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The effects of background music on word processed writing

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Abstract

College students often listen to music while they use a computer. This experiment investigated whether background music disrupts their ability to word process fluently and effectively. Forty-five psychology undergraduates wrote brief expository essays. Background music significantly disrupted writing fluency (words generated per minute controlling for typing speed and including those words deleted before the final draft) even though no response to the music was required. Those with some musical training and high working memory span wrote better essays with longer sentences and were also more likely to pause at clause boundaries. Even unattended music places heavy demands on working memory and disrupts word processed writing. © 2001 Elsevier Science Ltd. All rights reserved.

Keywords: Word processed writing; Working memory; Writing fluency; Background music

1. Introduction

Word processed writing clearly demands a wide range of simultaneous subprocesses such as formulating ideas, translating ideas into text, monitoring the text one has already composed and producing the appropriate motor movements (Hayes, 1996; Kellogg, 1996; McCutchen, 1996; Ransdell & Levy, 1994). In the present sample, the majority of college students report that they *also* listen to music while they write or study on the computer. It is therefore important to know how this multi-task strategy affects performance. Several researchers have found that writing medium, i.e. handwriting or word processing, affects the ability to create an effective essay (Bonk & Reynolds, 1992; Ransdell & Levy, 1994). For example, Ransdell and Levy found that handwritten essays were of higher quality than word

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processed and furthermore, that word processed writing contained a greater number of revisions. The revisions were more extensive than during handwritten essays but tended not to change the meaning or quality of the text. The purpose of this study is to compare writing in silence or while listening to music to determine how background music may affect word processing fluency and effectiveness.

2. Background sounds and working memory

Working memory is the mental work space in which dual tasks are coordinated (Gathercole & Baddeley, 1993). Background speech and music have often been presented to subjects as they perform a primary task in order to determine the limits of working memory. For example, Martin, Wogalter, and Forlano (1988) found that background speech reduced the accuracy of reading comprehension even when it was not attended to. Salame and Baddeley (1989) similarly found a disruptive effect of irrelevant vocal music on serial recall of visually presented sentences. Waters, Komoda, and Arbuckle (1985) found that talking out loud disrupted reading performance, while a nonverbal task of equal difficulty (tapping) did not. Ransdell, Levy, and Kellogg (1996) and Madigan, Johnson, and Linton (1994) both found that unattended irrelevant speech interfered with word processing fluency. McCutchen et al. conclude that fluent translating processes may actually help reduce the memory load (McCutchen, Covill, Hoyne, & Mildes, 1994). Translating from ideas in the head to words typed on the page requires phonological coding. So if, as McCutchen et al. suggest, translating may be particularly affected by working memory demands, then even unattended background music may disrupt writing. Music should impair word processed writing because like irrelevant speech, it should disrupt at least two important writing subprocesses, reading text and the translation of ideas into text.

3. Individual differences in working memory

Working memory is also implicated in writing while listening to background sounds because there is a significant correlation between writing span and writing fluency. Ransdell and Levy (1999) found that an individual difference measure of working memory, writing span, can predict word processed fluency and effectiveness in college-level writers. Writing span is a task where written sentences are produced while the participant tries to remember the last word in each generated sentence. The writer must coordinate the generation of grammatical sentences while trying to hold the last words generated in memory. The sets begin with two sentences, then three, and finally four sentences before a recall of all final words is requested in each sentence set length is requested. High writing span writers (above the median in memory performance) can more easily coordinate storage and processing tasks while writing and remembering than low span writers. Writers who scored higher on writing span measures wrote better essays, more fluently, and with longer sentences. Those with high span also produced a greater proportion of long pauses (greater than five seconds) at clause boundaries than did those who scored more poorly on writing span. In reading research, pausing during clause boundaries rather than in random locations is associated with better comprehension (Aaronson & Scarborough, 1977). In the present study, those with high working memory span should be better able to word process essays while listening to music. High span writers should also write more fluently, with high quality and longer sentences, and pause more often at clause boundaries. A self-report measure of musical training was also collected since there is some evidence to suggest that those trained in music process it differently than those not trained (Bever & Chiarello, 1974).

4. Methods

4.1. Population and sample

Forty-five participants randomly sampled from upper-division undergraduate psychology courses volunteered for extra credit. A total of 38 women and seven men were tested. A questionnaire administered after all experimental trials indicated that 67% had been trained to sing or play a musical instrument, 51% sometimes listened to music while word processing, and 64% sometimes listened to music while using a computer for school work. Average typing speed to dictation was 35 words per minute and no subjects were included who were not experienced touch typists. Headphones were chosen as the method of stimulus delivery since we were trying to recreate the atmosphere and characteristics of our general-use computer labs.

4.2. Experimental manipulation

The main experimental manipulation consisted of two levels manipulated between-subjects: music (which could be vocal, instrumental or both) or a silent control. Participants heard three different songs from the same genre of music. All songs were slow ballads taken from a sing-along with a Nelson Riddle Orchestra tape. Each song was repeatedly played for each 10-min writing session except the silent control. This was a karaoke-style tape that included two versions of every song: one instrumental and the other with singing (The Singing Machine company — tape M-727). The instrumental condition song was "The More I See You" and was taken directly from the tape. The other two conditions were recorded by a woman singing along to the instrumental versions on the tape. The song "I Had the Craziest Dream" was used for the music and singing condition while the song "The More I See You" was used for the singing condition. All songs were roughly equal in length, volume, general content, style, and tempo. In the singing version, just the vocals were recorded.

Two other control variables, also manipulated between-subjects, were essay topic and essay topic order. Essay topics were the "best possible college class", "best possible college instructor", "best possible boyfriend/girlfriend", and "best possible vacation", and were counterbalanced for order. All experimental effects generalized across essay topic and essay topic order so these variables are not mentioned further in the paper.

Individual differences in working memory (writing span), were measured as well as self-reported musical training. Writing span was designed by the authors as an analog of Daneman and Carpenter's (1980) reading span test. Five sets of two, three, and four words were presented one at a time on a computer screen. Participants were given 8 s per word to generate sentences using the words on slips of paper. At the end of each set, they were asked to recall the entire set of words at the end of each sentence they had created. Participants were asked not to use the target words at the beginning or end of the sentence. Writing span was measured as the total percentage of words recalled from the end of each generated grammatical sentence. Internal consistency of the span scale was, on average, 0.78.

In the self-report of musical experience, 67% of the participants reported some musical training. No subjects reported that they were familiar with any of the music or singing they heard. Participants indicated that on average, they liked the singing and music 5.7 points out of a possible 10 points.

4.3. Instrumentation

Dependent variables included writing fluency, writing quality, average sentence length, and the percentage of long pauses (greater than 5 s in length) located at clause, sentence, or paragraph boundaries in each essay written.

Writing fluency was defined as the number of words written per minute (controlling for typing speed) including complete words created during writing but later deleted. Fluency was measured by a program called FauxWord (Levy & Ransdell, 1995) which captures keystrokes as the participant types and replays them in real or fast time.

Writing quality was scored by independent judges (student peers) using the Six Subgroup Quality Scale (Ransdell & Levy, 1996). Quality analysis is determined by combining two student peers' scores for each of six subgroups across 13 dimensions on 5-point scales and converting the resulting combined number to a percent score. The procedure is taken from English placement exam scoring at the University of Maine. The six subgroups in the scale include organization, technical quality, word choice and arrangement, content, purpose, audience and tone, and style. Factor analysis indicates that these six subgroups load on a single factor, writing quality. After training to a high degree of reliability with samples not in this experiment, the raters read each essay once for each of the 13 dimensions. Raters were blind to essay condition. Interrater reliability averaged across the 13 dimensions was 0.80.

Average sentence length was calculated from the sentence count of the word processor divided by the word count to yield the mean number of words generated per sentence. The percentage of long pauses located at clause, sentence, or paragraph boundaries was calculated by the FauxWord program and a trained native speaker of English. The program replayed the essay and stopped at each pause greater than 5 s. The native speaker then judged whether the pause was located at a clause, sentence, or paragraph boundary and divided each sum by the total number of long pauses in a given essay.

4.4. Procedure

Participants were recruited from a psychology major research pool. They were told that the study was about how people coordinate listening to music while they write on a computer. All subjects participated in both the silent and music conditions. Participants wrote two 10-min essays using a simple word processor, first in a silent control condition, and second with one of the following, instrumental music, vocal music, or both. The silent control will henceforth be compared to simply the "music" condition since none of three types were reliably different from one another on any dependent measure. Participants wore headphones in both conditions and were not required to respond or make any judgments; participants were told to concentrate on writing. They were told to write as if writing for a professor in a class. Participants were notified when they had 5 min and 1 min left to write. The two 10-min essays were written on the following topics: the best possible college class, best possible college instructor, best possible boyfriend/girlfriend, and best possible vacation, and were counterbalanced for order. Participants then completed the writing span test in which they were instructed to focus on writing the best possible sentences with the words provided, but also try to remember the last word in each sentence they created. Finally, participants completed a brief questionnaire which asked about their familiarity with the music and their word processing and computer study habits. They were also asked if they had ever learned to play a musical instrument or studied singing. Music experience was operationally defined as a "yes" or "no" in response to either previous instrumental or vocal instruction.

4.5. Design and analysis

The main experimental condition was music versus silence while writing and it was manipulated within-participants. Although three types of music were tested, instrumental, vocal, and both, no differences were found between them in terms of any of the dependent measures. All statistical analyses were conducted using a one-way univariate analysis of covariance with two levels of the independent variable, music versus silence, and two covariates, writing span score, and whether the participant had any musical training. All analyses reported as reliable reach an alpha of 0.05 or better.

5. Results

As predicted, the music condition significantly slowed word processed *fluency* with mean words generated per minute at 18.8 in the silent control condition and 17.8 in the music condition, $F(1,43)=3.50$, M.S.E. $=14.6$, $P<0.05$, controlling for typing speed and including words in the essay that were not in the final draft. Neither writing span nor musical training yielded reliable effects or interactions in terms of fluency. Even though writers did not have to respond to the music in any way, they nonetheless could not word process as efficiently as they could in silence. It also did not matter if the music was vocal or instrumental, the disruptive effect was the same. Silent control writing fluency was reliably correlated with writing effectiveness or quality, $r=0.30$, mean sentence length, $r=0.41$, and total number of long pauses, $r=-0.43$. See Table 1 for a correlation matrix that includes all the variables in the study.

Word processed writing *effectiveness* or quality was reliably correlated with writing span, $r=0.35$, average sentence length, $r=0.61$, music experience, $r=0.29$, and pause location, $r=0.28$. But it was not significantly reduced by the music condition, $F<1$. Writers who had high writing span, or who had some musical training, wrote essays of higher quality containing longer sentences than those with low span or no musical training. Higher writing quality was also associated with a tendency to pause at clause boundaries rather than at random locations in a sentence.

6. Discussion

The present results show that music can, like background speech, disrupt writing fluency. Writers apparently slow writing production to preserve quality when writing is accompanied by background music. It does not matter if the music is vocal or instrumental or both, despite some students' anecdotes that instrumental music does not disrupt their writing as much as vocal. Poorer writing quality, shorter average sentence length, and the tendency to pause randomly, were particularly evident for those writers with low writing span and no musical training. Of course, many other factors are important in determining the fluency and effectiveness of writing. This study isolates one of those factors, background music, while letting other factors such as rhetorical knowledge, writing instruction, and writing expertise vary freely in the design.

Table 1
Correlations among all measured variables under the baseline silent control condition ($n=45$)[a]

Variable	1	2	3	4	5	6	7
1 Writing span	1	0.22	−0.23	−0.02	0.27	0.35*	−0.39*
2 Writing fluency		1	0.41*	0.03	0.16	0.30*	−0.43*
3 Sentence length			1	−0.02	−0.13	0.61*	−0.03
4 Music experience				1	0.15	0.29*	0.25
5 Pause location					1	0.28	−0.27
6 Writing quality						1	0.05
7 Pause frequency							

[a] All significant correlations at alpha = 0.05 are marked with an *.

6.1. Individual differences in musical training

Of course, it is likely that self-reported musical training serves as a proxy for other variables, perhaps related to one's early educational experiences. Musical skill was not measured directly, but previous research suggests that musical training can influence musical processing. Bever and Chiarello (1974) found that those trained in music processed it more analytically (and were left hemisphere dominant for music) relative to those less trained. Untrained subjects processed music holistically and tended to be right hemisphere dominant for musical processing. In the present study, those who had received some type of instrumental or singing instruction scored five percentage points higher in quality than those with no such training. Further research should explore the links between a variety of childhood experiences, such as computer use and subsequent college-level writing performance.

6.2. Individual differences in working memory span

Complex working memory spans have been shown in numerous studies to predict performance in other language comprehension and production tasks (Daneman & Carpenter, 1980; Ransdell & Levy, 1999). The present research extends this finding to a writing span measure and to written language fluency. Digit span, a simple measure of the number of digits that can be recalled, does not predict complex behaviors like reading or writing because it does not include a processing task. The combination of processing, comprehending or generating a sentence, and storage, remembering the final word in each sentence, is what makes the task predictive.

6.3. Advise to students writing on a computer

For all those college students who listen to music while they write on a computer, the advice from this study is clear. One's writing fluency is likely to be disrupted by both vocal and instrumental music. And quality will be especially poor if one also has relatively poor memory skill and limited musical training. A reliable reduction in fluency, about 60 words an hour, is likely to be caused by unattended background music. Sixty words an hour does not sound like much, but since fluency is related to quality and to the ability to manage simultaneous subprocesses of writing, any decrements could prove important.

It comes as no surprise to teachers that working memory resources are in demand when writing processes are invoked. Basic writers struggle to manage planning, sentence generation, and revising in discrete, linear steps. More advanced writers use working memory to juggle the simultaneous constraints of these subprocesses and move rapidly among them (Ransdell & Levy, 1994, 1995). A student's best bet would be to word process their work in silence, or at least try to reduce background sounds. Unless group work is important, students should use computers for school work in as silent an environment as practically possible.

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