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BRIEF REPORT

Thinking one thing, saying another: The behavioral correlates of mind-wandering while reading aloud

Michael S. Franklin · Benjamin W. Mooneyham · Benjamin Baird · Jonathan W. Schooler

Abstract Although mind-wandering during silent reading is well documented, to date no research has investigated whether similar processes occur during reading aloud. In the present study, participants read a passage either silently or aloud while periodically being probed about mind-wandering. Although their comprehension accuracies were similar for both reading conditions, participants reported more mind-wandering while they were reading aloud. These episodes of mindless reading were associated with nearly normal prosody, but were nevertheless distinguished by subtle fluctuations in volume that were predictive of both overall comprehension accuracy and individual sentence comprehension. Together, these findings reveal that previously hidden within the common activity of reading aloud lies: (1) a demonstration of the remarkable automaticity of speech, (2) a situation that is surprisingly conducive to mind-wandering, (3) subtle vocal signatures of mind-wandering and comprehension accuracy, and (4) the promise of developing useful interventions to improve reading.

Keywords Attention · Reading

Any parent who has spent much time reading bedtime stories is likely to have had the impression that it is possible to read a story aloud while simultaneously thinking about something entirely unrelated. Though the quality of such distracted storytelling may be compromised, these experiences suggest that it may be possible to maintain a semblance of normal prosody while remaining largely oblivious to the actual contents of what is being said. Interestingly, although no research has specifically investigated mind-wandering while reading aloud, considerable research has indicated that mind-wandering during silent reading is both common and detrimental to comprehension (Schooler, Reichle, & Halpern, 2004; Smallwood, Fishman, & Schooler, 2007; Smallwood, McSpadden, & Schooler, 2008). Given anecdotal reports and the established phenomena of silent mindless reading, it seems plausible that a similar process might occur when reading aloud. However, the unique processing demands associated with reading aloud make it unclear whether it would be associated with an increase or decrease in the frequency of mind-wandering.

Indeed, from a theoretical perspective, there are several reasons to suspect that reading aloud might discourage, or even prevent, mind-wandering. Reading aloud requires resources for the processes of generating the phonology (Reynolds & Besner, 2006) and prosody (Kuhn, Schwanenflugel, & Meisinger, 2010) necessary to convey the meaning of the material that may exceed those needed when reading silently (Eiter & Inhoff, 2008). Such processes might be too demanding to be carried out while simultaneously thinking about something entirely unrelated. Moreover, since mind-wandering draws on the phonological loop (Teasdale et al., 1995), reading aloud might compete for limited phonological resources, thereby discouraging mindless reading. Furthermore, hearing one's own voice could increase self-awareness (Silvia & Gendolla, 2001), which could increase the likelihood that individuals notice themselves mind-wandering (Schooler, 2002).

We also have theoretical reasons to think that reading aloud could be conducive to mind-wandering. For example, occupying the phonological loop does not always decrease mind-wandering, especially when the articulated speech has been rehearsed and is spoken at constant, predictable intervals (e.g., saying "the, the, the"; Levey, Aldaz, Watts, & Coyle, 1991). Moreover, the engagement of self-reflective processes has

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been shown to increase certain categories of task-unrelated thoughts, such as spontaneous thoughts about the future (Smallwood et al., 2011). Indeed, the brain regions (i.e., the default mode network) most closely aligned with mind-wandering (Christoff, Gordon, Smallwood, Smith, & Schooler, 2009; Mason et al., 2007) are also highly involved in self-referential thought (e.g., Mitchel, Banaji, & Macrae, 2005). Accordingly, if reading aloud increases self-awareness or self-related thoughts, this might increase rather than decrease mind-wandering.

Studies comparing comprehension accuracy for reading silently versus aloud have also been equivocal in their predictions regarding the relative incidences of mind-wandering in the two situations. Whereas research has pointed toward the benefits of reading aloud in younger children (Grades 1–5; e.g., Fletcher & Pumfrey, 1988), the findings for older, more skilled readers are mixed. For example, some studies have revealed a comprehension advantage for silent reading in older children who are average or strong readers (up to Grade 7; Davis, 1988; Prior et al., 2011); other investigators have failed to find any difference in comprehension based on reading mode (McCallum, Sharp, Bell, & George, 2004). Unfortunately, no studies have been conducted with college students, and even if there were a straightforward relationship between comprehension and reading mode, the implications regarding this issue of mind-wandering would be limited. For example, readers could be completely on task while reading aloud but focus on the pronunciation and articulation of each individual word at the expense of semantic content, resulting in poor comprehension.

Although the extant findings are equivocal in their predictions regarding the relative incidences of mind-wandering while reading aloud versus silently, they are potentially more informative regarding the impact that mind-wandering might have on the prosodic elements of participants' speech. Various lines of research have suggested that mindless reading alters behavioral patterns that are sensitive to variations in the lexical properties of words. For example, eyetracking has revealed that mindless reading is associated with longer fixations, reduced sensitivity to lexical features, and increased blinking rates (Reichle, Reineberg, & Schooler, 2010; Smilek, Carriere, & Cheyne, 2010). Measures of reaction times in a word-by-word reading paradigm similarly revealed reduced sensitivity to the lexical properties of words during mindless reading. Indeed this paradigm was sufficiently sensitive to fluctuations in attention to the text to enable the successful online prediction of whether or not a participant would report mind-wandering when probed (Franklin, Smallwood, & Schooler, 2011). Taken together, these results suggest that speech patterns during reading may also vary as a function of mind-wandering: Just as participants show less variability in silent reading behavior while mind-wandering, we suspect that reading aloud while mind-wandering may be associated with less variability in volume and pitch. The identification of vocal markers of mind-wandering while reading aloud could be useful in future work aimed at reducing mindless reading by providing real-time feedback regarding a reader's attentional focus.

Present study

In the present study, participants read a story either silently or aloud, one sentence at a time, while periodically being asked whether or not they were mind-wandering. Previous work had demonstrated that probing participants does not influence reading comprehension (Franklin et al., 2011). The present study had two primary aims: (1) to assess whether comprehension accuracy and mind-wandering would vary as a function of whether participants read silently or aloud, and (2) to assess the prosodic elements of speech during episodes of mind-wandering. Within the reading-aloud condition, vocal data were analyzed on the basis of whether or not a participant was mind-wandering. Given the established relationship between psychiatric symptomatology and speech qualities such as energy (i.e., volume) and frequency (i.e., pitch; Cannizzaro, Harel, Reilly, Chappell, & Snyder, 2004), we assessed the mean and standard deviation of both the volume and pitch of the speech patterns. It was expected that, if mind-wandering during reading aloud were observed, it would influence speakers' cadences, potentially resulting in less variability in volume and pitch.

Method

Participants

A group of 74 participants from the University of California, Santa Barbara, were tested in the experiment (48 female, 26 male, mean age = 20.2 years; 37 vocal, 37 silent) and received either course credit or $10 in compensation.

Materials

Text The text used in this experiment was a shortened version of the Sherlock Holmes story "The Red-Headed League" (Conan-Doyle, 1892/2001), which was edited to approximately 5,000 words. Twenty-three multiple-choice questions were administered, with each question having four possible answers (see the supplemental materials for a copy of the text/questions). The majority of the questions were designed to assess whether key facts pertaining to particular sentences were missed (Smallwood et al., 2008). Previous studies with this particular text and set of comprehension

questions have revealed a significant correlation between reading comprehension and reported mind-wandering (Franklin et al., 2011; Smallwood et al., 2008), suggesting that the measures have adequate variance to reveal differences based on reading condition.

Procedure

The text was presented one sentence at a time in black on a white screen. The participants advanced sentences by pressing the spacebar. Those in the vocal condition were instructed to read the story aloud and wore a standard headset with a microphone to record the vocal data. At pseudorandom intervals (ranging from 100 to 230 words), all participants were given one of 15 thought probes during which the question "Just prior to being asked, were you mind-wandering?" was displayed, to which they responded either "yes" or "no" by pressing "y" or "n." After participants had finished reading the text, they were given the comprehension test. The session lasted approximately 50 min.

Results

The vocal data were sampled at 44100 Hz and processed with MATLAB.[1] Since the volume of the recording between participants was not always constant (due to slight differences in microphone placement), all within-subjects vocal data were *z*-transformed. As such, we were unable to make any inferences across participants regarding their overall mean volume/pitch and their behavior (i.e., mind-wandering and performance variables). For each sentence, the mean volume and standard deviation of the volume were calculated. Additionally, we calculated the mean and standard deviation of the pitch for each sentence using a pitch-tracking script included as part of the Voicebox toolbox.[2] In order to investigate the effects of mind-wandering on reading, we analyzed vocal data using a time window that extended ten sentences prior to the thought probe (corresponding to approximately 40 s, which is consistent with previous studies investigating mind-wandering and reading; Franklin et al., 2011).

Comprehension

Overall, we did not find a significant difference in accuracy between the vocal (mean = .57, *SD* = .15) and silent (mean = .54, *SD* = .16) conditions [$t(72) = 0.77$, $p = .44$, Cohen's $d = 0.18$]. Consistent with previous research, comprehension accuracy correlated significantly with participants' thought probe reports across both conditions, with the proportion of time spent off task leading to lower accuracy ($r = -.31$, $p = .007$). Although this correlation was higher in the vocal condition, this difference did not reach significance (silent, $r = -.16$; vocal, $r = -.51$; difference $z = 1.64$, $p = .10$).

Reaction time (RT)

We observed a significant difference in the mean RTs (i.e., the average time spent per sentence) between conditions, with participants in the vocal condition taking longer (mean RT = 5,414.2, *SD* = 470.06) than those in the silent condition (mean RT = 4,759.8, *SD* = 776.15; $t(72) = 4.39$, $p < .001$, $d = 1.03$).

Mind-wandering

A significant difference emerged in the amount of mind-wandering between conditions, with participants in the vocal condition reporting more mind-wandering (mean proportion off task = .32, *SD* = .25) than those in the silent condition (mean proportion off-task = .21, *SD* = .17) [$t(72) = 2.19$, $p = .03$, $d = 0.52$].

Vocal parameters

Both the mean and the standard deviation of the volume varied significantly on the basis of whether participants reported being on versus off task. Six participants were not included in the on- versus off-task analysis because they reported always being on task; therefore, the analyses below included 31 participants. The mean volume[3] was higher for off-task (mean = 0.00015, *SD* = 0.00041) than for on-task (mean = −0.00007, *SD* = 0.0002) reports [$t(30) = 2.57$, $p = .016$, $d = 0.94$]. Greater variability in volume was associated with on-task reports (mean = 0.97, *SD* = 0.03) than with off-task reports (mean = 0.94, *SD* = 0.08) [$t(30) = 2.86$, $p = .008$, $d = 1.04$]. We observed no differences in either the mean pitch (on task = 157.05, *SD* = 43.67; off task = 157.09, *SD* = 43.65) or standard deviation (on task = 41.43, *SD* = 14.25; off task = 40.86, *SD* = 13.61) of the pitch on the basis of reports of mind-wandering (all *p*s > .50). Consistent with the notion that variability in volume tracks a participant's attention to the text, a significant positive correlation emerged between the standard deviation of the volume and comprehension accuracy ($r = .36$, $p = .03$), such that participants who displayed more variability in their vocal volume tended to have higher comprehension accuracy. Since the answers to 18 of the 23 comprehension questions could be

[1] Version 7.10.0 (2010; The MathWorks Inc., Natick, MA).

[2] Available at www.ee.ic.ac.uk/hp/staff/dmb/voicebox/voicebox.html.

[3] These values are so close to zero because of the vast number of *z*-transformed samples that were averaged together (44,100/s). Although this may make it appear that the effect is small, the particular scaling is a consequence of the transformation. All of the vocal effect sizes (as measured by Cohen's *d*) are considered large (>.8).

determined from information presented within particular sentences of the text, we were also able to assess the relationship between volume variability and comprehension at the sentence level by examining the vocal volume standard deviation for each of the sentences that directly corresponded to 18 of the comprehension questions. The vocal volume standard deviation for these particular sentences was significantly higher when participants were correct in answering the corresponding question (mean = .96, *SD* = .10) than when they were incorrect (mean = .87, *SD* = .11) [$t(35) = 3.23$, $p = .003$, $d = 1.09$]. These results imply that vocal data alone can predict whether or not a participant is following the meaning of the text.

Discussion

The results of this study have shown for the first time that it is not only possible to mind-wander while reading aloud, but that reading aloud actually promotes mind-wandering, relative to silent reading. The capacity for the mind to carry on an unrelated train of thought while simultaneously reading aloud illustrates the remarkable automaticity of the processes involved in oral reading. Apparently, automatic low-level word recognition mechanisms are not only capable of freeing up resources for higher-level, integrative text comprehension (e.g., LaBerge & Samuels, 1974), but also can afford the ability to articulate words and the prosody necessary to represent their grammatical relationships. Indeed, although participants' intonations and volume were subtly affected by mind-wandering, they nevertheless were able to maintain reasonably appropriate prosody. Evidence for this claim came from a follow-up investigation in which 26 participants listened to a recording from one of two participants who had reported mind-wandering 50% of the time. The listeners were probed at the same time as the speaker and asked whether the speaker was mind-wandering. The results revealed that listeners were only slightly above chance at distinguishing whether or not speakers were mind-wandering [52.7%; $t(25) = 1.89$, $p = .07$, $d = 0.76$].

Given anecdotal reports of mind-wandering while reading aloud, it is perhaps not that surprising that such lapses are possible, but the fact that reading aloud produces significantly more mental drifting than does silent reading was heretofore unknown. Although future research will be needed to determine why oral reading particularly encourages mind-wandering, several potential explanations are worthy of exploration. One possibility is that reading aloud causes individuals to become self-conscious of themselves, thereby inducing self-thoughts that are known to be associated with mind-wandering (Baird, Smallwood, & Schooler, 2011; Smallwood et al., 2011). Alternatively (or additionally), by occupying the phonological loop, reading aloud may discourage the internal self-talk that has been linked to meta-awareness of mind-wandering (Bastian, Schooler, & Sackur, 2012). A reduction in meta-awareness of mind-wandering could thereby contribute to its increased occurrence during reading aloud. These alternative accounts might profitably be explored by comparing the mind-wandering associated with silent versus oral reading with respect to both its content (e.g., proportion of self-related thoughts) and likelihood of being self-caught by the reader.

Despite the significant differences in task focus between reading modes, we observed no significant differences in comprehension accuracy. Although no other studies to our knowledge have investigated the effect of reading mode on comprehension in college age students, the results are comparable to those of McCallum et al. (2004), who showed equivalent comprehension and recommended reading silently because it could be done more efficiently (i.e., students read faster silently) without sacrificing comprehension. The results are also consistent with those of Taub and Kline (1978), who found no differences in passage recall performance across silent-reading and reading-aloud conditions. An intriguing possibility raised by the present findings is that there may in fact be an overall comprehension advantage to reading aloud, since participants take more time with the text, but that this advantage is offset by higher rates of mind-wandering. Interestingly, even though one might suspect that comparable comprehension accuracy across reading modes might mean that mind-wandering is less damaging to text comprehension when reading aloud, the robust correlation between proportion of time off task and accuracy suggests otherwise.

Perhaps most intriguing is the finding of speech patterns associated with mind-wandering that are similar to those associated with poor comprehension. Although no differences in pitch were apparent (either mean or *SD*), differences emerged in both the overall mean and standard deviation of volume in terms of whether a participant reported mind-wandering. Consistent with previous work that has shown less variability in reading behavior when mind-wandering (Franklin et al., 2011; Reichle et al., 2010), the present findings suggest that mind-wandering attenuates the normal variation in a speaker's volume. Consequently, speakers who exhibited low variability in volume when reading a particular sentence were more likely to incorrectly answer a comprehension question corresponding to information within that sentence. Whereas lower volume levels while mind-wandering would be consistent with less energy being devoted to speaking, the results instead revealed an increase in volume when participants were mind-wandering. This increase in volume suggests a potential disruption in regulation—that is, a lack of focus on the material occupying the phonological loop that may hamper appropriate volume regulation. Such a monitoring impairment may be a consequence of the executive control failure associated with mind-wandering (McVay & Kane,

2010). These findings can also be explained by the perceptual-decoupling theory of mind-wandering. If, as is proposed in the decoupling theory, stimuli from the external environment are dampened (Smallwood, 2013), the increased volume associated with reading out loud while mind-wandering could be akin to speaking louder when wearing earplugs/headphones.

Together, these results document the existence of mind-wandering while reading aloud, showing that skilled adult readers actually mind-wander more when reading aloud than when reading silently. Additionally, these results reveal particular vocal parameters associated with mind-wandering while reading aloud: higher average volume with decreased variability. Given the prevalence of mind-wandering while reading and the resultant negative impact on comprehension, future work could focus on assessing individuals' speech patterns in real time in order to externally disrupt mind-wandering episodes. In principle, such feedback could lead to more effective reading, both aloud and silently. For example, training individuals to recognize incidences of mind-wandering while reading aloud may produce a transfer of the skill to silent reading.

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