

The Spontaneous Prioritization of “Unfinishedness” in Perception: A Visual Zeigarnik Effect

Joan Danielle K. Ongchoco^{1, 2}, Kimberly W. Wong^{2, 3}, and Brian J. Scholl^{2, 4}

¹ Department of Psychology, The University of British Columbia

² Department of Psychology, Yale University

³ Department of Psychology, Williams College

⁴ Wu Tsai Institute, Yale University

The events that occupy our thoughts in an especially persistent way are often those that are unfinished—from half-written papers to unfolded laundry. These events seem to also be privileged in memory, as in the “Zeigarnik effect”: When people carry out various tasks, but some are never finished due to extrinsic interruptions, memory tends to be better for those tasks that were unfinished. But just how foundational is this sort of “unfinishedness” in mental life? The Zeigarnik effect is often explained by appeal to the salience of goals or the weight of obligation, but might unfinishedness also be spontaneously prioritized even in visual processing— independent of these high-level social/motivational factors? Across four experiments ($N = 120$), observers viewed paths that gradually unfolded through mazes, from a start point to an end point. Probes briefly appeared along the path, and observers later simply reproduced their positions. Critically, each path either reached its end point or stopped shortly before—remaining visually unfinished. Although this manipulation was entirely task-irrelevant, it greatly influenced performance—with more precise reproductions on unfinished trials. This same pattern held across multiple experiments, even while carefully controlling for various lower level visual properties, and it generalized across different types of displays. This new *visual Zeigarnik effect* shows how vision extracts an unexpectedly rich property that is usually associated with higher level thought, and how the unfinishedness of events is privileged in the mind at a deep level.

Public Significance Statement

Those parts of life that most occupy our thoughts are often those that are (or seem) unfinished. The partly composed letter, the half-completed crossword puzzle, and the interrupted dinner preparation are events that seem to stick in our minds, much more so than events that are either completed or unstarted. This phenomenon—called the “Zeigarnik effect” in psychological research—is often described in terms of explicit tasks or commitments. But here we showed that it is more foundational in the mind, occurring even when we are passively watching unfinishedness in the context of simple visual displays. Observers watched shapes follow motion paths that either reached a landmark or stopped short, and their memory for the details of those paths was far better for the unfinished ones while carefully controlling for properties such as elapsed time and distance. This new effect might help explain the mental prominence of unfinishedness.

Keywords: event perception, unfinishedness, visual working memory, Zeigarnik effect

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Joan Danielle K. Ongchoco  <https://orcid.org/0000-0001-5839-651X>

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Correspondence concerning this article should be addressed to Joan Danielle K. Ongchoco, Department of Psychology, The University of British Columbia, 2136 West Mall, Vancouver, BC V6T 1Z4, Canada. Email: joan.ongchoco@psych.ubc.ca

For many of us, few things are more satisfying than finishing tasks. (At least one of the authors will admit to retrospectively adding already-completed items to their to-do list so as not to lose the satisfaction of crossing them out.) The flip side of this is that unfinished tasks are often especially salient—as in half-written papers, half-completed crossword puzzles, or interrupted dinner preparations. These items tend to preoccupy our thoughts in a persistent (sometimes even frustrating) way, which seems specific to unfinishedness: the not-yet-started puzzle (or dinner) seems of little concern, and the completed puzzle/dinner is often already on its way to being forgotten—but when half-completed, the same tasks become especially mentally prominent.

This phenomenon was first explored empirically in the 1930s, in the Zeigarnik effect (Zeigarnik, 1938). Subjects were instructed to complete various tasks but were interrupted by an experimenter and kept from completing some of them. Afterward, subjects were asked to recall as many tasks as they could, and those left unfinished were more likely to be remembered. This was attributed to a “state of tension” (p. 300) that arises when an interruption keeps us from finishing tasks (see also Baddeley, 1963; for a contemporary review, see MacLeod, 2020). And this state of tension has far-reaching consequences: Unfinished tasks reduce cognitive flexibility (Freeman & Muraven, 2010), impair sleep (Syrek & Antoni, 2014), and reduce competence

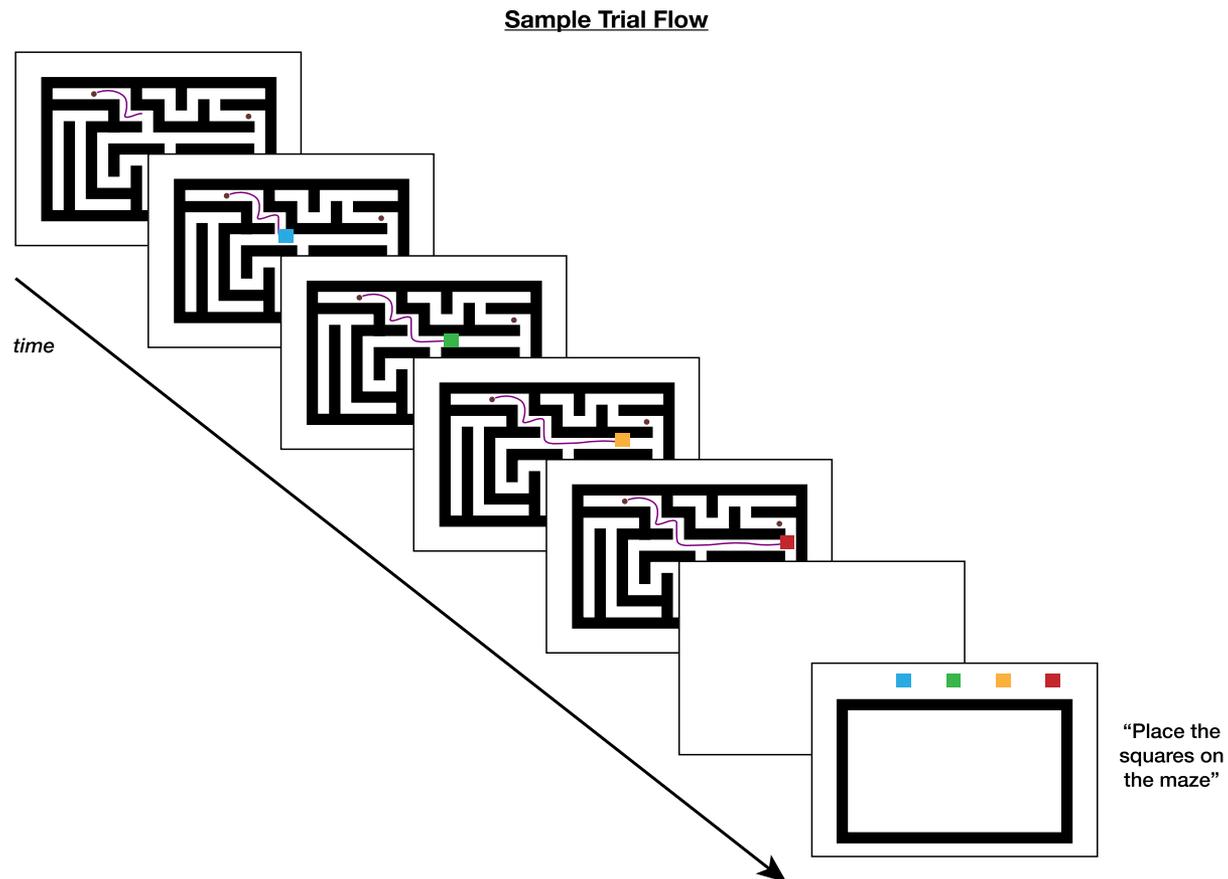
and work satisfaction (Weigelt et al., 2019). More generally, this property of unfinishedness may be one of the origins of ruminative thought (e.g., Gold & Wegner, 1995; Watkins, 2008).

Explanations for the Zeigarnik effect and its consequences are varied, but what perhaps unites them is a focus on high-level social motivations. People intrinsically value tasks that are nearly complete or able to be completed (Converse et al., 2023; Ruan et al., 2024). Such effects may depend on goal salience (Eitam et al., 2013; Ferguson & Cone, 2013) and may vary as a function of motivation (Atkinson, 1953), personality (Di Paula & Campbell, 2002; Martin & Davidson, 1964), and fear of failure (Moot et al., 1988). Here, by contrast, we explore a very different sort of explanation, based on a much lower level form of unfinishedness.

The Present Study: Perceiving Visual “Unfinishedness”?

Observers in the present study merely watched animations of simple shapes (as depicted in Figure 1). On each trial, they viewed a path that gradually unfolded through a 2D maze, in the form of either a simple line or a dot that moved from a salient start point to an end point (depicted by the small discs in Figure 1). As the path unfolded, probes (depicted by the colored squares in Figure 1) appeared at haphazard times, and observers later simply reproduced the probes’

Figure 1
Caricature of a Trial From Experiments 1 and 2



Note. Observers viewed a path gradually unfolding between a start point and an end point. Probes appeared along the path at haphazard times, and afterward, observers simply reproduced the probes’ positions. See the online article for the color version of this figure.

positions. The key manipulation was that the unfolding path sometimes reached its end point (e.g., Figure 2A) or sometimes stopped shortly before this point (e.g., Figure 2B and 2C). Animations of these conditions are available online as Supporting Information (Supplemental Animations S1–S5) or at <https://perception.yale.edu/unfinishedness/>.

This experimental design and its associated theoretical questions differ from past research on the Zeigarnik effect, in at least five related ways: First, and perhaps most obviously, these studies test a simple and novel form of visual unfinishedness rather than involving rich and semantically-laden tasks and obligations. (A sense of unfinishedness in the present study cannot be driven by a fear of failure or motivation to succeed.) Second, observers viewed the unfinishedness passively in the third person, rather than being directly involved in it themselves. Third, the unfinishedness in these displays was entirely task-irrelevant, whereas in past work it centrally involved subjects' tasks. Fourth, we tested the resulting implications for the memory of surrounding visuospatial elements (i.e., the probe locations rather than the path), whereas past work only ever tested memory for the elements (i.e., the tasks) that could themselves be unfinished. Fifth, as explored in the General Discussion section, this design allows us for the first time to distinguish unfinishedness from related notions such as expectations and pattern completion.

In summary, observers in the present study experienced unfinishedness that was visual (rather than cognitive), passive (rather than active), and spontaneous (rather than task-relevant). Would this

still yield a type of visual Zeigarnik effect? We tested this in a series of four experiments. We first tested gradually unfolding paths while controlling for lower level properties of speed (Experiment 1), as well as path lengths and durations (Experiment 2). We then generalized these effects beyond fully visible paths (as shown in Figure 1) by studying dots which moved through mazes without leaving traces (Experiment 3). Finally, we tested whether the Zeigarnik effect truly represented a memory benefit for unfinishedness rather than a cost for completion (Experiment 4). We close by emphasizing the importance of these results for characterizations of both the Zeigarnik effect and the nature of perception itself.

Experiment 1: A Visual Zeigarnik Effect?

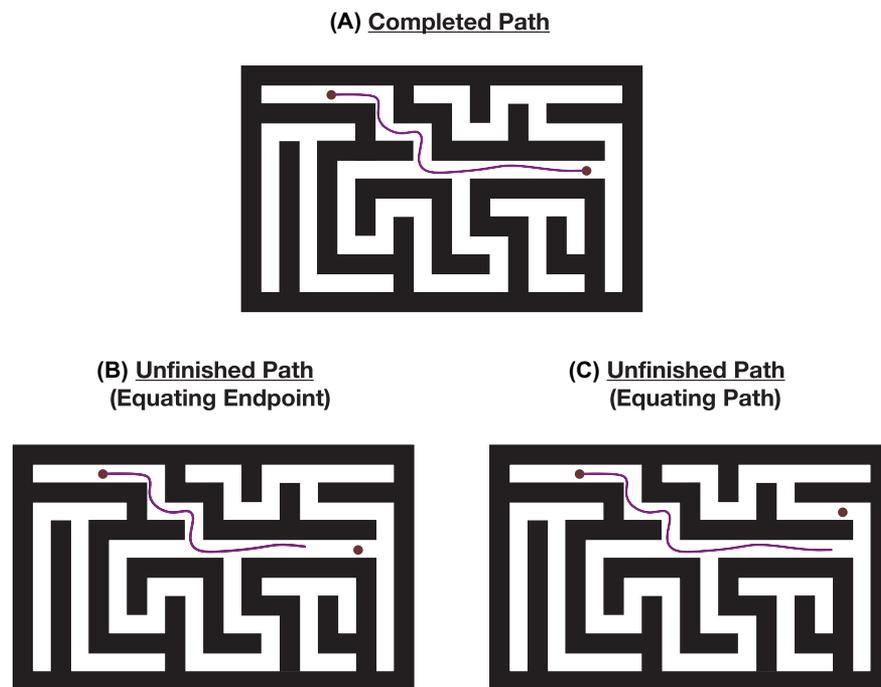
We first explored the possibility of a visual Zeigarnik effect using paths that gradually unfolded in mazes while remaining fully visible (Supplemental Animations S1 and S2).

Method

Participants

Thirty observers ($M_{\text{age}} = 19.06$ years; 22 females, eight males) from the Yale and New Haven communities participated in exchange for credit or monetary payment. This sample size was determined before data collection began (based on a power analysis run on an

Figure 2
Sample Mazes and Paths



Note. Sample mazes and (A) a sample complete path, (B) a sample unfinished path (with the same endpoint as the complete path), and (C) another sample unfinished path (now with a different end point, but with the same path length and duration as the complete path). See the online article for the color version of this figure.

average effect size of Cohen's $d = .58$ from pilot experiments) and was then fixed to be identical across the four experiments reported here. All experimental methods and procedures were approved by Yale University's Institutional Review Board, and all observers confirmed that they had read and understood a consent form outlining their risks, benefits, compensation, and confidentiality and that they agreed to participate in the experiment.

Apparatus

After agreeing to participate, observers were redirected to a website wherein stimulus presentation and data collection were controlled via custom software written using a combination of HTML, CSS, JavaScript, PHP, and jsPsych libraries (de Leeuw et al., 2023). Observers completed the experiment in full-screen mode on a Dell 2208WFPT monitor with a 60-Hz refresh rate, with the functional part of the display subtending $43^\circ \times 28^\circ$.

Stimuli

Twelve mazes were generated via custom Python code from a 21×13 grid (collectively $20.77^\circ \times 12.57^\circ$), with each grid square being $1.00^\circ \times 0.94^\circ$. Each maze appeared randomly in one of four positions (with its upper right corner independently either 15% or 30% of the browser's width and height). Some grid squares were colored white to form the "passages," while others were colored black to form "walls." Walls were continuous such that all black grid squares were connected, with the squares on the grid's perimeter all colored black as a maze "border." As depicted in Figure 2, this yielded a mazelike stimulus, but without an entrance or exit. For each maze, two brown discs (a start point and an end point) were arbitrarily placed within the passages. Unfolding paths were animated via a sequence of 0.13° points (HTML color code purple) that appeared in the passages (in a persistent manner, to effectively leave a visible path trace, as depicted by the purple lines in Figures 1 and 2). Paths unfolded at a constant speed of $1.48^\circ/\text{s}$, for a total duration between 8 s and 12 s. Complete paths (as depicted in Figure 2A, e.g., Supplemental Animation S1) began at the start point and ended at the end point. Unfinished paths (as depicted in Figure 2B, e.g., Supplemental Animation S2) ended on average 2.43° (or 1,640 ms) before the path would have reached the end point. As a path unfolded, a sequence of four colored (HTML color codes blue, orange, sienna, and green) square (0.67°) probes flashed, each at the current leading edge of the path itself. Each probe appeared for 800 ms, and the probes appeared respectively when the path was 20%, 40%, 60%, and 80% of its eventual maximal duration (with the actual values randomly jittered between -8% and 8%). As such, the interprobe latency (from the offset of one to the onset of the next) was approximately 1,140 ms.

Procedure and Design

Each trial began with the presentation of a maze, through which its path immediately began gradually unfolding, after which the final tableau remained visible for 250 ms. After a 500-ms blank delay, an empty rectangular frame (the maze's black border) appeared in one of the other three possible maze locations, with the four probes again displayed simultaneously at its top border. Observers then simply dragged-and-dropped each probe to the location where they remembered it originally appearing during that trial (with its border appearing

in red while actively selected). Probes could be repositioned as often as desired. Observers then pressed a key to record their final responses, after which there was a 500-ms delay before the next trial began. A caricature of this procedure is depicted in Figure 1.

Observers completed one practice trial (the results of which were not recorded), followed by 10 experimental trials (2 animation conditions [complete vs. unfinished] \times 5 repetitions, with trials presented in a different random order for each observer and with the particular mazes corresponding to complete vs. unfinished animations counterbalanced across observers).

Exclusions

Per the preregistered criteria, we excluded observers (with replacement) whose total experiment completion time was greater than 2 standard deviations from the grand mean ($n = 0$). Individual trials were also excluded in which either (a) the overall error was greater than 2.5 standard deviations from the grand population mean ($M = 0.23$, $SD = 0.50$) or (b) response times were greater than 2.5 standard deviations from the grand population mean ($M = 0.23$, $SD = 0.62$).

Results

Probe localization errors (measured as the Euclidean distance between the actual and reported positions) were smaller for unfinished versus complete animations, 57.55 px versus 64.22 px; $t(29) = 2.38$, $p = .024$, $d = 0.43$, 95% CI [0.94, 12.40]. This pattern also held for each of the four individual probes independently—and this was true for each of the relevant experiments reported here (with the full breakdown detailed in the Supplemental Data File).

Experiment 2: Controlling Path Length and Duration

In Experiment 1, the paths unfolded at a constant speed across complete and unfinished animations—and so path lengths and durations were always shorter for unfinished (vs. complete) animations. To ensure that this could not explain the results, we replicated Experiment 1 while manipulating the end point positions such that unfinished and complete animations were equated for path length and duration.

Method

This experiment was identical to Experiment 1 except as noted. Thirty new observers ($M_{\text{age}} = 20.80$ years; 22 females, eight males) participated (with this sample size chosen to exactly match that of Experiment 1). To equate path lengths across unfinished and complete trials, the end point appeared either at its same location from Experiment 1 (at the very end of the path, for complete animations, as depicted in Figure 2A) or at a further distance along the maze passages (for unfinished animations, as depicted in Figure 2C). These actual displacements averaged 2.45° , and the actual linear interdisc distances ("as the crow flies," ignoring the maze walls) were always equated between the corresponding complete and unfinished versions of the same maze. The details of these displacements also allowed us to equate the total path duration across unfinished and complete animations (8 s). As a result, the path speed—which was held constant across conditions in Experiment 1—now varied from

1.45°/s to 2.00°/s. Per the preregistered criteria, we excluded observers (with replacement) whose total experiment completion time was greater than 2 standard deviations from the grand mean ($n = 1$). Individual trials were also excluded in which either (a) the overall error was greater than 2.5 standard deviations from the grand population mean ($M = 0.30$, $SD = 0.70$) or (b) response times were greater than 2.5 standard deviations from the grand population mean ($M = 0.23$, $SD = 0.57$).

Results

Probe localization errors were again smaller for unfinished versus complete animations, 63.54 px versus 73.61 px, $t(29) = 3.42$, $p = .002$, $d = 0.62$, 95% CI [4.04, 16.10].

Experiment 3: Generalizing to Traceless Paths

Experiments 1–2 establish a memory advantage for visual information presented during unfinished paths, which cannot be explained by speed or path duration/length. However, complete paths still differed in another powerful visual property: connectedness. (The two discs in Figure 2A are connected into a single contour, unlike the two discs in Figure 2B and 2C.) To ensure that this could not explain the results, we replicated Experiment 2 while generalizing the effects to displays with a moving dot but a traceless path.

Method

This experiment was identical to Experiment 2 except as noted. Thirty new observers ($M_{\text{age}} = 19.55$ years; 15 females, 14 males, one other) participated (with this sample size chosen to exactly match that of Experiments 1 and 2). A 0.13° purple dot moved along the path between the start point and end point, leaving no visible trace (Supplemental Animations S3 and S4). Per the preregistered criteria, we excluded observers (with replacement) whose total experiment completion time was greater than 2 standard deviations from the grand mean ($n = 1$). Individual trials were also excluded in which either (a) the overall error was greater than 2.5 standard deviations from the grand population mean ($M = 0.23$, $SD = 0.57$) or (b) response times were greater than 2.5 standard deviations from the grand population mean ($M = 0.23$, $SD = 0.50$).

Results

Probe localization errors were again smaller for unfinished versus complete animations, 59.91 px versus 65.89 px, $t(29) = 2.10$, $p = .044$, $d = 0.38$, 95% CI [0.42, 12.34].

Experiment 4: An Unfinishedness Benefit or a Completion Cost?

Like previous work on the Zeigamik effect, Experiments 1–3 interpreted memory performance differences in terms of an unfinishedness benefit. But without an independent baseline, such contrasts could instead be interpreted in terms of a completion cost (cf. Tsubomi et al., 2024). To determine which interpretation is appropriate, we replicated Experiment 3 while adding a baseline condition (see Supplemental Animation S5) in which we simply removed the end point (so that there was no basis on which to perceive a path as

either unfinished or complete). Relative to this neutral baseline, would we observe a cost for completion, or a benefit for unfinishedness?

Method

This experiment was identical to Experiment 3 except as noted. Thirty new observers ($M_{\text{age}} = 19.17$ years; 16 females, 12 males, two other) participated (with this sample size chosen to exactly match that of Experiments 1–3). In addition to unfinished and complete animations, there was also a baseline condition, which was identical except that no end point was displayed. Observers completed nine experimental trials (3 animation conditions [unfinished, complete, and baseline] \times 3 repetitions, with trials presented in a different random order for each observer). Per the preregistered criteria, we excluded observers (with replacement) whose total experiment completion time was greater than 2 standard deviations from the grand mean ($n = 1$). Individual trials were also excluded in which either (a) the overall error was greater than 2.5 standard deviations from the grand population mean ($M = 0.17$, $SD = 0.38$) or (b) response times were greater than 2.5 standard deviations from the grand population mean ($M = 0.13$, $SD = 0.43$).

Results

Probe localization errors were again smaller for unfinished versus complete animations, 57.29 px versus 66.62 px, $t(29) = 2.87$, $p = .008$, $d = 0.52$, 95% CI [2.69, 15.97]. Critically, errors were also smaller for unfinished versus baseline animations, 57.29 px versus 67.32 px, $t(29) = 2.74$, $p = .010$, $d = 0.50$, 95% CI [2.54, 17.52]—whereas errors did not differ for complete versus baseline animations, $t(29) = 0.15$, $p = .880$, $d = 0.03$, 95% CI [−8.78, 10.20].

Transparency and Openness

The hypotheses, methods, analysis plans, and sample sizes were preregistered on October 5, 2022, for data collection on October 6, 2022, for Experiment 1 (https://aspredicted.org/WF3_5D6); on September 14, 2022, for data collection on September 23, 2022, for Experiment 2 (https://aspredicted.org/SD7_5BZ); on November 8, 2022, for data collection on November 10, 2022, for Experiment 3 (https://aspredicted.org/1VP_G5K); and on November 1, 2022, for data collection on February 5, 2023, for Experiment 4 (https://aspredicted.org/71Z_55P). All primary data and analysis scripts are available in the Supplemental Data File, included with this submission.

Discussion

The results of the current project were clear, powerful, and consistent: A novel form of simple visual unfinishedness (a path ending before vs. after reaching a landmark) led to a marked benefit in visual working memory. This central result replicated in four separate preregistered experiments and generalized across both unfolding visual paths (Experiments 1–2) and traceless motions (Experiments 3–4). This effect cannot be explained by appeal to lower level properties of speed (equated in Experiment 1), path distance/duration (equated in Experiment 2), or connectedness (tested in Experiment 3). It cannot be explained by general notions of surprise (that the path/dot did not reach the end point)—because it persisted across multiple

trials even after observers had already encountered the unfinished animations. And it cannot be explained by notions of unpredictability (about when or where the path/dot would end in the unfinished animations)—because performance in unfinished animations was also reliably greater than that in baseline animations, in which the endings were also unpredictable.¹ Finally, the results show that this effect truly reflects a benefit for unfinishedness rather than a completion cost (relative to the independent baseline tested in Experiment 4). These results have implications for both the nature of perception and for the mental prominence of unfinishedness.

Implications for Visual Perception

We typically think of visual perception as extracting relatively low-level properties, such as color, orientation, and motion. But the current results suggest that we also spontaneously extract the property of unfinishedness, which is traditionally more associated with higher level cognition (in both existing science and everyday intuition)—and that we do so even for exceptionally simple visual motions and even when this property is entirely task-irrelevant. Moreover, this property has an outsize impact on visual working memory, independent of explicit goals and obligations.

In fact, many observers reported not even consciously noticing whether the motions were unfinished or not. In some of the key experiments, for example, observers answered the following question after completing the experimental trials: “Sometimes, the path ended when it reached the final disc, while other times, it stopped short (before it had reached the final disc). Did you notice this during the experiment itself?” In response to this and related questions (with the details provided in the [Supplemental Data File](#)), 34% of observers across experiments indicated that they had not noticed this difference. Yet the key unfinishedness benefit also held when looking at those observers alone. This further supports the origin of such effects in relatively automatic visual processing—because one cannot reason (or devise a conscious strategy) about a distinction that one does not even notice in the first place.

Overall, these results are consistent with a broader trend in recent work, in which visual perception has also been found to traffic in other seemingly higher level properties—such as causality (e.g., [Kominsky & Scholl, 2020](#); [Rolfs et al., 2013](#)), agency (e.g., [Gao et al., 2009, 2010](#)), and intuitive physics ([Wong et al., 2023](#)).

The Mental Prominence of Unfinishedness

The current results also show how unfinishedness may be privileged in the mind at a deep level—in that the observed memory benefit does not seem to require the salient social and motivational factors from previous work. To our knowledge previous Zeigarnik effects always involved semantically rich stimuli (such as explicit tasks and obligations) and explicit and task-relevant manipulations—such as interruptions (which no subject could fail to notice) to the very tasks subjects were later asked to remember. By contrast, the current work demonstrates a visual Zeigarnik effect that occurs spontaneously, even during passive viewing of simple visual displays. Thus, effects of unfinishedness may reflect not only people’s explicit plans and priorities but also the underlying architecture of visual processing.

One theoretical possibility is that both the current results and the traditional Zeigarnik effect may be understood from a framework of event segmentation. Completing events may be satisfying (as when

crossing off items on to-do lists), but it is also mentally influential—especially in the sense that event boundaries lead to a type of directed forgetting in working memory (e.g., [Kurby & Zacks, 2008](#); [Ongchoco et al., 2023](#); [Radvansky, 2012](#)), which may be adaptive insofar as it prevents now-obsolete information from guiding behavior in a new event. While this work clearly implicates memory costs (as a result of event segmentation), the current results explicitly identify a memory benefit (due to unfinishedness). How these effects interact is an avenue for future work.

Constraints on Generality

The present study (involving simple visual displays) and traditional Zeigarnik effects (involving explicit goals and tasks) collectively represent an impressive range of contexts. But there remains a substantial unexplored middle ground. In simple visual displays, we do not yet know whether such effects would generalize to other sorts of displays (beyond paths in mazes) and manipulations (beyond the cessation of visual motion). And we similarly do not yet know whether the kinds of innovations presented here might also apply to traditional Zeigarnik effects—for example, with passive viewing (i.e., watching another person be interrupted during explicit tasks or obligations), or task-irrelevant manipulations of unfinishedness (i.e., testing whether the interruption of certain tasks also enhances memory for other information).

Conclusion

The current project deepens the notion that when an ongoing event is unfinished, its information may be actively maintained in working memory because this information can still be relevant for what is to come next (and for potentially completing the event). This may be especially true in visual perception, where anticipating what is about to unfold can be critical for guiding online behavior. In perception, unfinished events may not necessarily reflect frustrated, unresolved goals of the past but rather represent possibilities of what is about to come.

¹ We are also doubtful that these results could be explained by the disappearance point (in the unfinished animations) itself serving as an additional sort of anchor point in visuospatial memory, for two reasons. First, this point did not occur until more than 6 full seconds had elapsed since the initial probe presentation, with several other probes in the interim—yet our effects occurred for each of the individual probes in isolation (as detailed in the [Supplemental Data File](#)). Second, it is not clear how or why this point would have served as a useful anchor, beyond the many other salient potential contours and corners of the maze itself—which of course were much nearer to the probes themselves.

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