The impact of WhatsApp on Dutch youths' school writing and spelling

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Abstract: This paper examines whether use of computer-mediated communication (CMC) and non-standard informal written language therein harms youths' literacy skills. An experiment was conducted with 500 Dutch youths of different educational levels and age groups to assess if social media use affects their school writings. It was measured if chatting via WhatsApp directly impacts youths' performance on a narrative writing task, in terms of writing quality and spelling, or their ability to detect and correct deviations from the standard language in a grammaticality judgement task. WhatsApp use had a direct effect on the story writing task, but only on participants' spelling: adolescents who were primed with WhatsApp immediately beforehand produced significantly fewer misspellings in their narratives. The present study thus gives no cause for concern about negative transfer from social media to school writing: if anything, CMC use may provide youths with greater orthographic awareness and positively affect their spelling performance.

Keywords: computer-mediated communication, social media, WhatsApp, writing, spelling

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1. Introduction

It is widely believed that social media may be harmful to youths' literacy skills (e.g. Thurlow, 2006), including in the Netherlands (Jansen, 2004; Nederlandse Taalunie, 2012). This paper reports on an empirical study to examine such claims. A large-scale experiment was conducted to find out whether there is a causal connection between social media use and writing produced by youths in an educational context – in particular, if we can find a direct impact of WhatsApp on school writing by Dutch adolescents and young adults in secondary and tertiary education.[1]

Youth are nowadays constantly using computer-mediated communication (CMC) via social media such as WhatsApp, Facebook Messenger, and Snapchat and, if they get the chance, also at school. In the Netherlands, educational institutions can determine their own policy on mobile phone use by students; the Ministry of Education has no guidelines for this (Vernhout, 2018). This has resulted in great differences in mobile phone policies: in many schools, students are instructed to turn off their phones and put them out of sight during class (unless teachers give explicit permission to use them in class), while some schools opt for a total ban where mobile phones have to be stored away in lockers (Vernhout, 2018). Irrespective of whether students can use their phones between classes or during breaks, students will definitely use them in their leisure time to send informal messages to friends, family, and peers, also while doing their homework. Examples 1-3 present chat messages by Dutch youths (English translation below):

1. *OMG!* Had je mijn mijn verhaal gezien
   Hahahahhaahhaaha kwam ik pas vanochtend achter
   k kan me *nie* eens herinneren *da* ik die gemaakt heb
   Miss in *mn* slaap *ofzo hagahagagaa*
   ('OMG! Did you see my story
   Hahahahhaahhaaha only found out this morning
   i cant even remember making dat
   Mayb in me sleep or somethin hagahagagaa')

2. Beetje te vroeg ik val echt in slaap maar alvast *happy birthdayyyyyy tooooooo youuuuuuuuuuu*! 💓💓🎁🎁🎀🎀❤❤🎉🎉 *loveyouuuuuu xxxxxxxxx*
   ('Bit too early I'm really falling asleep but anyway…')

3. *Liefie*❤ gaat ie weer met jou? Wat het je😂😱 bel me *weneer* je online bent😎✓✓ *ly*❤❤❤❤ zie je morgen☺ BEL ME ☺ *chatt*😈😵
   ('Luv❤ you doin okay again? What hare you😂😱 call me whn you are online😎✓✓ ly❤❤❤❤ see you tomorrow☺ CALL ME ☺ honeyy😈😵')

All words in italics deviate from Standard Dutch. They contain non-standard abbreviations, letter repetitions, phonetic respellings, and other 'textisms'. These

examples feature visual, lexical, orthographic, and grammatical deviations from Standard Dutch, in the form of emoji, English borrowings, omission of punctuation, non-standard use of capitalisation, ellipses, and sentence fragments. Since such deviations are characteristic of 'CMC language' or 'textese' (Verheijen, 2017; 2018), they have caused concern that informal typed communication via new media may interfere with writing in more formal settings. Such worries have existed for decades now (Thurlow, 2006) or even for centuries,[2] especially among teachers (Ross, 2007) and parents (Spooren, 2009). The impact of CMC is still a subject for public discussion, as is apparent, for instance, from an ongoing online debate about the question "Is texting killing language?" (Debate.org, n.d.).

Although some research has indeed demonstrated such a negative relationship (Cingel & Sundar, 2012; Rosen et al., 2010), other scholars point out that youth literacy may benefit from social media, via creative language use, greater exposure to writing, more engagement in writing, and greater metalinguistic awareness (Crystal, 2008; Wood, Kemp, & Plester, 2013). Now that youths are in possession of mobile phones at increasingly younger ages, the discussion about the relation between texting and literacy has heated up again. In the Netherlands, for example, children's average age when first acquiring a mobile phone has dropped to eleven, and some children are even receiving mobile phones at the age of four (RTL Nieuws, 2017). The present study aims to surpass "polarized, dichotomous arguments often presented in the research literature as well as media reports" (Zebroff, 2017:3) and to contribute to the debate with new empirical evidence.

From a descriptive linguistic perspective, the register (language variant) of informal written CMC and its linguistic traits and features are, of course, in no way inferior to the formal standard language. Nevertheless, many people still regard textese as 'substandard', 'improper', or 'incorrect'. For example, Van Vrijaldenhoven (2016) speaks about Dutch youths' 'crappy' language use on social media and Banerji (2015) claims that "[t]exting and Whatsapp have really screwed our language." Along those same lines, Wil (2017) writes the following about the English language:

> [T]ext messaging is completely devastating the English language. […] [S]choolchildren in the 1960s and 1970s were far more literate than children of today. … [T]he average schoolchild [now] struggles more with spelling, grammar and essay-writing: essential skills which before now were considered key to a good grasp of the English language. Text messaging is alienating English speakers from their native tongue and confusing non-natives who wish to learn the language. It promotes mis-spelling. English is a beautiful tongue with a rich literary history which does not deserve to be overshadowed by phrases like 'c u l8r' and 'megalolz'. (n.p.)

Such comments reflect societal norms on language use: despite the informal nature of much CMC, traditional notions on standard language use remain alive in this

digital age. Standard Dutch enjoys overt prestige (Labov, 1966): orthographic or grammatical deviations from the standard language are frequently and openly criticized, irrespective of the covert prestige of CMC language among youths. As noted by Sebba (2007), orthography is often equated with 'writing correctly' – the term itself comes from the Greek *orthographia*, meaning 'correct writing': spelling is situated within social practices, in which deviations from the written norms are often seen as an illegitimate or marginal practice. It obviously takes more than classic reading and writing skills to survive in this world of digital technologies: traditional literacy no longer suffices and has, in the last decades, become supplemented with all kinds of new literacies (Coiro et al., 2008) such as digital literacy, media literacy, and information literacy (Jacobs, 2006; Koltay, 2011; Mills, 2015). Yet mastery of the standard language and traditional literacy skills are still crucial for achieving success in education, business, and life (Christoffels et al., 2016; Powell, 2009; Smit, Hazelzet, & Bohnenn, 2006; Twickler et al., 2009). Youths thus need to master multiple registers, formal and informal, online and offline, standard and non-standard, and should develop an ability to switch between these registers with ease. The aim of this study is to determine if school writings of Dutch youths with different demographic characteristics reveal any direct impact of chatting with peers on WhatsApp – specifically, an impact on text quality or spelling.

2. Theoretical Background

2.1 Interference in Writing?

Switching between registers can be likened to code-switching between languages. While bilinguals alternate between two spoken or written linguistic codes (languages, language varieties, dialects) (Milroy & Muysken, 1995), youths move back and forth between two written registers. Code-switching by bilinguals can occur within the context of a single conversation (Auer, 2013), but can also occur between different social contexts or conversational settings, whereas register-switching by CMC-using youths occurs between different writing contexts. Hence, youngsters need to be adept in shifting between their online, informal register and offline, formal register and use these in appropriate settings. A school setting requires the standard language, while social media allow (and expect) use of CMC language. Today's youths should thus be like bilinguals:

> [T]he best way to think of text messaging is not as a degradation of [our standard language], and certainly not as an improvement of it, but rather as a separate language entirely. Good students today are effectively bilingual: they turn on the Textese when conversing with their friends, then turn it off when it's time to write a paper. (Farhap12, 2015)

Switching between two registers bears comparison with switching between two languages. These registers may be in constant competition, and simultaneously active, when youths write – parallel to bilinguals, whose two languages may constantly be activated when writing or speaking (Hermans et al., 1998). While using one register, the other need not be completely suppressed, and, consequently, linguistic features of the deactivated register may cause interference (Richards, 1972), a negative form of linguistic transfer or interlingual influence (Milroy & Muysken, 1995). Lems, Miller, and Soro (2017) define interference as "obstacles to second-language literacy based on first-language features" (38). However, it can also entail obstacles in one's first language based on features of one's second language. Transfer can occur in either direction, from L1 to L2 and vice versa (Cook, 2003; Gass & Selinker, 2008); in fact, any post-L1 language can be a source for transfer (Jarvis & Pavlenko, 2008). In the context of social media, Standard Dutch may form the basis for CMC language, but the latter register can also interfere with the former, even though CMC language may have been acquired at a later stage.

Although transfer can occur in language comprehension and perception (Jarvis & Pavlenko, 2008; Ringbom, 1992), interference between languages more saliently occurs in language production, so speech or writing (Vildomec, 1963). School writing obviously involves a productive literacy skill, which makes it a likely candidate for orthographic, lexical, or syntactic interference of the register of CMC language. This study examines if Dutch adolescents and young adults, when having to switch between these registers, show signs of interference of immediately preceding WhatsApp use in their school writing.

2.2 Effects of CMC on Traditional Literacy

The relationship between literacy and use of CMC (language) has been investigated in prior research, but reviews of the literature conclude that findings are inconclusive (see Verheijen, 2013, 2019; Zebroff, 2017 for extensive reviews). There is some empirical evidence of negative relationships, confirming societal concerns, while several other studies found positive relationships between CMC use and literacy skills, or no significant associations at all. These varied results can, to a great extent, be attributed to differences in previous studies' methods and populations: (a) how literacy was operationalized, (b) how use of CMC (language) was measured, and (c) which youths participated. This complicates any comparison of prior studies.

Demographic factors such as age, education, and gender may be important in the relationship between CMC and literacy skills. For example, for age, Wood, Kemp, and Waldron (2014) found different results for children, adolescents, and young adults in the effects of texting on grammar skills. The possible role of education in the relationship between writing and textisms was confirmed by Rosen et al. (2010), who found negative associations with formal letter writing and positive associations with informal writing exercises, but these associations varied by

education level. Research has noted differences regarding age, gender, and – to a lesser extent – education in use of CMC (language). Adolescents have been found to use more textisms than older users (Hilte, Vandekerckhove, & Daelemans, 2016, 2017; Schwartz et al., 2013; Verheijen, 2017, 2018). Females have been reported to use CMC more frequently and to incorporate more textisms and expressive markers (Baron, 2004; Grace & Kemp, 2015; Hilte, Vandekerckhove, & Daelemans, 2016; Rosen et al., 2010; Varnhagen et al., 2010). Youths with college experience have reported using more textisms than those with a college degree and no college education (Rosen et al., 2010), while youths with more theoretical educational tracks have been found to use more non-standard features in CMC (Hilte, Vandekerckhove, & Daelemans, 2017). Such age-, gender-, and education-related differences in social media use may affect associations with literacy.

Most previous studies in this area are, furthermore, somewhat outdated in that they studied the impact of text messaging on literacy. In many countries, operator-based texting via SMS has by now been replaced by instant messaging (IM), a type of online chat, such as via Facebook Messenger, WhatsApp, and WeChat (Statista, 2021). Since IM apps differ from texting in terms of message size limits (present in texting, absent in IM) and synchronicity (texting is asynchronous; IM involves real-time text transmission), it is unclear whether findings on texting are still relevant. The present study focuses on the mobile instant messaging app WhatsApp, which has over two billion monthly users worldwide (Statista, 2021) and is the most popular chat application in the Netherlands (van der Veer, Boekee, & Hoekstra, 2021).

The large majority of previous research involved correlational analyses based on quasi-experimental studies, comparing self-reported CMC use to performance on some kind of writing, spelling, or reading task (e.g. Verheijen, Spooren, & van Kemenade, 2020). There are only a few exceptions, namely one intervention study (Wood et al., 2011a) and a couple of non-experimental longitudinal studies (Wood et al., 2011b; Wood, Kemp, & Waldron, 2014). Correlational, quasi-experimental studies do not warrant conclusions about the causality of any relationship between CMC use and literacy. The present study is innovative in using an experimental design, allowing us to investigate the direction of any relationship between students' WhatsApp use and their school writing.

2.3 Assessing School Writings: Text Quality

A text can be assessed on relatively superficial properties that concern 'correctness', such as spelling, but also on more deep-seated linguistic aspects. A variety of features can be included when analysing texts with digital tools (Crossley, Greenfield, & McNamara, 2008; Pitler & Nenkova, 2008): features related to syntax (e.g. grammatical constructions, embedding, number of noun/verb phrases), lexis (e.g. word frequency), semantics, and discourse, as well as text cohesion,

comprehension, and processing. Automated analyses of texts have been shown to produce not only consistent scores, but scores similar to those by trained human raters (Deane & Quinlan, 2010). For an overview of how advanced digital tools can be used to conduct linguistic text analyses for the purposes of assessing writing quality, see Crossley (2020). One of the broadest tools for automated textual assessment is the Coh-Metrix, which analyses English texts for over 200 linguistic and readability measures (McNamara et al., 2014). Such a tool may even outperform manual assessment of texts.

In the context of social media use, Spooren (2009) designed a model to reliably measure text quality of school writings, which included measures of both the writing product (lexical, grammatical, cohesion/coherence features) and the writing process (typing fluency, number of backspaces) and he conducted computer-assisted analyses of these features. In view of previous studies, the current study uses sophisticated computer software that analyses Dutch texts for a wide range of linguistic features in order to establish their quality. This has been supplemented by a systematic manual analysis of orthographic deviations from Standard Dutch, since many concerns about the impact of CMC use on writing specifically involve the surface features of spelling and grammar.

2.4 Language Priming

A priming experiment was conducted to find out whether engaging in synchronous written CMC on WhatsApp directly impacts Dutch youths' productive or receptive school writing or spelling, as measured via story writing and a grammaticality judgement task. In both first and second language research, priming is a frequently used method. Linguistic priming has been defined as "the phenomenon in which prior exposure to language somehow influences subsequent language processing, which may occur in the form of recognition or production" (McDonough & Trofimovich, 2011:1). This means that "the exact forms and meanings that speakers use can be affected by the language that occurred in discourse they recently engaged in" (McDonough & Trofimovich, 2011:2). The process underlying a linguistic priming experiment is that the exposure phase triggers some language structure or representation that was already entrenched in people's long-term memory and temporarily activates it, which then affects their behaviour or performance on an ensuing task (Bowers & Marsolek, 2003). Since language priming is a diverse phenomenon (e.g. syntactic, semantic, lexical, auditory, phonological, and orthographic priming), one cannot predict the duration of priming effects, that is for how long such language structures or representations remain activated, but effects have been reported to last for hours or even days (Squire, Shimamura, & Graft, 1987). How long effects will last, of course, also depends on the duration of the exposure (Ferrand & Grainger, 1993).

The present study measures if engaging in CMC discourse with exposure to CMC language, with its non-standard orthographic representations of words and non-standard grammatical structures, interferes with youths' subsequent production of the standard language in writing tasks. Participants who were primed with WhatsApp and, hence, had to switch registers were compared on their performance on school writing tasks to participants who performed a control task unrelated to CMC before the writing tasks. Priming has been used in writing research before (e.g. Hudson, Lane, & Mercer, 2005) and is an appropriate method for the present study, because if effects of social media use on school writing or spelling already appear after using WhatsApp for a short while, youths' continuous use of social media in daily life – also while completing writing assignments at home or even at school – will, in practice, result in continuous priming and, therefore, an ongoing impact on their school writing or spelling. To increase the ecological validity of our experiment, a priming phase was designed that resembles naturally occurring language use in students' WhatsApp chats.

2.5 Research Questions

This study explores whether Dutch adolescents' and young adults' frequent use of social media, specifically WhatsApp, affects their writing or spelling in an educational context. Considering that prior research does not provide conclusive answers, our experiment into the direct impact of WhatsApp use on youths' formal writing will be a valuable addition to the literature. The first research question is as follows:

> **RQ1.** Does Dutch youths' use of CMC (in particular, WhatsApp) directly affect their school writings produced immediately afterwards, in terms of writing quality or spelling?

Based on the mixed findings of previous studies (Verheijen, 2013), no hypothesis was formulated about whether any direct impact of WhatsApp use on school writings would be found, whether Dutch adolescents and young adults would show linguistic interference after priming and switching between registers.

Furthermore, this study explores whether the demographic variables of age, education, and gender have a moderating effect on any relationship between CMC use and school writing. Previous research suggests that these factors may moderate any impact of CMC on literacy. The analysis will, therefore, include educational level ((pre-)vocational vs. (pre-)university), age group (adolescents vs. young adults), and gender (boys vs. girls) as independent variables and study any interactions with experimental condition. This yields the second research question:

> **RQ2.** Do age group, educational level, or gender moderate any direct effects of Dutch youths' WhatsApp use on their subsequent school writings?

If a direct impact of CMC use on school writings will be found, this may be greater for youths of a younger age group or with a (pre-)vocational educational level. Today's adolescents and children have been using social media from a younger age, when their literacy skills had not yet fully developed and were still fluid, which increases the chances of transfer occurring between the registers of CMC language and standard language as compared to young adults. In the Netherlands, youths are separated into pre-vocational, pre-professional, and pre-university tracks early on in secondary school. In contrast to the theory-focused writing culture in (pre-)university education, where students are frequently assigned writing tasks, both as homework and in class, (pre-)vocational education is more practice-focused, so those youths are less accustomed to writing school texts and switching between registers. The extent to which youths are tested on their writing skills also depends on their educational level, with more writing testing in (pre-)university education than in (pre-)vocational education (Meijerink et al., 2009). Therefore, any impact of CMC use on literacy is more likely to occur among youths with a (pre-)vocational educational level. Prior research suggests that youths in a vocational education track have more trouble distinguishing informal online writing from formal offline writing repertoires (Vandekerckhove & Sandra, 2016). In Dowdall's (2006:162) terms, such youths may experience more 'dissonance' between writing as a leisure activity, as in CMC, versus for school. It may be more difficult for vocationally educated or younger participants to switch between different registers without interference.

3. Methodology

3.1 Participants

Participants were 500 youths from secondary and tertiary educational institutions, from different educational levels and age groups. For the final analyses, one cohort of participants was excluded, so data of 408 youths were used.[3] The adolescents (N = 300, data used from N = 208; 101 pre-vocational, 107 pre-university) were around 14 years old (for N = 208: $\bar{x}$age = 14.1 years, range 13-16; 107 male, 101 female), all in the third grade. The young adults (N = 200; 102 vocational, 98 university) were around 20 years old ($\bar{x}$age = 20.4 years, range 18-27; 72 male, 128 female). These age groups were selected since adolescents and young adults are heavy users of social media.

Underage participants were given an information document to take home to their parents or guardians, which complied with the standards of the faculty's Ethics Assessment Committee. If the latter objected to their children's participation in the study, their data would be deleted permanently, but none did. When participants were interested, and time permitting, the researcher elaborated on the aim of the study.

3.2 Data Collection

The data were collected in 2016 at four secondary schools, two locations of one vocational school, and one university. Most participants were tested in class; only a small number of participants (in university) took part outside of class and were reimbursed with € 5 gift certificates. In the priming phase, each class was randomly split up into an experimental group and a control group: half of the participants were primed with WhatsApp, while the other half carried out a control task. Next was the testing phase, in which they all wrote stories and completed grammaticality judgement tasks, to measure the direct impact of CMC use on their productive and receptive school writing skills.

3.2.1 Priming Phase

Experimental groups: WhatsApp. During the priming phase, experimental groups were primed with CMC. They were instructed to chat via WhatsApp on their own smartphones for fifteen minutes. This medium was selected for several reasons. First of all, practically all Dutch youths use WhatsApp nowadays; with over 12 million users, it is now the largest social media platform in the Netherlands (van der Veer et al., 2021). As a consequence, participants were familiar with the medium and already had the app installed on their phones. Secondly, WhatsApp involves near-synchronous CMC, so communication takes place in real time, which resembles spoken conversation, in stark contrast with the school writing that was tested. In addition, regardless of the possibilities of including audio and visuals in WhatsApp, textual content is still a crucial part of this medium, as opposed to other social media that are currently popular among Dutch youths like Instagram, TikTok, and Snapchat (van der Veer et al., 2021), which are more focused on sending and receiving photos and videos rather than text. A final practical reason for choosing WhatsApp is that chats can easily be exported by sending them via email.

Although users of WhatsApp in the European Union must currently be at least 16 years old (WhatsApp LLC, 2021), that was not the case when we collected the data in 2016: the age limit was raised from 13 to 16 in 2018, to comply with the European General Data Protection Regulation (Gibbs, 2018). Accordingly, this experiment was ethically approved by the Ethics Assessment Committee Humanities of Radboud University's Faculty of Arts. Since users' age is checked with only a single question about their age during registration, WhatsApp is currently still widely used among Dutch youths below the age of 16 (van der Veer et al., 2021).

Participants had been instructed beforehand by their teachers to bring their mobile phones to class. To increase the efficiency of the testing procedure, WhatsApp groups had been formed in advance. Boys and girls were roughly equally divided over the experimental and control groups, and friendships among classmates had been taken into consideration in forming the app groups, so as to minimize the awkwardness of the somewhat forced in-class WhatsApp chats.

The chats took place in groups of three or four students rather than in dialogues, to prevent breaks in the conversation if one of the interlocutors were to fall silent. Certain topics were proposed as inspiration for the WhatsApp chats (the weekend, holidays, hobbies, sports, food), but no obligatory conversation topics were provided, in order to generate as naturalistic chat conversations as possible. Participants were asked to chat via WhatsApp as they would in daily life outside of class, with friends. They had to chat individually and in silence. The chats were not monitored by the researcher or teacher, because WhatsApp is a private social medium; accordingly, participants had no cause to produce socially desirable language and could use CMC language as they normally would. No voice messages were allowed and sending pictures was discouraged, to maximize the production of written CMC within the fifteen-minute timespan. The use of autocorrect or word predictors in WhatsApp was not regulated, because in real life youths can also decide for themselves whether or not to use such software. The WhatsApp chats were collected afterwards if participants agreed to share them. About 15% of the participants in the experimental groups – mostly university students – did not share their WhatsApp chats produced during the priming phase: these participants could, therefore, not be included in the priming check, but were still included in the main analyses. Participants were not informed beforehand that they would be asked to share their chats with the researchers, so they had no reason to cut down on their textism use due to social desirability: their texts should resemble those composed under private, non-experimental conditions.

Control groups: colouring. While half of the participants chatted via WhatsApp, the control groups coloured mandalas. This task was primarily chosen because it is not related to CMC and does not involve language, whether standard or non-standard. Moreover, it is practicable (and, it was hoped, enjoyable) for all participants, irrespective of education or age. The activity of drawing or colouring mandalas is reportedly also calming and relaxing (Borman, 2016; Kovacs-Donaghy, 2013), which kept the control groups focused and quiet, not distracting the experimental groups. In a small-scale pilot study (Riemens, 2016), using colouring as a control task proved effective in revealing a direct impact of WhatsApp use, the experimental manipulation, on writing skills (specifically, on orthography production and perceived language correctness). Alternative control tasks were tested in other pilot studies, such as doing sums, solving sudokus (number-placement puzzles), or underlining certain letters in a text fragment, but these turned out to be unsuitable for participants of all ages and educational levels or simply too boring to keep participants focused. Colouring and drawing have been used in other writing intervention studies as control tasks (e.g. Martins et al., 2013).

Participants were urged to take the task seriously and perform it individually and in silence. They were explicitly instructed not to use their mobile phones during the colouring nor after having finished the mandala (but completion was rare – only

five participants managed to finish colouring). Notwithstanding some initial hesitations among some (especially older or male) participants, most of them afterwards expressed their enjoyment in executing this task.

3.2.2 Testing Phase

Productive writing skills: stories. The testing phase first involved measuring productive writing skills. To this end, all participants spent about 20 minutes writing a story. The genre of narrative storytelling is typical for writing at school. Another genre central in the Dutch curriculum is that of expository discussion, but a previous study showed that such essays may be problematic in terms of writing productivity, because some youths are worried about their argumentation (Verheijen et al., 2020), as argumentative writing can be a challenging task (Luna et al., 2020). Participants were provided with a pre-determined sentence for inspiration, so that they had a starting point for their stories. The importance of individual completion of the task was emphasized. Participants were not allowed to use mobile phones during this task, since that might affect the writing process, yet participants in the experimental groups were allowed to use WhatsApp after they had finished writing their story, before the next writing task started, so as to maximize the priming.

Because participants were tested at multiple schools, not all classes had easy access to digital tools such as computers or laptops. For the sake of consistency, participants wrote their stories by hand, which yielded the added advantage of prohibiting access to spelling or grammar checkers. The texts were typed out afterwards for analysis – exactly as they were written, including all deviating spelling, grammar, punctuation, capitalisation, etc.

Receptive writing skills: grammaticality judgement tasks. After writing a story, participants completed a grammaticality judgement task (GJT), to test their receptive spelling skills. This consisted of twenty sentences (see Appendix A), which had to be judged for 'correctness': participants had to detect and correct 'language errors'. These were orthographic deviations typical of CMC language: various textisms (phonetic respelling, letter reduplication, shortening, single letter homophone, initialism); non-standard orthographic details (missing capitalisation, diacritics, and punctuation); 'misspellings' that are heavily frowned upon by Dutch language users (see 'Spelling of the stories' below); emoticons; omissions; English borrowings; and extra spacing. This task was also executed individually and without a mobile phone.

3.3 Data Analysis

First, the WhatsApp chats were analysed for the presence of CMC language. The writing quality of the stories was determined with software analyses and a principal

component analysis. The spelling of the stories was assessed with manual orthographic analyses. The grammaticality judgement tasks were processed by computing two scores. Finally, regression analyses were conducted to test whether condition and/or demographic variables, or the interaction between those independent variables, significantly predicted the writing quality or spelling of the stories or performance on the GJT.

3.3.1 Priming Check

To make sure that the WhatsApp chats produced during the priming phase resembled those composed under non-experimental conditions, we conducted a corpus analysis of the chats. This revealed that participants indeed deviated from Standard Dutch in their chats by using textisms, non-standard orthographic details, and misspellings. Adolescents produced, on average, 119.9 textisms per 1,000 words and young adults 72.4 (van Helden, 2018). These relative frequencies closely resemble those reported in a corpus study of WhatsApp data produced under non-experimental conditions: Verheijen (2017) reports frequencies of 113.1 for adolescents and 72.8 for young adults per 1,000 words. This suggests that during the priming phase with WhatsApp, participants used CMC language as they normally would, which confirms the validity of the experimental manipulation. Example 4 shows some typical WhatsApp messages that have been produced during the priming phase (English translation below), with the coded textisms presented in square brackets:

4. Niet omdat *t* moet, maar omdat *t* kan [*t* < *het*: single letter homophone]
   ('Not because *u* should, but because *u* can')
   Fantastisch! Het toppunt van *me* weekend was ook echt in de top [*me* < *mijn*: accent stylisation]
   ('Fantastic! The pinnacle of *me* weekend was also really in the top')
   Zeka nice [*zeka* < *zeker*: accent stylisation]
   ('*Definately* nice')
   Was *t* maar weekend [*t* < *het*: single letter homophone]
   ('If only *t* were weekend')
   Ooh bijnaaa weekend [*Ooh* < *Oh*: phonetic respelling; *bijnaaa* < *bijna*: reduplication]
   ('*Ooh aaalmost* weekend')
   Jaaaa jarig! Nog maar *ff*! [*Jaaaa* < *Ja*: reduplication; *ff* < *effe*: phonetic respelling]
   ('*Yeaaaah* birthday! Just a little *longa*!')

Further regression analyses were conducted, with, as independent variables, three kinds of spelling deviations in the WhatsApp messages (specifically: textisms ['word adaptations'], non-standard orthographic details ['structural adaptations'], and

misspellings) and as dependent variables the measures of productive and receptive writing skills (the writing quality of the stories (see 'Writing quality of the stories') and their scores in detecting and correcting so-called language errors on the GJT (see 'Grammaticality judgement task scores')) (van Helden, 2018). These revealed no significant effect of individual variation in frequency of using orthographic deviations during the priming phase on performance on the school writing tasks (ibid.), but that may be due to insufficient statistical power because of the high number of variables included in the research design, relative to the amount of WhatsApp output per participant.

3.3.2 Writing Quality of the Stories

Automatic analysis with T-Scan. Given the set-up of the present study, the quality of the stories had to be determined afterwards, based on the writing product. Text quality is, of course, context-dependent. It hinges upon the context of writing, on factors such as text genre, the writer's objectives, and the intended readers' needs (Louis, 2012; Renkema, 2000; Spooren, 2009). Jacobs (2008b) rightly points out that "[w]hat is good essay writing for a high school [...] class is not good writing for IM [instant messaging]" (205). Good writing should "meet […] the purposes of the author and fulfil [...] the requirements of the audience as defined by the social and cultural expectations of the community" (ibid.). Written CMC has very different demands than school writing. The former is generally informal, rapid, and spontaneous, while the latter is more formal, structured, and should adhere to standard language conventions.

Text quality of school writings is often determined holistically and somewhat subjectively by experts, that is teachers. Yet for a quantitative scientific study such as the present, more objective and multidimensional analyses of writings (following Spooren, 2009) were preferred. The stories were automatically analysed using a tool similar to the Coh-Metrix, but for Dutch: T-Scan, software for conducting linguistic complexity analyses of Dutch texts (Pander Maat et al., 2014). T-Scan was selected because it is current, up-to-date, and available free of charge. No other tool offers automated assessment of Dutch texts on so many levels (word, sentence, text) and for such a broad range of measures.

All texts were formatted to make them suitable for analysis with T-scan (Pander Maat, Kraf, & Dekker, 2016). The software provided a staggering 411 variables, out of which a selection of 27 relevant variables was made, following a previous study (Verheijen et al., 2020). These 27 selected variables were divided into six categories. Length measures took into account the length of the text, of the sentences, and of words. Structural measures determined to what extent complex constructions were used, including subordinate clauses, D-level or developmental level (a measure based on an ordering of sentence structures in eight levels of increasing complexity), dependency length (the distance between a sentence/phrase head and

its dependent – the longer, the more difficult to process). Diversity and density measures were based on, firstly, the variation in word choice, by means of the classic type-token ratio (TTR) and the measure of textual lexical diversity (MTLD, similar to TTR but unaffected by text length). Secondly, they were based on the proportion of content words, namely, lexical density. Verbal measures gauged the relative presence of different kinds of verbs: finite, modal, auxiliary, copula, imperative and elliptical, and passive. Nominal measures counted the relative presence of different kinds of nouns, including pronouns; nominalisations; and proper nouns, names and special words. Finally, other parts of speech measures established the relative presence of adverbials, conjunctions, articles, interjections, punctuation, and abbreviations. The selection of these variables crucially depended on their *combined* meaningfulness for determining the level of school writings (see Verheijen et al., 2020 for further explanation). Many of these variables were density variables, measuring the presence of a linguistic phenomenon per 1000 words, which takes into account differences in text length.

A consideration in selecting the variables was that one notion is often measured by several variables in T-Scan, for example, density of passive forms and number of passives per clause. To avoid multicollinearity in subsequent statistical analyses, only one representative for such a set of variables was selected.

Identifying writing variables. The 27 variables from the T-Scan analysis were still too many for the statistical analyses, so exploratory factor analysis (EFA, with the extraction method of principal component analysis, PCA) was used to further reduce these to a smaller set of overarching components that are indicative of the writing quality of the stories (cf. Deane & Quinlan, 2010, who used EFA in a similar way in their automated analysis of student writings).[4] The inflexion of the scree plot, which is used to determine how many components to extract, was not quite clear: it justified retaining three up to five components. Finally, three components were retained, since the items that clustered on these were practically identical to those identified in a previous study (Verheijen et al., 2020): this is a solid confirmation of the appropriateness of these writing variables in analysing student texts for their writing quality.

The results of the PCA after rotation can be found in Table 1. The items that cluster on the same factors suggest that component 1 represents 'syntactic complexity', component 2 'lexical richness', and component 3 'writing productivity'. The total variance explained by the three factors is 38.08%. The resulting factor scores were saved as Anderson-Rubin variables. High values for syntactic complexity, lexical richness, and writing productivity may suggest that school writings of the genre of narrative storytelling have a higher text quality: the production of sentence structures that are complex, of vocabulary that is varied and informationally dense, and of a greater volume of text are suggestive of more high-quality narrative stories and, accordingly, are usually valued by teachers in educa-

Table 1. PCA results for writing quality analysis

Rotated Component Matrix

Writing variable	Rotated factor loadings*		
	1[a]	2[b]	3[c]
maximal dependency length per sentence	**.868**	.141	.106
D-level [developmental level]	**.818**	-.193	.016
average number of subordinate clauses per sentence	**.792**	-.089	.077
average of all dependency lengths per sentence	**.764**	.221	.232
average number of words per sentence	**.720**	.004	-.087
density of punctuation	**-.718**	-.077	.065
density of conjunctions	**.556**	-.287	.072
density of interjections	-.240	-.117	.186
density of adverbials	.221	-.004	.107
density of proper nouns, names and special words	-.147	.016	-.057
density of finite verbs	-.167	**-.762**	-.037
density of nouns	-.059	**.698**	-.166
density of personal and possessive pronouns	-.102	**-.680**	.066
average number of letters per word	-.002	**.624**	-.153
density of content words [lexical density]	-.045	**.554**	.054
density of articles	-.047	**.520**	-.232
measure of textual lexical diversity (for words)	-.060	**.450**	.004
density of nominalisations	-.034	**.423**	.028
density of copula verbs	-.127	-.189	.020
density of modal verbs	.057	-.145	.136
density of imperatives and elliptical constructions	.039	-.099	.066
number of words per story	.023	.004	**.917**
type-token ratio (for words)	-.141	.281	**-.800**
number of sentences per story[d]	**-.529**	-.038	**.782**
density of auxiliary verbs of time	-.078	-.043	-.378
density of passive forms	-.038	.028	-.139
density of abbreviations	-.095	.053	-.095
Eigenvalues	*4.496*	*3.246*	*2.539*
% of variance	*16.652*	*12.021*	*9.405*

Note. All density measures count the average frequency of a feature per 1,000 words.

* Factor loadings > .40 or < -.40 appear in bold and grey.

[a] > .40 = high, < -.40 = low syntactic complexity

[b] > .40 = high, < -.40 = low lexical richness

[c] > .40 = high, < -.40 = low writing productivity

[d] This variable loads on two factors, but since the cross-loadings differ by more than 0.2, this is unproblematic.

tional settings. Note that the linguistic constructs of syntactic complexity and lexical richness (diversity, density, and sophistication) have been frequently used to explain writing quality, and that text length is also recognized as a strong predictor of writing quality (Crossley, 2020).

3.3.3 Spelling of the Stories

The stories of the CMC-primed youths versus those of the control group were manually analysed for the occurrence of orthographic deviations from Standard Dutch, using the coding software MAXQDA. A distinction was made between three kinds of spelling deviations: textisms, 'misspellings', and non-standard orthographic details.

For textisms, that is transformations of conventionally spelled words, the textism taxonomy by Verheijen (2017, 2018) for Dutch CMC language was implemented. Misspellings were limited to a restricted set of spelling deviations from Standard Dutch that are strongly disapproved of by (prescriptivist) language users: incorrect use of *d / t*, *ei / ij*, *is / eens*, *jou / jouw*, *na / naar*, *n* (the letter *n* used to connect two words, or word-finally), errors with borrowings, and obsolete spellings (ibid.). Only these selected 'word adaptations' were classified as misspellings, any others as textisms. For non-standard orthographic details, all 'structural adaptions' were coded (Cingel & Sundar, 2012): deviations from the standard language punctuation, capitalisation, spacing, and diacritics. The relative frequencies of these three types of spelling deviations to the total number of words per story were calculated and normalized per 1,000 words, to be able to compare the texts irrespective of their length.

Over 10% of all texts were double-coded to check whether the codebook was correctly applied. Krippendorff's alpha was calculated per type of spelling deviation: for textisms $\alpha = .453$ (poor), for misspellings $\alpha = .792$ (good), and for non-standard orthographic details $\alpha = .737$ (sufficient). The intercoder reliability was insufficient for textisms because, despite coder training in advance, there turned out to be some systematic differences between the first and the second coder, which resulted in the second coder incorrectly coding certain spelling deviations as misspellings rather than textisms.[5] After deliberation, the first coder's codes were kept as these were best in line with the definitions in the codebook (van der Laan, 2018).

3.3.4 Grammaticality Judgement Task Scores

Two scores were computed for each participant for the GJTs. First, the detection score: whether they correctly identified the sentence as containing a 'language error' or not (max. 20 points). Second, the correction score: whether they correctly managed to correct it (max. 15). Because five sentences contained no orthographic deviations, participants could detect and correct a maximum of fifteen 'errors'. The

'errors' were all orthographic or grammatical deviations for which the 'correct' (standard language) alternatives were obvious (see Appendix A), so the scoring involved no ambiguity and could be reliably executed by one of the researchers.

3.3.5 Statistical Testing

The data were statistically analysed with linear multiple regressions using IBM SPSS Statistics. The outcome variables of the regressions were the three factor scores (of syntactic complexity, lexical richness, and writing productivity) resulting from the principal component analysis of the stories, the three spelling scores resulting from the manual orthographic coding of the stories, and the two grammaticality judgement scores (detection and correction). Separate regressions were carried out for each dependent variable. The predictor variables were condition (colouring vs. WhatsApp) and the demographic variables educational level, age group, and gender. There were no strong correlations between the predictors. They were entered in four blocks with the forced entry method, because prior research gave no clear indication for predictions about which independent variable could be the best predictor. The first block only contained the main effects; the interactions between condition and the demographic variables were entered in subsequent blocks. Significant interactions were further analysed with PROCESS (Hayes, 2013).

As there is a hierarchy within the random variables (students are embedded within different schools), multilevel regression analyses were carried out for each outcome variable, with schools as a random factor and condition, educational level, age group, and gender as predictors. All analyses led to very similar results as the non-multilevel regression analyses. For the sake of simplicity, only the traditional regression analyses are reported here.

4. Results

The means and standard deviations of participants' performances on the story writing task and grammaticality judgement task are presented in Table 2. The results of the linear multiple regressions, per dependent variable, are shown in Table 3.

4.1 Syntactic Complexity

Educational level was a significant negative predictor (β = -.16**) of syntactic complexity: youths in (pre-)university education wrote syntactically less complex stories. Gender was a significant negative predictor (β = -.12*), which is an artefact of the coding: male participants (coded as 0) wrote syntactically more complex stories than female participants (coded as 1).

Table 2. Descriptive statistics

Productive writing task: writing quality	Syntactic complexity		Lexical richness		Writing productivity	
	$\bar{x}$	*SD*	$\bar{x}$	*SD*	$\bar{x}$	*SD*
Condition						
Colouring, *N* = 207	-0.02	1.00	0.06	1.04	0.00	1.09
WhatsApp, *N* = 201	0.07	1.05	0.09	0.96	0.03	0.99
Educational level						
(Pre-)vocational, *N* = 203	0.19	1.06	-0.03	0.93	-0.17	1.04
(Pre-)university, *N* = 205	-0.13	0.96	0.18	1.06	0.20	1.00
Age group						
Adolescents, *N* = 208	0.01	1.14	-0.24	0.92	0.00	1.08
Young adults, *N* = 200	0.05	0.88	0.40	0.98	0.03	1.00
Gender						
Male, *N* = 179	0.16	1.16	0.09	1.00	-0.14	1.11
Female, *N* = 229	-0.08	0.89	0.06	1.00	0.14	0.97
TOTAL, *N* = 408	0.03	1.02	0.07	1.00	0.01	1.04

Productive writing task: spelling*	Textisms		Misspellings		Non-standard orthographic details	
	$\bar{x}$	*SD*	$\bar{x}$	*SD*	$\bar{x}$	*SD*
Condition						
Colouring, *N* = 207	10.03	51.13	8.08	49.69	176.40	998.82
WhatsApp, *N* = 201	7.10	12.62	2.58	5.30	93.89	335.58
Educational level						
(Pre-)vocational, *N* = 203	10.59	16.54	6.78	30.75	167.64	733.48
(Pre-)university, *N* = 205	6.61	50.21	3.97	39.95	104.18	765.84
Age group						
Adolescents, *N* = 208	11.68	51.51	8.31	49.57	204.19	1044.93
Young adults, *N* = 200	5.37	9.51	2.31	5.00	64.59	60.46
Gender						
Male, *N* = 179	13.27	55.59	9.45	53.29	226.05	1125.59
Female, *N* = 229	4.92	7.86	2.18	5.41	65.17	51.96
TOTAL, *N* = 408	8.53	37.33	5.33	35.53	134.76	747.01

Receptive writing task: GJTs	GJT detection score		GJT correction score	
	$\bar{x}$	*SD*	$\bar{x}$	*SD*
Condition				
Colouring, $N = 207$	14.44	3.16	13.82	1.03
WhatsApp, $N = 201$	14.71	3.04	13.74	0.99
Educational level				
(Pre-)vocational, $N = 203$	12.68	2.87	13.53	0.99
(Pre-)university, $N = 205$	16.44	2.00	14.03	0.96
Age group				
Adolescents, $N = 208$	14.10	3.09	13.75	1.01
Young adults, $N = 200$	15.06	3.04	13.81	1.01
Gender				
Male, $N = 179$	14.25	3.14	13.60	1.02
Female, $N = 229$	14.82	3.06	13.92	0.98
TOTAL, $N = 408$	14.57	3.10	13.78	1.01

4.2 Lexical Richness

Lexical richness was positively predicted by educational level (β = .16*) and age group (β = .32***). The stories of participants in (pre-)university education and of older participants were lexically richer. In addition, there was a significant interaction between gender and experimental condition (β = -.22**).

This was further explored with a simple moderation analysis, which estimated the conditional effect of condition (colouring vs. WhatsApp) on lexical richness at the two values of the moderator gender. For the male participants, there was a significant positive relationship between condition and lexical richness, b = 0.285, 95% CI [0.002, 0.568], t = 1.98, p < .05, so the preceding use of WhatsApp positively affected the lexical richness of male participants' stories. When the gender was female, there was a non-significant negative relationship between condition and lexical richness, b = -0.203, 95% CI [-0.447, 0.042], t = -1.63, p = .104.

4.3 Writing Productivity

Writing productivity was positively predicted by educational level (β = .18***); youths in (pre-)university education produced significantly longer stories. Gender was a significant positive predictor of writing productivity too (β = .13**); female participants wrote longer stories than male participants.

Table 3. Results of linear multiple regressions

Productive writing task: writing quality	Syntactic complexity				Lexical richness				Writing productivity			
	B	*SE B*	*β*	*p*	*B*	*SE B*	*β*	*p*	*B*	*SE B*	*β*	*p*
Condition	0.09	0.10	.04		0.32	0.19	.16		0.03	0.10	.01	
Educational level	**-0.32**	**0.10**	**-.16**	**	**0.31**	**0.13**	**.16**	*	**0.37**	**0.10**	**.18**	***
Age group	0.06	0.10	.03		**0.64**	**0.13**	**.32**	***	-0.01	0.10	.00	
Gender	**-0.24**	**0.10**	**-.12**	*	0.11	0.13	.06		**0.27**	**0.10**	**.13**	**
EL × C					-0.14	0.19	-.06					
AG × C					0.08	0.19	.03					
G × C					**-0.50**	**0.19**	**-.22**	**				
R^2	.04				.13				.05			
ANOVA	$F(4, 403) = 4.24$ **				$F(7, 400) = 8.90$ ***				$F(4, 403) = 5.19$ ***			
Productive writing task: spelling	Textisms				Misspellings				Non-standard orthographic details			
	B	*SE B*	*β*	*p*	*B*	*SE B*	*β*	*p*	*B*	*SE B*	*β*	*p*
Condition	1.00	1.84	0.05		**-2.78**	**1.16**	**-0.23**	*	-12.27	11.10	-0.10	
Educational level	**-4.55**	**1.29**	**-0.23**	**	**-4.62**	**0.81**	**-0.37**	**	**-50.45**	**7.79**	**-0.41**	**
Age group	-2.12	1.30	-0.11		**-2.44**	**0.82**	**-0.20**	*	**-19.50**	**7.83**	**-0.16**	*
Gender	**-3.23**	**1.31**	**-0.16**	*	-1.40	0.82	-0.11		**-19.86**	**7.90**	**-0.16**	*
EL × C	-3.10	1.84	-0.15		2.16	1.16	0.15		4.52	11.09	0.03	
AG × C	1.36	1.86	0.06		**2.68**	**1.17**	**0.19**	*	2.34	11.22	0.02	
G × C	1.26	1.88	0.06		-0.51	1.18	-0.04		2.83	11.32	0.02	
R^2	.14				.13				.20			
ANOVA	$F(7, 400) = 9.09$ ***				$F(400, 407) = 8.48$ ***				$F(7, 400) = 14.60$ ***			
Receptive writing task: GJTs	GJT detection score				GJT correction score							
	B	*SE B*	*β*	*p*	*B*	*SE B*	*β*	*p*				
Condition	0.21	0.24	.03		-0.09	0.19	-.05					
Educational level	**3.77**	**0.24**	**.61**	***	**0.39**	**0.13**	**.20**	**				
Age group	**0.99**	**0.24**	**.16**	***	-0.11	0.14	-.06					
Gender	0.35	0.24	.06		**0.51**	**0.14**	**.25**	***				
EL × C					0.22	0.19	.10					
AG × C					0.31	0.19	.13					
G × C					**-0.44**	**0.20**	**-.20**	*				
R^2	.40				.11							
ANOVA	$F(4, 403) = 67.21$ ***				$F(7, 400) = 6.71$ ***							

*$p < .05$, **$p < .01$, ***$p < .001$, EL = educational level, AG = age group, G = gender, C = condition. Significant findings appear in bold and grey.

4.4 Textisms

Both educational level (β = -.23**) and gender (β = -.16*) were significant negative predictors of textism use. Textisms were produced more in the narrative writing task by youths in (pre-)vocational education than youths in (pre-)university education, and more by male participants than female participants.

4.5 Misspellings

Misspellings were significantly negatively predicted by educational level (β = -.37**) and age group (β = -.20*). Participants in (pre-)vocational education and adolescents made more misspellings than participants in (pre-)university education and young adults. Moreover, the experimental condition was also a significant negative predictor of misspellings (β = -.23*). Since the colouring condition was coded as 0 and the WhatsApp condition as 1, this means that students who used WhatsApp directly prior to writing the stories (i.e. were primed with CMC beforehand) produced *fewer* misspellings. In addition, a significant interaction effect was observed between experimental condition and age group (β = .19*).

The interaction was further scrutinized with a simple moderation analysis which estimated the conditional effect of condition (colouring vs. WhatsApp) on misspellings at the two values of the moderator age group. For the adolescent participants, there was a significant negative relationship between condition and misspellings, b = -1.713, 95% CI [-3.400, -0.026], t = -2.00, p < .05, so when using WhatsApp directly before writing, the adolescents' produced fewer misspellings in their stories. For the young adult participants, there was a non-significant positive relationship between condition and misspellings, b = 0.406, 95% CI [-1.302, 2.113], t = 0.47, p = .641. This means that the relationship between condition and misspellings was only present for adolescents. The interaction is visualized in Figure 1.

4.6 Orthographic Details

Educational level (β = -.41**), age group (β = -.16*), and gender (β = -.16*) were significant negative predictors of non-standard orthographic details (punctuation, capitalisation, spacing, and diacritics). Such deviations occurred more in stories by participants in (pre-)vocational education, adolescents, and males than in stories by participants in (pre-)university education, young adults, and females.

4.7 GJT Detection Score

For the grammaticality judgement tasks, educational level (β = .61***) and age group (β = .16***) were significant positive predictors of the detection score, so youths in (pre-)university education and older youths were more successful in spotting 'language errors' in the twenty sentences.

4.8 GJT Correction Score

The correction score of the grammaticality judgement tasks was significantly positively predicted by educational level (β = .20**) and gender (β = .25***). Participants in (pre-)university education and female participants were more successful in correcting 'language errors'. The interaction between gender and experimental condition was also significant (β = -.20*).

A simple moderation analysis estimated the conditional effect of condition on the GJT correction score at the two values of gender. For girls, WhatsApp had a negative effect on their correction score. When the gender was female, there was a significant negative relationship between condition and correction score, b = -0.247, 95% CI [-0.489, -0.004], t = -2.00, p < .05, so using WhatsApp immediately before completing the writing tasks negatively affected girls' ability to correct orthographic deviations, as compared to colouring beforehand. When the gender was male, there was a non-significant positive relationship between condition and correction score, b = 0.143, 95% CI [-0.160, 0.445], t = 0.93, p = .354.

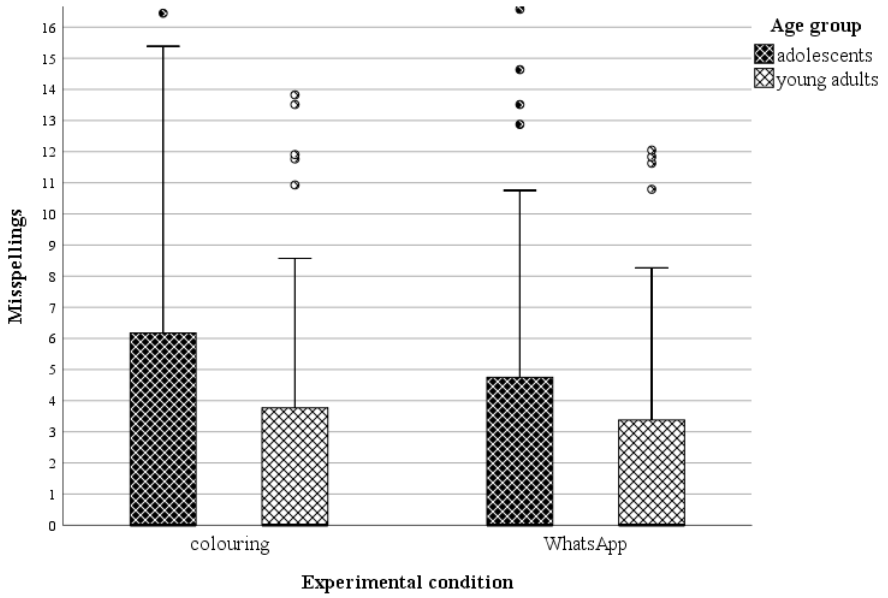

Figure 1. Clustered box-whisker plot of misspellings for the interaction between Condition and Age group (95% CI) – relative frequencies normalized per 1,000 words.

5. Discussion

5.1 Impact of CMC Use on School Writing and Spelling

The first research question addressed whether Dutch youths' use of CMC immediately prior to a writing task directly affects their school writing and spelling. The findings indeed revealed a direct impact of priming with WhatsApp use on participants' narrative writings, but only for one spelling measure. Condition significantly predicted the presence of 'misspellings' in youths' stories in the productive writing task. But there was no negative transfer of CMC language to the school writing. In fact, the preceding WhatsApp use was associated with improved standard language spelling production; fewer misspellings were produced by youths who had been primed WhatsApp immediately beforehand than by youths who had performed a control task. This means that the priming with CMC use influenced their school writing but, rather than interfering, it positively affected their spelling performance. How can we explain this unexpected result? A possible theoretical explanation is that the instant messaging in the experimental condition activated students' meta-linguistic orthographic awareness, leading to improved spelling in the stories written afterwards (Wood, Kemp, & Plester, 2013). Experimental intervention tasks eliciting the use of non-standard spelling have been found to improve orthographic awareness with younger children (Martins et al., 2013); our study suggests that this also applies to adolescents. In other words, active writing in a different register such as CMC may make youths more aware of their written language, resulting in fewer misspellings that are frowned upon in their school writing. This is in keeping with a previous quasi-experimental study in which we found predominantly positive relationships between self-reported social media use and school writing performance (Verheijen et al., 2020).

No significant main effects were found on the spelling measures of textisms or non-standard orthographic details, even though these features are typical of CMC language (Verheijen, 2017, 2018). The results show that deviating writing details are much more common than textisms and spelling errors in school texts: an average of 135 non-standard orthographic details per 1,000 words, compared to 9 textisms and 5 misspellings, a result in line with Vandekerckhove and Sandra's (2016) findings on the frequent omission of punctuation and capitalisation in Flemish school writings. The present study gives no evidence that deviations in school writing from standard language norms on punctuation and capitalisation are caused by social media use.

Neither were there any main effects of condition on the writing quality of the stories, nor on the grammaticality judgement task. This cannot be attributed to a lack of sensitivity in the methods that were employed for measuring writing quality or in the GJT, because their effectiveness was established by the main effects found for the demographic variables. This shows that analysing the stories with the

measures selected from T-Scan and measuring receptive spelling ability with the GJT are successful ways of detecting differences in youths' writing performance. Despite the sensitivity of the measuring instruments, no positive or negative transfer of CMC language due to the WhatsApp priming were found for these measures.

5.2 Impact of Demographic Variables on School Writing and Spelling

Educational level significantly predicted all outcome variables: as could be expected, youths in (pre-)university education wrote lexically richer and longer stories; produced fewer textisms, misspellings, and non-standard orthographic details in their stories; and were more successful in detecting and correcting 'language errors'. Yet they also wrote syntactically less complex stories. This may seem counterintuitive, but rather fits the narratives that resulted from the obligatory starting sentence "*I was alone in a dark room. My hand groped for the light switch, but suddenly…*". This opening sentence creates suspense and anticipation, the perfect start for a thriller. It has been suggested that suspense is more effectively maintained and tension more effectively heightened by succinctness, rather than long, flowery sentences, which are more appropriate for literary writing (East, 2013; Luke, 2011; Rivera, 2015). It can thus be argued that youths in (pre-)university education showed more mastery of the genre of thriller stories.

Age group was a significant predictor for lexical richness, misspellings, non-standard orthographic details, and GJT detection score, with young adults producing lexically richer stories, fewer misspellings, fewer non-standard orthographic details, and revealing more proficiency in spotting 'language errors'. Since young adults have had more writing education than adolescents, this is not a surprising finding.

Finally, gender significantly predicted syntactic complexity, writing productivity, textisms, non-standard orthographic details, and GJT correction score. Similar to participants in (pre-)university education, female participants wrote syntactically less complex, but longer stories, with fewer textisms and non-standard orthographic details, and were more adept in correcting 'language errors'. These results correspond with those of Bourke and Adams (2011), who found (for a younger population) that in a story writing task, girls tended to outperform boys on all writing measures except for grammatical complexity. The lower presence of spelling deviations in the girls' stories and their higher correction score on the GJT might be explained by the fact that women in Western societies tend to adhere more to the prescriptive language ideology and linguistic norms than men: females generally use more standard variants than males, irrespective of other social characteristics such as age (Labov, 1990; Cheshire, 2004). This has especially been found in formal contexts, as is the present study, which was conducted in an educational setting, and has been confirmed for the Netherlands (Romaine, 2003).

Girls' production of stories that were syntactically less complex (which, as explained above, is appropriate for thriller writing) as well as longer may be attributed to their motivation to complete the story writing task. Dutch girls have been reported to enjoy writing assignments at school more than boys do (Heemskerk et al., 2012:32). Similar gender differences have been attested for primary school children in the Netherlands: Dutch girls perform better in spelling and grammar, and produce longer spontaneous writings, than Dutch boys (van Til et al., 2014).

5.3 Interactions between CMC Use and Demographic Variables

The second research question asked if age group, educational level, or gender moderate any direct effect of CMC use on youths' school writing or spelling. If any direct impact of the priming with WhatsApp on participants' performance on the writing tasks could be found, it was expected to be greater for youths with a (pre-)vocational education or of a younger age; we had no expectations about any moderating effect of gender. Results revealed two small but significant interactions with gender: condition was positively related to lexical richness for male participants, and negatively related to correction score for female participants. The effect of condition on lexical richness thus only emerged for boys, and on correction score only for girls: CMC use might slightly improve boys' lexical richness and slightly impair girls' ability to correct orthographic deviations, but both effects were very small and theoretically difficult to explain, so would require replication in further research.

More importantly, there was a significant two-way interaction between age group and experimental condition (WhatsApp priming vs. colouring) for misspellings. The relationship that was found between CMC use and spelling performance was moderated by age and, upon further inspection, only present for adolescents. This supports earlier findings by Wood, Kemp, and Waldron (2014) on age as a moderating factor in the relation between social media and literacy. The interaction shows that adolescents are slightly more susceptible to effects of WhatsApp chat on formal writing, at least where misspellings are concerned, and appear to be more easily primed by CMC use than older populations. Young adults may be less susceptible to priming effects of CMC language because they have had more time to stabilize their Standard Dutch and to practice switching between registers. In addition, survey research shows that their experience with CMC started at a later age: Dutch adolescents' age of first acquiring a mobile or using CMC software was, on average, 10.9 years, while for young adults it was 12.7 years (Verheijen et al., 2020). Although both age groups can be considered digital natives, this two-year discrepancy may make the difference between the standard language being consolidated in their long-term memory versus open to any influence. But perhaps surprisingly, adolescents' writing seems to benefit rather than suffer from CMC use, as there was no negative transfer but rather a positive effect, possibly

because of orthographic register awareness being activated by the priming with WhatsApp.

No interactions between WhatsApp use and educational level were found, so the current study does not support Rosen et al.'s (2010) findings on education as a moderating factor.

6. Conclusion

This paper reports on the first experimental study into the impact of WhatsApp on school writing and spelling. Central to this research was to determine empirically if interference of Dutch youths' CMC use with school writing tasks could be found directly after switching from one register to the other. This question was researched with a priming experiment that allowed us to establish causality. We measured whether a fifteen-minute period of using written CMC had a direct impact on participants' performance on two school writing tasks, specifically on the text quality and spelling of narrative writing products and on their ability to detect and correct 'language errors' in grammaticality judgement tasks. The stories were first analysed with T-Scan, software for automatic assessment of Dutch texts on numerous levels, which was used to assess their syntactic complexity, lexical richness, and writing productivity, and then manually analysed for three kinds of orthographic deviations from Standard Dutch, namely textisms, misspellings, and non-standard orthographic details. To determine whether condition (experimental group: WhatsApp, vs. control group: colouring) had an impact on performances on the productive or receptive writing tasks, regression analyses were conducted. Additional predictor variables included in the analyses were age group, educational level, and gender, because if interference did occur, it was expected to be more present for youths with a (pre-)vocational education or of a younger age.

A direct impact of the priming with WhatsApp use was found on participants' spelling performance on the narrative writing task, where experimental condition made a significant contribution to the explanatory power of the regression model. Youths who had been primed with WhatsApp immediately before writing the story produced significantly *fewer* misspellings than youths who performed the control task. This relationship between CMC use and spelling performance mostly applied to the younger age group. No evidence was found for the expectation that educational level impacts the relationship between CMC use and school writing performance.

All in all, the present study gives no reason to fear the impact of CMC use on youths' school writings. As Baron (2005) predicted, "[t]he writing style commonly used in IMing, texting, and other forms of computer-mediated communication need not spell the end of normative language" (29). Youths appear capable of incorporating different registers in different writing contexts, as long as they know when to heed standard language norms and are aware of the importance of using

context-appropriate language. This priming study did not find any evidence of negative transfer from the register of CMC language to the register of the standard language, but rather suggests that texting and instant messaging with unconventional spelling may increase youths' metalinguistic and orthographic awareness, making them think more about the way they write. This has some practical implications in that not only should we refrain from scolding youths for using textisms in social media messages, but educators may even capitalize on textese by using it in language classes to illustrate concepts such as register differences and code-switching. Although further research is essential to confirm the findings of this priming experiment, perhaps concerns may be replaced by cautious optimism about youths' active and creative language use in CMC.

7. Limitations and Suggestions for Further Research

Although we aimed to implement all of Graham and Harris's (2014) recommendations for high quality intervention research in writing, a critical note on the present study is that it cannot be guaranteed that what was measured was the impact of WhatsApp use on the experimental groups' performance on the school writing tasks, rather than the impact of colouring mandalas on the control groups' performance. Both interpretations are possible. This could have been prevented by having the control groups do nothing at all instead of assigning them to a control task. However, such a boring fifteen minutes could cause youths in control groups (a) to secretly find some other activity to keep them occupied (which would be hard to control for), thereby possibly distracting the experimental groups, or (b) to lose interest in the study, to not complete the subsequent writing tasks seriously, or even to drop out of the study entirely. Hence, the current control task was selected after careful piloting.

The experimental groups' WhatsApp use during the priming phase was a CMC writing activity, while the control groups' colouring was a non-CMC non-writing activity. Upon reflection, this compromises the internal validity of the current study, as our design involves two dimensions of variation in the priming (CMC vs. non-CMC and writing vs. non-writing) and allows for the possibility that not just WhatsApp or CMC use, but *any kind of writing* primes fewer misspellings in a subsequent writing task. In order to measure only the effects of CMC use on subsequent writing tasks, future research could include a control group engaged in a non-CMC writing activity. As such, it could be investigated whether priming with other (informal) writing has similar positive effects on youths' spelling on formal writing tasks. In the current experiment, we deliberately did not choose a writing activity as the control task, because after testing various control tasks in pilot studies, we aimed to maximize the contrast between the prime (WhatsApp use) and the control (finally, colouring). Still, the results of this study indicate that even

WhatsApp use with its non-standard CMC language can be beneficial for adolescents' spelling, maybe by heightening awareness of register differences.

Our findings could have been more telling had participants written another narrative prior to the priming phase, for comparison with the second narrative. Such a pre-test post-test design would have allowed us to pinpoint any direct impact of the priming with WhatsApp in greater detail. Unfortunately, time constraints during data collection hindered such expansion of our methodology.

These time constraints also limited the duration of the priming phase, which only lasted for fifteen minutes. This is a rather short intervention time but, given the fact that data collection (including giving explanations, dividing classes into experimental and control groups, priming task, narrative writing task, grammaticality judgement task, and wrapping up) had to be completed within a 50-minute class, longer priming was not feasible, neither was adding a survey to ask participants about their CMC use outside of this experiment (as done by Verheijen et al., 2020). Information about participants' experience with WhatsApp and frequency or intensity of using WhatsApp in non-experimental settings would have been quite valuable, though, so future research could complement our experimental set-up with a longitudinal study taking into account youths' WhatsApp use on a regular basis. For now, we should be cautious in generalizing our results beyond the priming effect that was found.

Another possible drawback is that the priming, that is WhatsApp use in a classroom context with groups created for the purposes of this research, was artificial in nature. Nonetheless, we tried to make sure that students could behave naturally in their WhatsApp chats, by (a) bearing friendships among classmates in mind in forming the app groups, (b) asking participants to chat as they would outside of class, (c) allowing them to chat about whatever topic they wanted, and (d) not monitoring their chats, neither the researcher nor the teacher. The priming check – a corpus analysis of the WhatsApp chats produced in the priming phase – revealed that participants' non-standard language use was linguistically similar to WhatsApp messages composed under non-experimental conditions (Verheijen, 2017). Despite the artificial setting of the experiment, we still found a significant effect of the priming on the subsequent writing task.

A possible explanation for why a direct impact was only found on misspellings, and not on other writing or spelling measures, is that the youngest participant group were adolescents in secondary school. Heightened effects might be found for even younger participants, that is children in primary school. This is suggested by Riemens' (2016) finding that WhatsApp use affected first-graders in secondary school more in their ability to detect 'language errors' than third-graders. It would be interesting to replicate the present study with children, although that would create ethical issues, since WhatsApp should no longer be used by Dutch children below the age of 16. Still, such a study would be especially relevant given that

children possess smartphones at an ever younger age and may, therefore, be exposed to CMC language while their traditional literacy skills are still developing. Register boundaries may be more fluid for children, which could cause more effects of CMC use on their school writings.

As a final point, future research should consider applying more sophisticated statistical techniques, such as path analysis or structural equation modelling (SEM), which are useful for testing causal relationships. These could help to establish whether CMC may affect school writing or vice versa.

Despite its limitations, this study shows that rather than WhatsApp interfering with school writings through negative transfer, youths appear to be well able to switch between registers, and adolescents' spelling may even benefit from WhatsApp use. The use of social media adds to the repertoire of linguistic registers that youths (and adults) shift between in their everyday language use. As long as youths receive proper education on how and when to employ different written registers and are taught about the conventions of formal writing in compliance with standard language norms, which they will need in further education and their professional careers, engaging in CMC certainly need not have deleterious effects on writing in formal settings.

Notes

[1] This paper is a greatly extended and revised version of a short conference paper by the authors: Verheijen, L., & Spooren, W. (2017). The impact of WhatsApp on Dutch youths' school writing. In E. W. Stemle & C. R. Wigham (Eds.), *Proceedings of the 5th Conference on CMC and Social Media Corpora for the Humanities* (pp. 6–10). Bolzano: Eurac Research.
https://cmc-corpora2017.eurac.edu/proceedings/cmccorpora17-proceedings.pdf

[2] See Deutscher (2005) for a historical note on concerns about language deterioration.

[3] 92 participants of pre-professional secondary education were part of the data collection. Yet it turned out to be impractical to collect data from their young adult counterpart (professional tertiary education), so this intermediate level was eventually omitted from the analyses rather than having an empty cell in the research design.

[4] An orthogonal rotation method was chosen (Varimax with Kaiser normalization): this method, which does not allow correlations between factors, facilitated the interpretation of results, since it maximizes the spread of loadings for a variable across all factors. There was no multicollinearity; none of the correlation coefficients were $r \geq .84$. Missing values were replaced with the mean, since listwise deletion would result in a loss of participants in the analysis and pairwise deletion would lead to a non-positive definite matrix. The Keyser-Meyer-Olkin measure was well above .5 ($KMO = .644$), which verified the sampling adequacy for the analysis.

Bartlett's test of sphericity showed that correlations between items were sufficiently large for PCA: χ^2 (351) = 6267.569, $p < .001$. The proportion of residuals with an absolute value greater than 0.05 was 50%. An initial analysis yielded eigenvalues for each component in the data. The sample size of this study permitted use of a scree plot with eigenvalues over 1 for deciding how many components to extract.

[5] This difference mostly originated from the second coder coding practically all words with a missing final-n as misspellings, while the first coder rightly only coded those whose form without final -n is 'correct' in a different grammatical context as misspellings and coded all other words with a missing final-n as textisms (specifically: clippings).

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Appendix A: Materials for grammaticality judgement task

No.	Sentence	Detection	Correction	'Error' type
1	Vanavond gaan zij naar de bioscoop.	correct		
2	Heej, de melk is alweer op.	incorrect	Hé	textism: phonetic respelling
3	Je weet wel wat ik bedoel ;)	incorrect	*no emoticon*	emoticon
4	Ga jij ook naar het feestje van emma?	incorrect	Emma	missing capitalisation
5	Mam heeft jouw sleutels gevonden.	correct		
6	Die oude man was zn paraplu vergeten.	incorrect	z'n / zijn	missing diacritic / contraction
7	Geef mij is de zak chips!	incorrect	eens	spelling 'error': *is/eens*
8	Ik weet totaaal niet waar je het over hebt.	incorrect	totaal	textism: reduplication
9	Ben er over vijf minuten.	incorrect	Ik…	omission
10	De hond moet sowieso mee op vakantie.	correct		
11	Ik vindt het een goed idee.	incorrect	vind	spelling 'error': *d/t*
12	Het afscheid na de date voelde echt awkward.	incorrect	raar/vreemd	English borrowing
13	De groeten! We gaan na huis.	incorrect	naar	textism: shortening
14	Hun nieuwe wiskundeleraar is best oké.	correct		
15	De trein botsing zorgde voor veel vertraging.	incorrect	treinbotsing	extra spacing
16	Wat een vies weer, t regent al de hele dag.	incorrect	het	textism: single letter homophone
17	Maar vertel eens, hoe was jou weekend?	incorrect	jouw	spelling 'error': *jou/jouw*
18	Ik heb het huiswerk btw niet af…	incorrect	trouwens	English textism: initialism
19	Hoe laat begint de film ook alweer, denk je?	correct		
20	Gelukkig is deze les bijna voorbij	incorrect	.	missing punctuation