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BRIEF REPORT

Task preparation as a mnemonic: The benefits of drawing (and not drawing)

Jeffrey D. Wammes[1] **· Brady R. T. Roberts**[1] **· Myra A. Fernandes**[1]

Abstract

Creating a visual representation of an item through drawing affords that item a substantive memory benefit, relative to several control tasks. Recent findings demonstrate the robustness of this drawing effect across several stimulus classes, irrespective of encoding time, setting, age group, or memory measure. The advantage for drawn information has been attributed to the integrated contributions of at least three components of visual production through drawing, which can independently facilitate memory: elaborative, motoric, and pictorial. In the current work, we investigated the importance of the elaborative process one must engage in while preparing to draw, and directly tested whether this generative period alone was sufficient to improve memory. Participants were prompted to either draw or write out presented words, and were provided with a 1- or 2-s preparatory period prior to completing the prompted task. Critically, on a subset of the trials, participants were prevented from completing the prompted task. There was strong evidence in support of better memory for drawn items, which replicates the drawing effect commonly observed in prior work. Interestingly, following prompts to draw, there was *also* a reliable memory benefit of the preparatory period alone. In other words, simply engaging in the elaborative process of *preparing* to draw (i.e., without completing the drawing) was enough to produce a reliable increase in later memory relative to *actually* writing.

Keywords Episodic memory · Recognition · Perceptual learning · Drawing

Drawing is an activity that serves not only as a creative outlet and artistic endeavor, but also as a communicative visual representation task, which can confer tangible benefits to one's memory performance. The advantages of drawing are robust to changes in encoding stimulus (Fernandes, Wammes, & Meade, 2018; Paivio & Csapo, 1973; Peynircioglu, 1989; Wammes, Meade, & Fernandes, 2016, 2017a, 2017b), task (Jonker, Wammes, & MacLeod, 2018; Wammes et al., 2016, 2017a, 2017b), and participant age (Meade, Wammes, & Fernandes, 2018. While the boundary conditions for the benefit remain unclear, drawing reliably improves memory for words, pictures, and educational materials (Wammes et al., 2016, 2017a, 2017b, respectively). In fact, the available evidence that has accrued suggests that, assuming one's drawing is semantically tied to the studied information (Meade, Wammes & Fernandes, in revision), and the time allotted for memory decisions is not severely limited (Wammes et al., 2017a), encoding through drawing will lead to substantial memory improvements.

Drawing improves memory in part because when one creates a visual depiction of an item, the trace that is encoded is rich in contextual information, forming an especially detailed memory (Wammes et al., 2017a) that is more readily retrievable. Moreover, subsequent work has suggested that this contextual information is likely distributed across three primary sources: the semantic or elaborative process one engages in when deciding how to depict a particular item, the manual motoric program required when putting pencil to paper to produce the image, and the visual inspection and analysis of one's developing work (Wammes, 2017; Wammes, Jonker & Fernandes, in revision). These sources of contextual information also happen to mirror the fundamental abilities proposed to underlie relatively error-free, skillful drawing (Cohen & Bennett, 1997, Kozbelt, Seidel, El Bassiouny, Mark, & Owen, 2010; Ostrofsky, Kozbelt, & Seidel, 2012). Each of our proposed components *should* provide a boost to memory on their own, if the amassed literature on the generation (Slamecka & Graf, 1978), enactment (Engelkamp &

✉ Jeffrey D. Wammes
jdwammes@gmail.com

[1] Department of Psychology, University of Waterloo, Waterloo, Ontario, Canada

Zimmer, 1984), and picture superiority effects (Rowe & Paivio, 1971) are any indication. While each component does not correspond precisely to the foregoing effects, the parallels between these studies and the proposed components are clear.

The question remains, however, why are the benefits of drawing (Wammes et al., 2016) so potent? While intuition would dictate that the pictorial aspect must be absolutely crucial, previous work has shown that drawing improves memory for images as well, which inherently contain pictorial information (Wammes et al., 2017a, in revision). Work in the broader memory literature, including our own, suggests that the contribution of the motoric system may also be critical (e.g., Backman & Nilsson, 1984, 1985; Backman, Nilsson, & Chalom 1986; Engelkamp, 2001; Engelkamp & Zimmer, 1984; Wammes et al., 2018). However, it would be difficult to design a task that isolates *only* the motor processes involved in creating a meaningful image, without also directly accessing that meaning! This idea is reinforced by the finding that the motor movement associated with doodling (c.f. unrelated drawing) in response to a stimulus is not sufficient to elicit a benefit (Meade et al., in revision).

Thus, the lone remaining component – elaboration – presents an alluring target for further study. Fortunately, previous work (Wammes et al., in revision) suggests that the elaborative processes involved in drawing are fundamental to the benefit it allows, at least to a greater extent than the pictorial information. Similarly, recent work indicates that skilled drawing ability might also be rooted in the internal generation of what the artist *intends* to draw (Kozbelt et al., 2010; Ostrofsky et al., 2012). This brings up a fascinating possibility: Could one attain a mnemonic benefit from 'drawing' without lifting their pencil? Is it possible that internally elaborating upon what one intends to draw would be sufficient to obtain a memorial benefit?

In the current work, we aimed to determine the importance of elaboration in driving the benefit that the act of drawing later affords memory. There are certainly a multitude of ways to promote deep, semantic processing in general; our target here, however, was elaborative thought of a very specific sort – the sort required in planning how one will depict an item through drawing. In our experiments, we asked two independent samples of participants to draw pictures of, or repeatedly (to match active encoding time) write out to-be-remembered words. On each trial, they were given a preparatory period of either 1 or 2 s, during which they had already seen the word, but were unable to act. Half of the trials then proceeded as normal, and the participant was able to implement their drawing (or writing). On the other half, however, the next item appeared immediately following the preparatory period, preventing the drawing or writing from being completed. We predicted, given previous findings highlighting the importance of the elaborative process in precipitating the drawing effect, that participants would show a memory boost, even without actually drawing! That is, we anticipated that this preparatory period for drawing would be enough to drive participants' performance higher than a period of equivalent length for writing.

Method

Participants

Power analysis using the smallest effect size from our previous word recognition studies (1.15; Wammes et al., 2017a, Experiment 1) indicated that 14 participants would be sufficient for 0.95 power to detect an effect of drawing relative to writing. However, we opted to collect two independent samples of 24 participants (0.9997 power) to be certain we had sufficient power. Participants who scored below 0.20 accuracy (near chance) were removed from all analyses, and their data were replaced with new participants (*n* = 3). This step was taken to reduce noise by removing data that were very likely to occur as a result of random responding, though the effects are identical (albeit smaller, due to noise) with these participants included.[1] Sample A consisted of 24 participants (19 female), ranging in age from 19 to 25 years (*M* = 20.88, *SD* = 1.67). Sample B consisted of 24 participants (19 female), ranging in age from 19 to 23 years (*M* = 20.92, *SD* = 1.23).

Materials

Target and lure words were taken from a larger set of 154 words – the verbal labels of Snodgrass images (see Appendix A; Snodgrass & Vanderwart, 1980; length: *M* = 5.64, *SD* = 1.80, frequency: *M* = 5.64, *SD* = 1.80). For each participant, 20 words were assigned at random to each trial type (80 total targets), and an additional 50 words were assigned to be lures.

Procedure

Participants were seated in front of a laptop/tablet (Toshiba Portege M750, 12.6-in. touchscreen). The computer was set into tablet mode, such that it was sitting flat on the

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[1] It is more typical to remove participants with accuracy lower than 0. However, very low positive accuracies are also rather likely to occur by chance. We selected 0.2 as a cut-off because there is only approximately a 1% chance that someone responding totally at random on our task could achieve accuracy above this threshold, based on simulated data. The participants removed due to this criterion had accuracies of -0.09, 0.03, and 0.04, all of which were more than 2.5 *SD* below the grand mean. A mixed-measures ANOVA was conducted using the whole sample, without outliers removed. Results were identical to those reported in the main text, revealing a main effect of Prompt (Draw > Write), $F(1, 49) = 117.77$, $MSE = .02$, $p < .001$, $\eta_p^2 = .71$, and of Condition (Complete > Prepare), $F(1, 46) = 44.51$, $MSE = .02$, $p < .001$, $\eta_p^2 = .48$. All other main effects and interactions were again not statistically significant, *ps* > .29.

workstation, akin to drawing on a sheet of paper. The researcher read the instructions to the participant, who followed along and tapped the screen with a stylus to advance. Participants saw a prompt word ('draw' or 'write') for 750 ms, a fixation for 500 ms, and then were presented with a target word for 750 ms. Following this, a line of six number signs (######) was presented for either 2 s (Sample A) or 1 s (Sample B). Eighty total word stimuli were presented. Half (40 words) followed the draw prompt, and half (40) the write prompt. In half of the trials within each prompt (20 words), when the number signs disappeared, participants performed the task (either 'draw' the item, or 'write' it out repeatedly), as indicated by the prompt for 15 s. In the other half (20), the program would simply advance immediately to the next item. Thus our design was a 2 x 2 x 2 mixed-design ANOVA, with Sample (A or B) as a between-subjects variable, and Prompt (Draw or Write) and Condition (Prepare or Complete) as within-subjects variables. Following the encoding phase, the computer was reoriented into laptop mode so that the keys were accessible for memory responses.

After a brief delay in which participants completed a 2-min irrelevant tone classification task (to ensure retrieval would be from long-term memory), they completed a recognition task, where all 80 studied words were presented in a mixed list with 50 lures. We selected recognition rather than recall, for instance, in an effort to sample prior experience more exhaustively. That is, we wanted to measure memory of varying strength, not *just* the strong recollective experiences known to drive performance in free recall (e.g., Yonelinas, 2002). While we were not particularly interested in differentiating recollection from familiarity, or otherwise teasing apart differences in memory strength in this particular experiment, we have given this distinction thorough investigation in prior work (Wammes et al., 2017a). Participants were instructed to press 1 if the word was old (i.e., they viewed it during the study phase) or 0 if the word was new. Words were then presented one at a time in the center of the screen, and participants had 2.5 s to respond to each. The response options were on-screen ("Old (1) New (0)") throughout the recognition task. If participants did not respond to a given trial in time, they heard a short auditory tone to alert them that they did not effectively submit a response and the next trial was displayed.

Results

Use of encoding time

As a manipulation check, we collected information at every screen refresh as to whether the stylus was on screen, and if so, to document its location. To determine whether or not participants were compliant (i.e., actually doing the task for the time allotted), we report two different measures. The first is a measure of the proportion of time in a trial that the stylus was pressed to the screen, which we will refer to as time with stylus pressed (TSP). Because participants should still be considered on task even while lifting the stylus between subsequent strokes, we also document the last time in a trial when the stylus was lifted from the screen, to determine whether or not participants were finishing early, and loafing for the remainder of the trial. This will be hereafter referred to as last lift (LL). In general, participants' TSP was about half of the total trial time (draw: $M = 0.45$, $SD = 0.08$; write: $M = 0.56$, $SD = 0.10$),[2] and participants' LL was near the end of the trial (draw: $M = 14.22$ s, $SD = 2.04$; write: $M = 14.54$ s, $SD = 1.67$), indicating that participants were compliant with the instructions. See Appendix B for example time courses from participants who ranked low, medium, and high in compliance.

Recognition accuracy

A mixed-measures ANOVA on accuracy data (hit rate minus false alarm rate) revealed a main effect of Prompt (Draw > Write), $F(1, 46) = 136.74$, $MSE = .02$, $p < .001$, $\eta_p^2 = .75$, and of Condition (Complete > Prepare), $F(1, 46) = 47.64$, $MSE = .02$, $p < .001$, $\eta_p^2 = .51$ (see Fig. 1). All other main effects and interactions were not statistically significant, *p*s > .42. Hit rate followed a pattern identical to the accuracy analyses (Table 1). There was no difference in the false-alarm rates between Sample A and Sample B, $t(46) = 0.70$, $SE = .03$, $d = 0.20$, $p = .490$ (Table 1).

Recognition response time

A mixed-measures ANOVA on Response Time revealed a main effect of Prompt, $F(1, 46) = 5.94$, $MSE = 9327.86$, $p = .019$, $\eta_p^2 = .11$, and of Condition, $F(1, 46) = 5.79$, $MSE = 10533.58$, $p = .020$, $\eta_p^2 = .11$, such that participants were slower to respond to items following a Write Prompt, and items in the Prepare Condition. The Trial Type X Sample, $F(1, 46) = 2.53$, $MSE = 9327.86$, $p = .118$, $\eta_p^2 = .05$, Condition X Sample, $F(1, 46) = 3.03$, $MSE = 10533.58$, $p = .088$, $\eta_p^2 = .06$, Trial Type X Condition, $F(1, 46) = 1.16$, $MSE = 11367.22$, $p = .287$, $\eta_p^2 = .03$, and Prompt X Condition X Sample, $F(1, 46) = 3.08$, $MSE = 11367.22$, $p = .086$, $\eta_p^2 = .06$, interactions were not significant (see Table 1).

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[2] TSP was greater in the write than the draw Trial Type, $F(1, 46) = 61.11$, $MSE = .01$, $p < .001$, $\eta_p^2 = .57$, but there was no main effect or interaction with Sample, *p*s > 0.22. The difference in LL was not significant across trial type, $F(1, 46) = 3.16$, $MSE = .76$, $p = .082$, $\eta_p^2 = .06$, and there was no effect of or interaction with Sample, *p*s > .58. Because there were differences between Trial Type in one measure, we tested whether TSP was associated with later memory performance in any way. Within each condition, there was no difference in TSP between items that later became hits, relative to misses, *p*s > 0.34. Moreover, there was no relation between TSP and later memory accuracy, either overall, $r(49) = 0.09$, $p = .521$, in either condition (draw: $r(49) = 0.23$, $p = .108$; write: $r(49) = -0.03$, $p = .831$), or comparing the difference scores between draw and write in the two measures, $r(49) = -0.07$, $p = .631$. In other words, TSP had no bearing on memory performance.

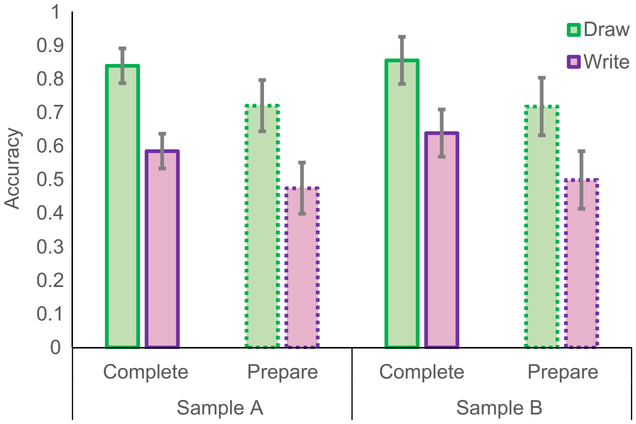

Fig. 1 Recognition accuracy (hit rate minus false alarm rate) across Draw and Write prompts and Complete and Prepare conditions, in both Sample A (2-s preparatory period) and Sample B (1-s preparatory period). Error bars are 95% confidence intervals

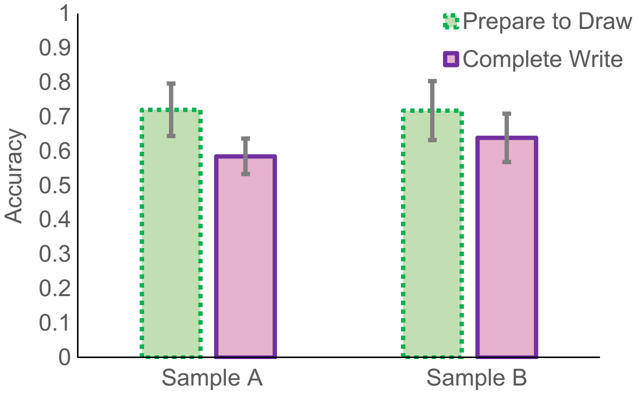

Fig. 2 Recognition accuracy (hit rate minus false alarm rate) in the Prepare to Draw, and the Complete Write prompt/condition pairings, in both Sample A (2-s preparatory period) and Sample B (1-s preparatory period). Error bars represent 95% confidence intervals

Benefits of a preparatory drawing period

It is clear from the above analyses that actually completing each encoding task leads to a benefit relative to preparing to do it, and that drawing is better than writing within each sample and condition. Perhaps most interestingly though, visual analysis of the figure seems to indicate that preparing to draw led to superior memory than *actually* writing an item across a 15-s period. We explored this possibility using targeted paired-samples t-tests. Preparing to draw led to better memory than actually writing in both Sample A, $t\,(23) = 3.72$, $SE = .04$, $d = 0.79$, $p < .001$, and Sample B, $t\,(23) = 3.00$, $SE = .03$, $d = 0.62$, $p = .004$ (see Fig. 2).

Discussion

The pattern of data in this work clearly replicated the previously observed beneficial effects of drawing on memory (Jonker et al., 2018; Meade et al., 2018; in revision, Paivio & Csapo, 1973; Peynircioglu, 1989; Van Meter & Garner, 2005; Wammes et al., 2016, 2017a, 2017b, in revision). That is, studied items that were drawn during encoding were much more memorable than those that were written. Participants were also provided with an extremely brief preparatory period between viewing the studied word, and the onset of task completion. Notably, across two independent samples, this preparatory period alone led to improved memory when it occurred following a draw, relative to a write prompt. In other words, preparing to draw benefited memory relative to preparing to write. This finding is analogous to studies of the enactment effect, which demonstrate that planning to enact without actually performing the action benefits memory (e.g., Koriat, Ben-Zur & Nussbaum, 1990; Zimmer & Engelkamp, 1984). Moreover, simply preparing to draw provided a memory boost above *actually* writing. Just 1 or 2 s of the elaborative processes associated with building up to creating a drawing was superior to nearly 15 s of actually engaging in writing. Indeed, this benefit of preparing to draw amounted to an approximate increase of 0.107 in accuracy over actually writing, while drawing itself was worth a more substantial 0.235 boost in accuracy over writing. This indicates that almost half of the benefit gained from drawing for nearly 15 s can be attained by simply elaborating upon the material and planning what to draw.

Previous work had suggested that the mechanistic underpinnings of the beneficial effect of drawing might be at least

Table 1 Response time to correct recognition decisions (ms) and hit rate and false-alarm rate for each sample across both draw and write prompts and both prepare and complete conditions (95% confidence intervals in parentheses)

Measure and sample	Draw		Write		Lure
	Complete	Prepare	Complete	Prepare	
Response Time					
A	844.57 (36.27)	898.03 (57.45)	899.97 (55.04)	866.21 (65.71)	-
B	842.41 (54.68)	893.41 (72.81)	888.15 (63.22)	959.98 (63.78)	-
Hits, False Alarms					
A	.92 (.03)	.80 (.08)	.67 (.06)	.56 (.08)	.08 (.03)
B	.95 (.02)	.82 (.05)	.74 (.07)	.60 (.09)	.10 (.04)

two codes (dual-coding; see Paivio & Csapo, 1973), but more than likely multiple codes, components, or sources of contextual information, which can facilitate retrieval of a multimodal trace (Wammes et al., 2017a, in revision; c.f. Engelkamp, 2001 for a similar conceptualization of the enactment effect). That is, it has been suggested that engaging in drawing provides contextual information from the elaborative process of deciding how to depict a particular item, from the motoric process of implementing that drawing, and from the pictorial processing of the image that is created. In a study that systematically dissociated the proposed components of drawing, the contribution of the more 'active' motor and elaborative components was determined to be substantially greater than that of the pictorial component (Wammes et al., in revision). The current work honed in on the possible benefits of the elaborative component by using task demands to isolate this process from the remainder of the act of drawing. Our results here reinforce the idea that elaborating upon a given item, and deciding how to draw it, is paramount in driving the benefits of drawing (Kozbelt et al., 2010; Ostrofsky et al., 2012; Wammes et al., in revision; c.f. generative drawing principle, Schwamborn, Mayer, Thillmann, Leopold, & Leutner, 2010; Schwamborn, Thillmann, Opfermann, & Leutner, 2011; generative theory of drawing construction, Van Meter & Garner, 2005).

There are some limitations to this work, which are important to address. Specifically, it is difficult to objectively verify what participants are actually doing, or what mental operations they are performing internally during the provided preparatory period. That is, we cannot state with certainty whether they are elaborating and creating a concept of what they will draw, as this is near impossible to ascertain behaviorally. Indeed, it could be the case that they were using this time to rehearse previous words, or to take a break, or engage in task-unrelated thought. If this were the case though, one might expect that following a trial in the prepare condition, participants might spend subsequent trials in the complete condition, at least in part, rehearsing the preceding prepare item. The available evidence suggests that this is not the case, as complete draw or write trials following prepare trials were not forgotten more than those following complete trials, $t(47) = 1.55$, $SE = .02$, $d = 0.23$, $p = .128$. In fact, the pattern of results trends numerically in the *opposite* direction. Additionally, we contend that simply demonstrating a benefit of the pre-draw preparatory period, as we reported here, is compelling enough evidence that participants are engaging in elaborative thought during this time.

Still, it could be the case that participants learned, through the course of the experiment, that items tied to draw prompts were more important, and thus the contents of the prompt alone became a cue for them to preferentially focus on a particular task or word. In an additional analysis though, whether items were encoded in the first half or the second half *did not* interact with condition (Prepare, Complete), and there was no three-way interaction ($ps > 0.52$). Moreover, when only the *first* preparatory items encountered were isolated, 87.2% of participants correctly recognized the first 'Prepare to Draw' item, while only 74.5% correctly recognized the first 'Prepare to Write' item (relative to 68% on average for all other 'Prepare' items). The significance of these percentages is that before it was possible to deduce the nature of our manipulation, participants still were more likely to identify a prepared drawn than a prepared written item on a later test. Accordingly, the evidence indicates that participants did not develop a different strategy over time to preferentially focus on any item associated with a draw prompt.

Last, it is important to indicate that in this particular experiment, we only measured the beneficial effects of preparing to draw, relative to writing, in a recognition memory test for printed words. Admittedly, it is not certain that similar effects would manifest using other stimulus sets, test types, or comparison trial types. For example, it could be the case that preparing to draw simply benefited memory because engaging in any deep semantic processing (whether it be preparing to draw, or a pleasantness judgment; Craik & Lockhart, 1972; Walsh & Jenkins, 1973) would improve memory. In our prior work however, we demonstrated that actually drawing to-be-remembered information improved memory relative to a deep LoP manipulation (Meade et al., 2018; Wammes et al., 2016), and that limiting the elaborative aspects of drawing by asking participants to trace existing images still provided a substantial benefit (Wammes et al., 2018). For this reason, we do not believe that the beneficial effects of drawing are wholly explainable by deep LoP. Similarly, while we only employed one type of stimulus and memory assessment in this particular experiment, our prior work indicates that the memory benefits of drawing are robust across many stimulus types (Wammes et al., 2016, 2017a, 2017b, in revision), assessment methods (Jonker et al., 2018; Wammes et al., 2017a, 2017b), comparison trial types (Wammes et al., 2016, in revision), and populations (Meade et al., 2018). Accordingly, the available evidence suggests that the effects of preparing to draw will be quite general as well, though future work will be needed to verify this.

The finding that a preparatory period alone improves recognition accuracy bolsters the applicability and generality of this drawing effect substantially. Drawing is not always possible in all circumstances. It might be the case that one does not have a pencil or paper with them, a hard surface available on which to draw, or, more practically, does not have the time or inclination to either retrieve the implements required from their bag or drawer, or to engage in drawing behavior with sufficient rigor. Our previous work showed that given as little as 4 s to draw some to-be-remembered information, which is far from enough time to produce a detailed or quality drawing, participants still gained a benefit from drawing (Wammes et al., 2016). The current findings extend the practicality of this work even further and indicate that simply taking a brief time period to ponder what one might draw if given the opportunity, is not only feasible, but also reliably improves memory.

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Appendix A Word List

Table 2

airplane
ant
antlers
axe
balloon
banana
basket
bee
beetle
blouse
boot
broom
butterfly
camel
cannon
carrot
cat
caterpillar
cherry
clock
coat
corn
couch
cow
desk
doll
door
drum
duck
ear
elephant
flute
fork
frog
giraffe
glove
gorilla
grapes
guitar
hammer
harp
kettle
kite
knife
ladder
lamp
lemon
lion
lips
monkey
mushroom
nurse
owl
pants
peanut
pear
penguin
pepper
pig
pineapple
pumpkin
rabbit
rooster
ruler
sailboat
scissors
screwdriver
sheep
shoe
skirt
spider
spoon
stool
stove
strawberry
sweater
toaster
trumpet
turtle
violin
wagon
whistle
baby
backpack
bag
bandaid
banjo
bathtub
beard
belt
bench
bird
bone
bottle
box
cactus
canoe
car
castle
chain
cheese
comb
crab
crackers
curtains
fan
feather
fire
firetruck
fish
ghost
globe
hamburger
helmet
knot
leaf
lizard
llama
magnet
mailbox
mouse
octopus
panda
peas
pillar
pizza
purse
puzzle
rainbow
robot
rocket
rose
shark
shell
shovel
skateboard
slide
snail
squirrel
submarine
tank
teapot
teepee
telescope
tie
tiger
toilet
unicycle
whale
wheat
wheelbarrow
wheelchair
wolf
zebra

Appendix B Example Encoding Time Courses

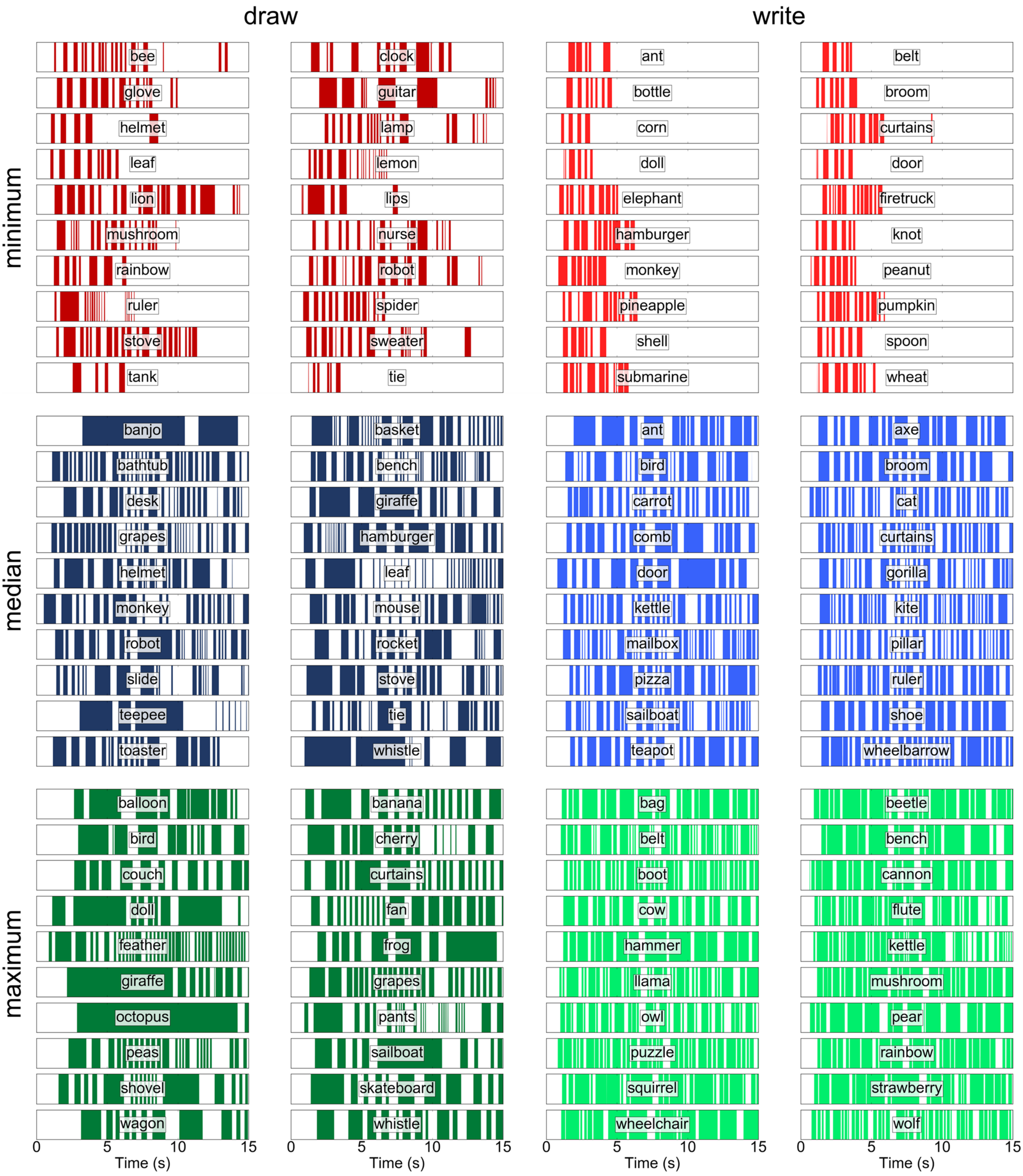

Fig. 3 A composite score was created by standardizing both last lift (LL) and time with the stylus pressed (TSP), then averaging them. In this figure, the time courses of all draw (left) and write (right) trials for the minimum scoring participant (red), the median scoring participant (blue), and the maximum scoring participant (green) on this composite score are displayed. Time (in seconds) is depicted on the x axis, and the shaded areas represent periods of time during which the stylus was pressed to the screen. As can be seen, the median participant more closely resembles the maximum participant, and the minimum participant was not indicative of the broader sample

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