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The motoric fluency effect on metamemory

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ABSTRACT

Predictions of future memory are often influenced by the ease or fluency of processing information. Susser and Mulligan (2015) recently demonstrated that motoric fluency (of writing with the dominant or non-dominant hand) may likewise affect these predictions. In the present study, we report five experiments that specify the locus of this motoric fluency effect. In Experiment 1, we examined whether the effect was driven by differences in effective study time across hand conditions. In Experiment 2, we assessed whether the effect could be obtained without any visual feedback from handwriting. In Experiments 3a and 3b, we investigated the contribution of visual feedback alone. In Experiment 4, we used prestudy JOLs to determine whether participants may develop a belief about handedness in the context of the experiment. Taken together, the results indicate that the motoric act of producing information in a fluent or disfluent manner is sufficient to produce an effect on memory predictions, that visual information from writing does not contribute, and that on-line interaction with the task plays a role. The experience of motoric fluency appears to be another cue that affects metamemory.

Introduction

Assessing how people monitor and predict their learning is a core component of metamemory, and identifying the cues that people use to make their predictions is a primary goal of this research. Recent research on metamemory has focused heavily on the extent to which people incorporate processing fluency (Alter & Oppenheimer, 2009) into their memory predictions. In particular, the ease of perceiving (e.g., Besken & Mulligan, 2014), retrieving (e.g., Benjamin, Bjork, & Schwartz, 1998), and encoding (e.g., Koriat & Ma'ayan, 2005) information have all been associated with greater memory confidence, even in cases where memory performance is not similarly affected (e.g., Benjamin et al., 1998; Besken & Mulligan, 2013, 2014).

Much of the research on fluency-based effects in metamemory has focused on perceptual or conceptual fluency upon initially encountering information. For example, Besken and Mulligan (2014) manipulated the perceptual fluency of auditory information by having participants hear either intact or degraded words over headphones. Participants heard a study word, said it out loud, and made a judgment of learning (JOL; a 0–100 confidence rating) regarding its likelihood of recall on a subsequent memory test. Participants were quicker to name the intact words and were also more confident in their ability to remember them, consistent with the notion that perceptual fluency affects metamemory. Actual recall performance, however, was greater for the more difficult-to-perceive degraded items. Other research has similarly assessed the role of fluency as study stimuli are first identified or processed (e.g., Benjamin et al., 1998; Besken & Mulligan, 2013; Undorf & Erdfelder, 2015).

After experiencing information, though, we frequently act on it. Research on fluency and metamemory largely focuses on variation in the internal processing of information, or what we might call cognitive fluency, but what of the fluency of motor response, or motoric fluency? Little research has examined the relation of physical or motor actions to metamemory, and still less the effect of the fluency of such actions. Alban and Kelley (2013), motivated by theories of embodied cognition, showed that variation in the physical weight of a held study object can influence JOLs. Although this study speaks to the role of physical actions in metamemory, it does not tap into any effect of fluency.

Susser and Mulligan (2015) more directly investigated motoric fluency by having participants read and copy down words on note cards. Participants wrote some of the words with their dominant hand and others with their non-dominant hand, and provided a JOL after each one. As expected, writing times were faster for words written with participants' dominant hand, validating the manipulation of motoric fluency. More critically, participants' JOLs were greater for words written with the dominant than

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non-dominant hand; however, actual memory performance was unaffected. An additional experiment using aggregate, list-end JOLs found the same pattern, while a separate questionnaire-based study revealed that participants did not have *a priori* beliefs about an effect of writing hand on memory. These results imply that the ease of motor processing affects metamemory, just as the ease of perceptual and cognitive processing does, but questions remain about how exactly this manipulation of motoric fluency produces its effects.

Recent research on perceptual and conceptual fluency has further explored the extent to which fluency effects in metamemory are actually due to their purported bases. For example, there is active debate about whether perceptual fluency effects are driven by the manipulation of perceptual processes (e.g., Mueller, Dunlosky, Tauber, & Rhodes, 2014; Susser, Jin, & Mulligan, 2016; cf. Rhodes & Castel, 2008). Indeed, a prerequisite for claiming a fluency-based locus necessitates that a manipulation has a measureable effect on perceptual processing. The font size of study words affects JOLs and was initially thought to do so through perceptual fluency (Rhodes & Castel, 2008). Subsequent research, however, indicated that font size did not actually influence processing measures (Mueller et al., 2014). In contrast, the manipulation of perceptual fluency used by Besken and Mulligan (2014) actually does affect the speed of perceptual identification.

Still, even demonstrating that a manipulation affects processing speed in the appropriate modality is insufficient to isolate the cause of the effect. A manipulation may have effects on multiple dimensions of processing and not just on the dimension of interest. As discussed below, in the case of writing hand, one needs to isolate the motor component from other correlated effects of the manipulation.

In a similar vein, research on metamemory often distinguishes between contributions of experience and beliefs to JOLs (e.g., Koriat, Bjork, Sheffer, & Bar, 2004). Experienced-based contributions reflect the subjective experience of interacting with materials, whereas beliefs refer to our theories about how memory operates (this distinction is similar to the non-analytic—analytic distinction, Matvey, Dunlosky, & Guttentag, 2001). Hypotheses about fluency and metamemory generally propose that the experience of fluent processing informs metamemory judgments directly (an experience-based or non-analytic contribution to JOLs). In contrast, it is also possible that the effect of a fluency manipulation might be based on a belief about memory (an analytic process), in which the individual expresses the belief that a certain class of items is, on average, more memorable than another class. Finally, it should be noted that belief-based contributions encompass *a priori* beliefs, in which the individual responds to metamemorial judgments with a preexisting belief about how memory operates, as well as beliefs that develop in the context of a set of memory judgments (e.g., in the context of an experiment on metamemory) (e.g., Mueller, Dunlosky, & Tauber, 2016). The latter case may seem to muddy the distinction between experiential and belief bases; these beliefs develop (or perhaps are triggered) through new experiences (e.g., with materials about which previously the individual had no beliefs). However, these on-line beliefs can be considered beliefs because, once developed, they are applied in a way that differentiates sets of items.

The issues relevant to other fluency effects also arise with respect to motoric fluency. It is certainly plausible that the effect of writing hand on JOLs represents an effect of motoric fluency. Supporting this idea, writing hand has a substantial effect on writing times. However, as with the case of manipulations of perceptual fluency, there are other plausible accounts. In the present study, the first several experiments assessed whether the motoric fluency effect is actually due to the motoric component of the manipulation or due to other factors implicated by this manipulation. The last experiment investigated the motoric fluency effect with respect to beliefs versus experience.

The results of Susser and Mulligan (2015) are certainly consistent with the idea that the motor component of the manipulation drives the effect in metamemory, but several alternative possibilities exist. The first has to do with the details of how the motoric fluency manipulation was implemented. Specifically, in Susser and Mulligan's experiments, the study-trial duration for each word was 13 s, which included the writing time (but not the JOL judgement). Therefore, participants had more time to study the word after writing in the dominant condition because these words were written much more quickly (in an average of 4.64 s compared to 7.82 s in the non-dominant condition). If participants were sensitive to the discrepancy in effective study time, they may have used this information in making their JOLs. In essence, the motoric fluency effect might be due to participants' beliefs about the effect of study time (see Koriat & Ma'ayan, 2005) rather than the effect of motoric fluency itself. To assess this possibility, Experiment 1 equated effective study time for all items by keeping post-writing times constant.

Another important issue arises from the research of Briñol and Petty (2003). These researchers documented an effect of handwriting (with the dominant or non-dominant hand) on affective judgements and suggested that the result might actually be due to the visual appearance of the writing as opposed to the feeling of motoric fluency or disfluency. In particular, writing with the non-dominant hand produces text that looks shaky and unclear, which may reduce confidence in that information. This idea represents a form of perceptual feedback that might account for the effect.

Based on this proposal, it is important to examine the potential role of perceptual (visual) feedback in the (purportedly) motoric fluency effect. We approached this goal from two directions. In Experiment 2, we examined whether the motoric fluency effect is obtained in the absence of visual feedback by having participants copy down words without being able to see any visual product. In other words, is the motoric component alone enough to inform JOLs? In Experiments 3a and 3b, we did the inverse: we examined whether presenting participants with the visual product of fluent or disfluent writing (by using the handwriting of other subjects) – without participants writing anything themselves – could produce the effect.

Finally, Experiment 4 assessed whether on-line beliefs contribute to this fluency effect. The results of the questionnaire study in Susser and Mulligan (2015) imply that the motoric fluency effect is not due to an *a priori* belief, but this does not rule out the possibility that participants develop a belief in the context of the experiment. As described in more detail later, Experiment 4 assessed this possibility using prestudy JOLs (e.g., Mueller, Tauber, & Dunlosky, 2013; Mueller et al., 2014).

Experiment 1

Experiment 1 examined whether differences in effective study time account for the effect of motoric fluency on JOLs by implementing a fixed 4 s of study time after participants copied down a word. If the effect really is due to motoric fluency, it should persist under these conditions; if the effect is due to differences in effective study time, the current implementation should eliminate it.

Method

Participants

Twenty-four undergraduate students from the University of North Carolina at Chapel Hill participated in exchange for course