level for each participant and to ensure a balance between groups by including 15 poor and 15 good spellers in each group (the difference between poor and good spellers was

relevant or sizable in every instance, $F(5,89) = 37.423$, $p < .001$ $\eta^2_p = .69$). Data on these 3 groups is shown in Table 3 (with Group 1 – No-Exposure; Group 2 – Mid-experiment Exposure; and Group 3 – Full-Exposure).

Table 3 – Gender, average age and standard deviation, average score on the SLT and standard deviation, by group and participant spelling level (i.e., "Good" vs. "Poor")

Information	Group 1		Group 2		Group 3	
	Good	Poor	Good	Poor	Good	Poor
Gender	7 boys/ 8 girls	7 boys/ 8 girls	9 boys/ 6 girls	7 boys/ 8 girls	8 boys/ 7 girls	7 boys/ 8 girls
Average age	13.52	13.5	13.59	13.61	13.51	13.55
Standard deviation	0.6	0.62	0.58	0.6	0.6	0.64
Average score (Spelling Level Test)	41.67	35.93	41.73	36	41.67	35.73
Standard deviation (Spelling Level Test)	1.84	0.88	1.98	0.85	1.88	0.8

Based on the effect of word use frequency (e.g., Cassar & Treiman, 1997; Deacon et al., 2008; Gombert, 2003; Largy et al., 2007; Lété, 2006; Nigro et al., 2015; Pacton et al., 1999; 2002; Perruchet & Pacton, 2004; Share, 2005), spelling performance of (a) the group that only produced SW (Group 1) will be better than that of (b) the group that produced SW first and then produced SW and DW in instant messaging (Group 2), which, in turn, will be better than that of (c) the group that produced SW and DW in instant messaging throughout the exposure phase (Group 3), with a significant difference between good and poor spellers each time (see Annex B.3 for illustration).

Material and procedure

Pre-test and post-test**.** Two dictation tests were given during the pre- and post-test (i.e., before and after the exposure phase that lasted 3 months). The instructions (i.e., text read, dictated, and read or not again) were the same as those used for Experiment 1 (see the Experiment 1 – "Material and procedure" heading,

below Table 2). The two dictation tests were given before and after the exposure phase.

Exposure phase. Thirteen pseudo-words have been made by considering the graphemes of the keywords included in the dictations (see Table 4). Pseudo-words are groups of letters that can be read and that have the same spelling characteristics than words of a particular language, but which have no real meaning (e.g., “turledeau” in French; “peengough” in English). They are often used in protocols in cognitive psychology for studying how/when spelling awareness has been consolidated, stored, recalled, etc. (see Cassar & Treiman, 1997; Pacton, Perruchet, Fayol, & Cleeremans, 2001, for example). By using pseudo-words in our protocol, we avoided reproducing orthographic disparities or variations (or at least limited them) between good and poor spellers. For instance, the pseudo-word “gibisessa” includes graphemes from the keywords “gib-ier”, “organ-isé(e)”, and “embra-ssa”. An amount of constituents have been taken into consideration: (a) the frequency of each grapheme in French (high vs. low)[6] and (b) the location of the syllable inside each keyword (initial, intermediate, final).

As mentioned supra, 3 types of exposure to DW in instant messaging (i.e., No Exposure, Mid-experiment Exposure, and Full Exposure) were put in place (see the “Participants” heading for a description) (see also Annex B.2 for illustration). Pseudo-words were written with the instructions to produce them (a) by memorizing the spelling provided by the researcher when the participants were using paper and (b) in the way in which they were accustomed when they were using the instant-messaging website:

- For Group 1, pseudo-words were only written on paper in SW.
- For Group 2, for the first 6 weeks, pseudo-words were only written on paper in SW. After that, for the last 6 weeks, pseudo-words were written both on paper in SW and in DW in instant messaging.
- For Group 3, pseudo-words were produced both on paper in SW and in DW in instant messaging in parallel throughout the exposure phase.

Each type of exposure included exercises that consisted in learning pseudo-words or in facilitating their recall. The whole set of exercises was given on a

[6] Controlled with the Wiktionnaire® database.

weekly basis. There were different types of exercises, but they all aimed at engaging the phonological loop (through reading activities undertaken by the participants themselves) and the visio-spatial scratchpad. The participants were asked to:

- Just copy the pseudo-words (they were dictated and written first, and then written on the blackboard for participants to copy);
- Learn the pseudo-words by heart (they were dictated and written first and displayed on a white screen for 1 minute) and then recall them (the participants wrote the pseudo-words with no help). When the participants seem to be lost, the pseudo-words were displayed for 1 minute more);
- Recognize the pseudo-words in a word-search puzzle. They had to circle them and to write them underneath the puzzle (the correct spelling of the pseudo-words was provided);
- Recognize the pseudo-words in a rebus (they had to decode and write them);
- Recognize the pseudo-words interspersed amongst other pseudo-words. The participants had to copy the pseudo-words they had already seen during the previous sessions among the following pseudo-words (all made using the keywords from the dictations): “ivait, res, envison, er, gibisoussant, reu, orbrat, detés, aporant, plassier, ampoite, re, rensuisaient, reux, voinie, marembés, agémotiée, dettés, maltir, orbrats, apporant, ré, gibisessa”;
- Learn the pseudo-words by heart (they were available on the blackboard for 1 minute and then wiped off) and then recall them (participants had to recall as many pseudo-words as possible, competing with another classmates);

After the 6 first weeks, these 6 exercises were done once again in the same order to avoid creating any bias between Group 2 and Groups 1 and 3.

Post-test. The post-test included two main activities: (a) the same dictations as those done during the post-test were produced on both types of medium. But the participants who had been asked to take the first dictation test on paper were then asked to transcribe it on an instant-messaging website, and vice versa for the second dictation test (the instructions were the same as those given during the pre-test); and (b) a dictation test of single pseudo-words (see Table 4). Had we expected a significant difference in terms of performance between the 3 groups for the dictation

test made up of pseudo-words, we would have had to determine that the spelling performance for the dictation tests made up of words remained the same – or improved – between the pre- and post-test phases (otherwise, the possible decrease in performance could have been attributed to other factors than those to which the participants had encountered during the exposure phase).

Table 4 – Pseudo-words that have been made starting from keywords in SW

Keywords	cér-émo-nie ma-ria-ge or-gan-isée de-pui-s en re-tir-ant voi-le	mar-iée de vis-age emb-ra-ssa les deux pla-ts	poi-sso(n) et gib-ier en-sui-te app-or-tés
Pseudo-words	gib-ise-ssa (1) re (2) r-en-sui-sée (3) or-bra-ts (4) voi-nie (5) en-vis-on (6)	res (7) mar-emb-és (8) er (9) app-or-ant (10) reux (11)	pla-ss-ier (12) de-tés (13)

Findings

To process data, a table (in three sections, by set of dictation test: i.e., the word dictation test in the pre-test, the word dictation test in the post-test, and the pseudo-word dictation test in the post-test phase, in SW and in DW each time) has been built (see Annex C). A calculation (made by two raters) of the kappa statistic for inter-rater reliability was performed and showed an acceptable tolerance (kappa coefficient: 0.91).

An ANOVA was performed, with 3 (Type of exposure: Group 1 vs. Group 2 vs. Group 3) x 2 (Spelling level: Poor vs. Good) x 2 (Medium: Standard vs. Digital in instant messaging). The dependent variable was equal to the rate of misspellings produced and modifications (by total number of each part included in each pseudo-word). The following results are related to the pseudo-word dictation tests

given after the exposure phase (see Annex D for the performance results for word dictations in the pre- and post-test phases, which in fact showed no significant differences between the 3 groups).

The Type of exposure effect is not significant, whether it involves the rate of misspellings produced in SW, $F(2,89) = 2.073$, ns., or the rate of modifications produced in DW in instant messaging, $F < 1$, ns. However, the Spelling level effect is significant with regard to the rate of misspellings produced in SW only for Group 2, $F(5,89) = 4.985$, $p < .001$, $\eta^2_p = .23$, and the modification rate produced in DW in instant messaging, only for Group 3, $F(5,89) = 5.561$, $p < .001$, $\eta^2_p = .25$. On the one hand, the post hoc analysis showed that the participants' performance for Groups 1 and 3 does not significantly differ with regard to the Spelling level and the produced misspelling rate (Scheffe = .757 ; Scheffe = .438). On the other hand, for the Group 2 participants , the Spelling level effect is significant when considering misspellings produced in SW but not significant when it comes to the modifications produced in DW in instant messaging (Scheffe = .564). The poor spellers from Group 2 have therefore produced significantly more misspellings in SW than the good spellers from Group 2 (Scheffe = .037). Lastly, for Group 3 participants, the Spelling level effect is significant with regard to the modification of pseudo-words produced in DW in instant messaging (Scheffe = .014), but not significant for misspellings produced in SW in Group 3 (Scheffe = .438).

Discussion

The purpose of this study consisted in determining whether or not performance regarding the production of pseudo-words was any different based on the type of exposure to DW in instant messaging (i.e., No Exposure, Mid-experiment Exposure, Full Exposure). We expected that the spelling performances of the adolescents of Group 1 would be better compared to those of Group 2, which in turn would be better than those of Group 3. Furthermore, we expected to see a significantly sizable performance gap between good and poor spellers.

Our findings do not confirm our hypothesis regarding pseudo-word spelling performance possibly different based on the type of exposure to DW in instant messaging (i.e., No Exposure, Mid-experiment Exposure, Full Exposure). No significant difference between the 3 cases was found: (a) neither with regard to misspellings, (b) nor concerning the instance of modifications. We conclude that

being exposed to DW in instant messaging does not affect spelling performance, whatever the type of exposure and spelling level. These findings confirm those of Bernicot et al. (2014), De Jonge and Kemp (2012), Gonthier and Leblanc (2012), Plester et al. (2008), Plester and Wood (2009), Plester et al. (2009), Powell and Dixon (2011), Wood et al. (2009) and of Wood et al. (2014a), who showed that there was no connection between the use of DW and spelling. At the cognitive level, the participants may have been able to make the distinction between the types of medium (i.e., paper or word-processing software documents used for producing SW; instant-messaging websites for producing DW – in instant messaging). Plester and Wood (2009) came to the same conclusion regarding British children. Therefore, medium specifics are all-important when it comes to writing. The fact that no difference was found may also have something to do with the intermediary role played by the mind's orthographic lexicon, which allows the expert to produce words in SW extremely quickly (Caramazza & Miceli, 1989). Consequently, it is safe to assume here that the participants relied on their explicit and implicit spelling knowledge to produce pseudo-words.

Our second hypothesis has been partially confirmed, as we have shown that significant differences come to the fore when the spelling level is taken into account. Thus, the adolescents with a poor spelling level would be more likely to produce misspellings while being exposed to DW in instant messaging at mid-term (1 ½ months) (Group 2). The likelihood that the connection between the use of DW in instant messaging and spelling performance proves to be detrimental is higher in the case of the Mid-experiment Exposure phase, and this is particularly true of bad spellers.

This difference may be explained as follows: when the participants can use only one or two types of medium to write throughout the exposure phase, they are able to make the distinction between SW and DW in instant messaging. When it comes to the Mid-experiment Exposure, SW is the only one to be used at first. The process of knowledge consolidation is still on-going when the option to write instant messaging by using DW is given. However, when DW in instant messaging is introduced at this point, the gap starts to widen between good and poor spellers. There is a risk at this point, and this is particularly true for adolescents with a poor spelling level.

These 2 studies helped to better understand the findings provided in the literature review. But we still need to further analyze the way resources are allocated

inside working memory and the kind of knowledge behind DW production.

General Discussion

These studies aimed at determining: (1) Whether the context of production affects the amount of modifications produced by comparing the performance of French French-speaking adolescents with those of American English-speaking adolescents (who use two languages with an opaque spelling); (2) whether using instant messaging in DW negatively affects spelling production, especially for adolescents with a low spelling level.

Our findings showed (a) the context of production has indeed an effect on the amount of modifications produced (as much as the orthographic opacity, see Panckhurst, 2009b and Plester et al., 2011) and (b) there is a risk for adolescents with a poor spelling level when knowledge is in the process of being consolidated. When gathering those findings together, the negative effect (for adolescents with a low spelling level whose knowledge is still being consolidating) that stood out from the last study may not be true for American English-speaking adolescents, since they use less modifications than French French-speaking adolescents. From a cognitive-psychology standpoint, the first highlights the central-executive monitoring activity in working memory (see Baddeley, 2000) and the second the kind of knowledge behind modification production (see Baker, 1989; Glaser & Chi, 1988; Garner, 1990). The central executive allocates resources that appear to be necessary for the three slave systems to run properly (i.e., the phonological loop, the visuospatial sketchpad, and the episodic buffer). Then, the central executive considers knowledge – which is here related to modifications and which is recalled from long-term memory – sometimes as relevant, sometimes as not relevant. For French French-speaking adolescents, the central executive allows modification production (or instances recall), as it authorizes knowledge activation/ recall for modification production. For American English-speaking adolescents, the central executive inhibits knowledge activation/ recall the more often. French French-speaking adolescents are more likely to meet requirements of this kind of communication, and this is particularly true when analyzing our cognitive system ability. It is able to handle resource allocation to ensure flexibility in order to ease information processing (Piolat, 2004) and reduce cognitive workload. French French-speaking adolescents are therefore more efficient – ore use the less but required resources to reach their objective – when it comes to

communicating through instant messaging than do American English-speaking adolescents.

But the effect of this use on spelling level still had to be identified. This was the objective of the second experiment, which showed this effect is negative for adolescents with a poor spelling level whose knowledge is still being consolidated. This gap between these adolescents and others can be explained by the kind of knowledge involved in written production. Indeed, we mentioned in the literature review there were three different types of knowledge that had been identified in cognitive psychology: declarative knowledge (e.g., knowledge related to orthographic rules), procedural knowledge (e.g., knowledge which allows applying grammatical and orthographic rules in specific conditions), and conditional knowledge (which allows us to know when and how to use declarative and procedural knowledge) (Baker, 1989; Glaser & Chi, 1988; Garner, 1990). Conditional knowledge would have made it possible to distinguish between the types of medium (and hence, the types of writing). If this were to be true, when conditional knowledge is recalled from the outset and the type/s of medium remain constant throughout the exposure phase, knowledge is activated or inhibited in the same way. When conditional knowledge is activated only to produce SW and then to produce SW and DW in instant messaging, knowledge consolidation is not done the same way, which decreases the quality of knowledge – at least for adolescents with a poor spelling level. This led us to consider the wide scope of this complex issue, which has intrigued the many researchers looking for a clear answer to the question.

Our conclusion is that (a) the context of production has to be taken into account, at least as much as orthographic depth, when considering DW production and how spelling knowledge may be impacted and (b) the use of DW in instant messaging poses a threat for adolescents with a poor spelling level and whose knowledge is in the process of being consolidated. On the other hand, adolescents with a good spelling level that use DW in instant messaging are not at risk at all. Future research should focus specifically on adolescents with a poor spelling level whose knowledge is not yet consolidated.

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