Rethinking attentional habits

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Abstract

Attentional habits acquired by visual statistical learning cause enduring biases towards specific locations. These habits, driven by recent search history, are thought to be independent of both goal-directed and stimulus-driven attentional mechanisms. This theoretical claim is based on three characteristics that these habits apparently exhibit, that is, they are inflexible, implicit, and efficient. We review methodological limitations in previous studies and briefly describe recent results that challenge this new framework. We conclude that it might be premature to assume that attentional habits are based on a special search history process that differs from the two traditionally recognized attentional mechanisms.

Keywords: attentional habits, implicit learning, working memory, statistical learning, probabilistic cuing.

The world bombards us with too many stimuli to attend to simultaneously. Therefore, it is important to control, moment by moment, which ones we are going to prioritise. Let's imagine we are talking to a friend while walking, and we want to cross the street. Momentarily, we will disengage from the conversation to watch for approaching traffic. This mechanism, called *goal-directed* attention, allows us to focus on what is relevant in the moment given our goals. Let's now imagine that, once we are crossing, and engaged again with the conversation, an ambulance approaches at speed. We will involuntarily redirect our attentional resources towards the ambulance. This mechanism, called *stimulus-driven* attention, reorients us towards a stimulus when it is physically salient.

In the last few years, several visuospatial attentional biases generated by prior experience that cannot straightforwardly be classified as stimulus- or goal-driven have been described. These so-called 'attentional habits' arise in situations where it is unlikely that bottom-up stimulus-driven attentional processes are engaged. In the visual search tasks employed in this area (which we describe in more detail shortly) the search target does not 'pop out' in virtue of possessing a unique feature (e.g., a red target amongst green distractors). Hence the key question is whether attentional habits can be viewed as a type of goal-directed attention. This possibility has been called into question (Jiang & Sisk, 2019; Theeuwes et al., 2022) since they are supposedly able to durably bias our attention even when they are no longer aligned with our current goals or when we are not aware of their effect, and hence they are unlikely to be represented as goals. Many of these habits arise from the statistical regularities that we find in the environment. For example, when closing a program in a Windows operating system, we automatically direct our attention to the top right corner of the screen to find the cross. However, when we switch to a macOS operating system, we know that we must go to the top left corner. Still, it is almost inevitable that we will inappropriately direct our attention to the right-hand side because that is where we habitually look.

Attentional habits arising from statistical learning have often been explored in the laboratory through tasks that involve searching for a target stimulus, usually surrounded by distractors. Unknown to participants, the location of the target, distractor or both follow certain rules. The critical characteristic of these tasks is that although performance is in accordance with the spatial regularities, participants do not seem to be aware of them. In this review, we will focus on three popular experimental tasks: contextual cuing, probabilistic cuing or location probability learning, and the distractor inhibition additional singleton task (see Figure 1). In a typical contextual cuing task, in half of the trials the spatial arrangement of target and distractors is repeated. Thus, the target is found faster than when their arrangement is random (e.g., Chun & Jiang, 1998). In a probabilistic cuing task, the target appears more frequently in a particular region of the scene, usually one of the quadrants of a computer display (e.g., Jiang et al., 2013). As a result, attention is prioritised towards that area and the target is found more quickly. In an additional singleton task, a salient distractor appears in a particular region of the scene and participants learn to suppress that area when searching for the target (e.g., Wang & Theeuwes, 2018).

It has been proposed that attentional habits have three important characteristics: they are inflexible and highly resistant to extinction, they are acquired implicitly or unconsciously[1], and they are efficient, that is, they "consume little or no processing resources or attentional capacity" (Moors & De Houwer, 2006, p. 317). Moreover, it is

[1] The opposing (or antagonistic) terms explicit/implicit, aware/unaware, and conscious/unconscious are commonly used interchangeably within the literature on attentional habits. In this article, we have maintained the interchangeable use of these terms. We define a process or a piece of knowledge as conscious, explicit, or aware when it is accessible to reasoning, recognition, and verbal report.

argued that the properties of this form of attention imply that it is distinct from both goal-directed and stimulus-driven attention (Jiang & Sisk, 2019; Theeuwes et al., 2022). Do our models of attention need to be supplemented with a third type? We review new evidence that calls into question these previous findings and conclusions.

Inflexibility

Goal-directed attentional control flexibly adapts to what we consider relevant at any given moment. If we are looking for a dollar bill in our wallet, other bills can distract us, but not the surrounding coins; then, when we look for a one-dollar coin, other coins will be distracting but the bills will not. In contrast, attentional habits are supposed to be highly inflexible. This implies that, even if our goals change, our attentional focus will not update accordingly. For example, when we visit a country where traffic travels on the other side of the road, it takes us some time to readjust our attention to the new direction of movement.

This topic has been studied mainly with the probabilistic cuing paradigm. When a search bias has been generated towards the 'rich' quadrant where the target appears frequently for hundreds of trials (biased stage), a superficially identical phase begins, but in this case, without explicit instruction, the target is homogeneously located in all of the quadrants of the screen (unbiased stage). Allegedly, during the unbiased stage, maintaining an attentional bias towards the previously rich quadrant does not obey the participant's goals. Because in most of these studies this bias does not seem to decrease across trials, it is inferred that the cuing effect is inflexible and not goal-directed (e.g., Jiang et al., 2013).

A closer look reveals several limitations that may undermine our confidence in this conclusion. One problem is that, generally, the unbiased stage is much shorter than the biased stage, so the participant has very little experience with the homogeneous spatial distribution of targets. Thus, they do not have enough time to become familiar with it. On the other hand, even when both stages are equally long, at the end of the task, the target has appeared more times in the rich quadrant, and it has not been made explicit to the participant at any point that the regularities may change. Therefore, continuing to prioritise that quadrant does not necessarily conflict with the participant's goal, but is consistent with their experience. It is quite possible that, if the participant could accumulate more experience with the new spatial distribution, the bias would flexibly adapt to it.

The critical requirement to establish that habits are inflexible is to make the habitual bias clearly counterproductive for participants (e.g., providing instructions on the change of the spatial distribution of the target or endogenously directing attention elsewhere) and show that the bias remains unchanged. The few studies that have adopted this approach have found that the bias can still be detected but is dramatically reduced, contrary to the inflexibility hypothesis (Golan & Lamy, 2023; Hong & Kim, 2022; Jiang et al., 2014). It is also important that, when switching the location of targets or distractors to evaluate if the bias is updated or maintained, we must consider to what extent the new spatial distribution is inconsistent with what participants may have learned during the training stage. For example, in the second switch stage of a probabilistic cuing task, the new rich quadrant should not be adjacent to the previous one. This is because a participant whose rich quadrant is on the upper right of the screen may have actually inferred that the rich region is the whole right-hand side of the display; if the rich region then moves to the bottom right quadrant, this participant might not perceive any change and their attentional behaviour will be unaffected. Unfortunately, no study has controlled for this possibility.

In addition, these studies usually have very small samples that do not grant sufficient statistical power to detect changes in attentional bias between stages. Recently, we have shown that by boosting statistical power, either by increasing the number of participants or by aggregating all available data in a meta-analysis, it is possible to detect a clear decrease in the bias across the unbiased stage (Giménez-Fernández et al., 2020; 2022a).

Regarding the additional singleton task, some studies have found that the suppression effect remains in an unbiased stage where the distractor is evenly located or there is no distractor at all (Britton & Anderson, 2020; Valsecchi & Turatto, 2021). However, they suffer from the same problems as the probabilistic cuing studies (i.e., the experimental samples are very small, and the unbiased stage is usually shorter than the biased one). For example, in their Experiment 2, Britton and Anderson (2020) found that the suppression effect was around 61 ms for the training stage and around 29 ms in the testing stage. Thus, even though this difference was not statistically significant, and the bias persisted, it was clearly reduced. To date, only one study has shown that the suppression effect of an initial regularity has lingering effects during the entire task even after it is changed (Wang & Theeuwes, 2020). We suggest that current evidence is inconclusive and provides little support for the rigid inflexibility of attentional habits.

Unconsciousness

Attentional habits, unlike goal-directed and stimulus-driven attention, allegedly operate implicitly, that is, without the participant being aware of the statistical regularities that are triggering the bias (e.g., Jiang & Sisk, 2019; Wang & Theeuwes, 2018). This claim may raise some suspicion, since during the 1990s it became clear that many of the studies supporting the idea that unconscious processes play a role in our cognition were plagued by theoretical and methodological problems (Shanks & St.

John, 1994). Often, when new studies attempted to overcome these limitations, they showed that the situations in which performance appeared to be driven by an unconscious process, such as classical conditioning, decision making, or subliminal perception, can actually be explained by conscious processes (Newell & Shanks, 2023; Shanks & St. John, 1994). This suggests that it is extremely difficult to conclude that a cognitive process operates unconsciously.

In the case of attentional habits, the most common strategy for testing whether participants are aware of the regularity that triggered them is to perform an awareness test at the end of the experiment. In the contextual cuing task, participants are asked to recognise the displays that were presented repeatedly during the experiment (Chun & Jiang, 1998). In the probabilistic cuing task and the additional singleton task, participants typically are asked to indicate the area in which the target or the distractor appeared most often, respectively (Jiang et al., 2013; Wang & Theeuwes, 2018) (see Figure 1).

In general, participants' performance on these awareness tests is very poor, and this result is used as evidence of unawareness of the regularity (Chun & Jiang, 1998; Colagiuri & Livesey, 2016; Jiang et al., 2013; 2014; Wang & Theeuwes, 2018). For example, Wan and Theeuwes (2018) found that only 15 out of 32 participants were able to report the correct location. However, the conclusion that participants were truly unconscious is debatable. As indicated above, the usual sample size of these studies may not grant sufficient statistical power to reveal participants’ true awareness. Also, these tests probably do not accurately measure participants’ conscious awareness since they are based on discrete measures with a very small number of trials or even with a single trial. Evidence suggests that these measures are unreliable and that most of the variability between one participant and another is simply measurement error (Vadillo et al., 2022). Simply including more participants and/or trials in the awareness test, or aggregating large samples of data through meta-analysis, is sufficient to show that participants are generally able to recognise the key statistical regularities embedded in the three tasks (Giménez-Fernández et al., 2020; Smyth & Shanks, 2008; Vadillo et al., 2016, 2020; Vicente-Conesa et al., 2022a).

Beyond psychometric and statistical problems, there are many reasons why participants may fail awareness checks without this implying a true lack of awareness. Perhaps participants do not express conscious knowledge because it is held with low confidence or because by the time they reach the awareness test they have forgotten what was learned during previous phases of the experiment. They may also harbour alternative hypotheses about the statistical regularity in question that may not exactly match the experimental manipulation, but nevertheless help to perform the task with some degree of success. For example, in the additional singleton task, participants do not always remember where the distractor previously appeared, but even when they fail to report the location precisely, they point to locations close to it. It is likely that these participants have learned to ignore a relatively large region rather than a specific location (Vicente-Conesa et al., 2022a). Thus, it is relatively easy for a person who is truly conscious of the regularity to perform poorly on an inappropriate awareness test and be misclassified as unconscious.

In recent years, an effort has been made to increase the sensitivity of awareness tests. In the case of contextual cuing, some studies have employed awareness tests with more trials than usual, have elicited confidence ratings that aim to go beyond the usual dichotomous yes/no responses, or have employed different tasks to measure awareness such as hiding the target and asking the participant to locate it within the display (e.g., Geyer et al., 2020; Smyth & Shanks, 2008; Vadillo et al., 2022). In the case of the probabilistic cuing and additional singleton tasks, instead of asking participants to indicate the location where the target or distractor appeared most frequently, they can be asked to rank positions or to estimate numerically how many times the target or the distractor appeared in each location (Giménez-Fernández et al., 2020; Vicente-Conesa et al., 2022a). This approach has allowed us to demonstrate that participants show high performance on these measures, thus revealing awareness of the manipulation (Smyth & Shanks, 2008; Vadillo et al., 2022; Vicente-Conesa et al., 2022a), and also that the level of conscious awareness is related to the magnitude of the attentional bias (Geyer et al., 2020; Giménez-Fernández et al., 2020).

Efficiency

Finally, both the learning and execution of these attentional habits appear to be efficient, in the sense that they affect behaviour even when the participant is not paying attention to the stimuli that trigger the bias (Jiang & Leung, 2005; Won & Jiang, 2015). To explore this issue, participants are usually asked to perform the visual search task concurrently with a demanding secondary task that engages their WM. In each trial, a series of stimuli to be memorised is presented, followed by a visual search display. After that, the same or slightly different stimuli are presented again. At this point, the participant must indicate whether the WM stimuli at the beginning and those at the end of the trial are identical. If performance on the learning task is not affected by the secondary task, the developed attentional habit is thought to be independent of deliberate cognitive processes, which would presumably be compromised by this type of distraction.

Most evidence shows that both the additional singleton task and probabilistic cuing are resilient to secondary WM tasks (Gao & Theeuwes, 2020; Won & Jiang, 2015). Results are less clear-cut in the contextual cuing task, where the consensus is that only the expression of the bias and not the learning itself is compromised by WM (Pollmann, 2019). However, these studies have methodological limitations that cast doubt on their conclusions. They generally have small sample sizes, so that if there were an effect of WM load, it would be difficult to detect statistically. In two Registered Reports we have attempted to solve some of these problems. In the case of contextual cuing, we have not found any decrease in attentional habit under conditions that overload WM (Vicente-Conesa et al., 2022b). In contrast, we did find a slight decrease in probabilistic cuing in one of three experiments (Giménez-Fernández et al., 2022b).

We suspect that the disparity of results lies in the type of secondary task used to recruit participants' WM resources. Most secondary tasks employed in these experiments may not be sufficiently demanding to drain the scarce resources needed to acquire these attentional habits. In this regard, Chen et al. (2019) have shown that taxing the executive component of WM by asking participants to manipulate information abolishes the acquisition and the expression of contextual cuing. Regarding the modality of the information, visuospatial information can partially disrupt contextual and probabilistic cuing (Giménez-Fernández et al., 2022b; Travis et al., 2013). Thus, some of the latest results suggest that it might be premature to infer that these biases are completely independent of WM resources.

Concluding remarks

It is not our intention to conclude that attentional habits do not or cannot exist. After all, there are numerous examples from everyday life, such as an inappropriate attempt to close a Windows program when one is used to working with the Mac operating system, which seem difficult to understand in other terms. In any case, what we question is whether the laboratory paradigms commonly used to study these phenomena induce anything comparable to such habits, learned over long periods of time. We also question whether these laboratory-learned attentional biases possess the special characteristics that are commonly attributed to them and that supposedly differentiate them from goal-directed attention. As we have explained, the evidence is ambiguous and inconclusive at best.

Progress on this problem will require not only more refined experiments and stronger evidence, but also a deep theoretical debate. For example, we need to define more clearly what the critical features are that an attentional response must have in order to be considered habitual. Some authors argue that all three properties mentioned in this review are necessary characteristics that dissociate attentional habits from goal-driven attention (Jiang & Sisk, 2019), while others put more emphasis on unconsciousness and efficiency (Theeuwes et al., 2022) or other features like goal-independence (Anderson et al., 2021). Stronger consensus on this question would not only facilitate progress in research on these particular experimental paradigms but would also clarify whether and in what sense attentional biases induced by other regularities, such as value-driven attentional phenomena (e.g., Watson et al., 2022), share mechanisms with visual statistical learning and deserve to be considered habits.

It should be noted that the very concept of history-driven attentional control, as a separate mechanism from bottom-up or top-down control, is not widely accepted in the community. For example, Gaspelin and Luck (2018) argue that top-down factors are all those that arise internally and, therefore, learning history would be included amongst them. On the other hand, although Wolfe (2021) recognises selection history as a third source of attentional control, he qualifies this by commenting that “priming, contextual cueing, value, marking, etc. could all be seen as variants of top-down guidance” (p. 1070).

We conclude that current evidence is insufficient to claim that so-called ‘attentional habits’ reflect a mechanism distinct from goal-directed attention. We urge caution about accepting a new framework in attentional control.

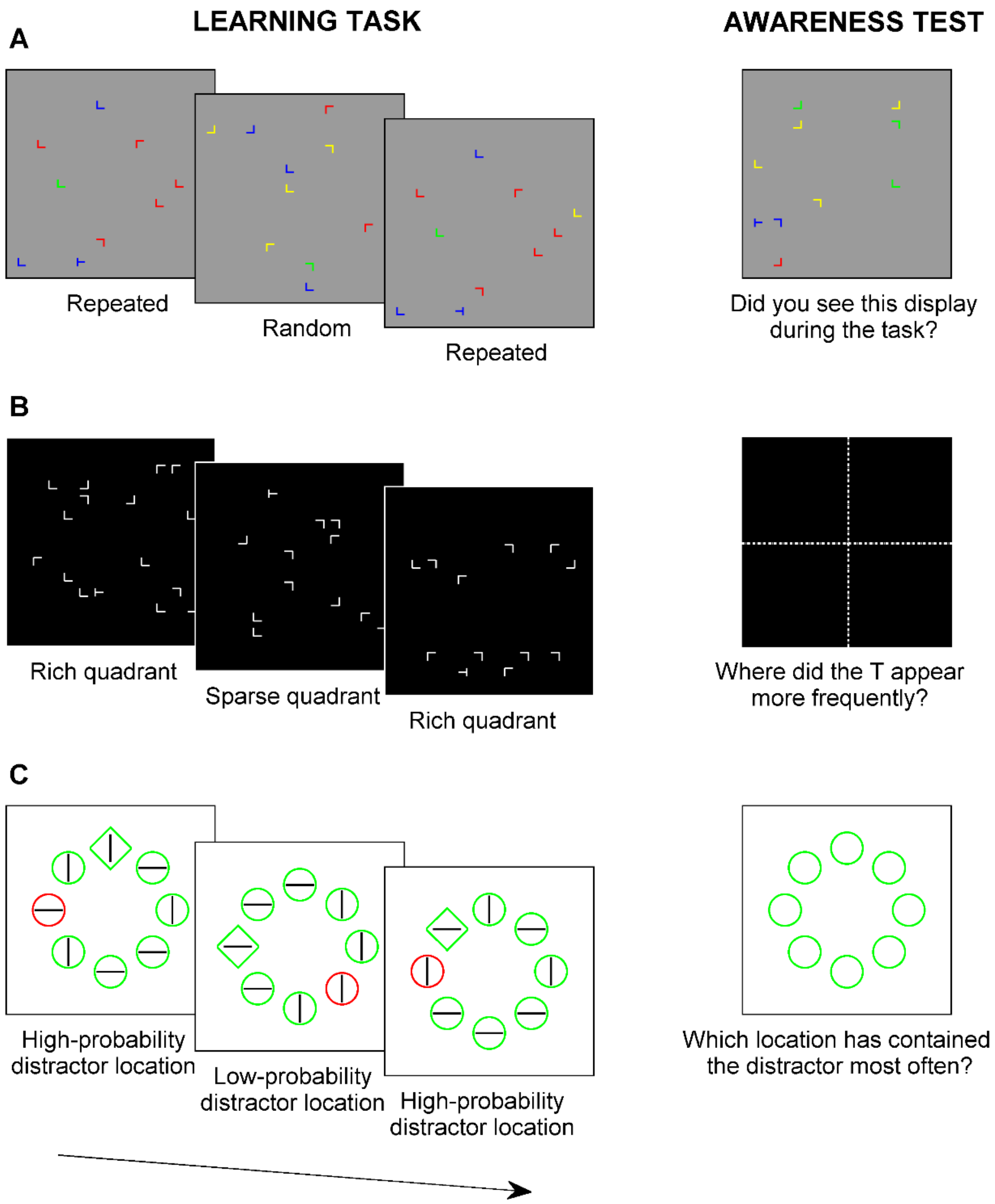

Figure 1. A. Contextual cuing. All displays contain a target (usually a tilted T) surrounded by distractors (usually rotated Ls). Participants are instructed to find the T as fast as possible and respond to its orientation. Unknown to participants, in half of the trials, the locations of target and distractors are the same (repeated patterns) while in the other half, the locations are random. Usually, between 8 and 12 repeated displays are presented during the experiment. **B.** Probabilistic cuing. The displays and task are the same as in contextual cuing. In this case, in half of the displays, the T appears in one of

the quadrants. In the rest of the trials, it appears evenly distributed across the other three quadrants. **C.** Distractor inhibition additional singleton task. Participants are instructed to locate a singleton shape (a diamond in the example) and indicate the orientation of the line inside it. In some trials the search display includes a salient distractor of a different color that is difficult to ignore. The crucial manipulation is that, when present, the singleton distractor is more likely to appear in a particular location.

Recommended Reading

Theeuwes et al. (2022). (See References). A recent review on visual statistical learning and history-driven visual attention mostly focused on the additional singleton task.

Jiang & Sisk (2019). (See References). Review that defines the characteristics of attentional habits focused on probabilistic cuing and contextual cuing.

Shanks, D. R., Malejka, S., & Vadillo, M. A. (2021). The challenge of inferring unconscious mental processes. *Experimental Psychology*, *68*(3), 113-129. doi: 10.1027/1618-3169/a000517. A recent and comprehensive review of the methodological problems faced by implicit cognition research.

Anderson et al. (2021) (See References). Theoretical framework that aims to define and categorise attentional habits as well as describe the different mechanisms involved.

Vadillo et al. (2016). (See References). Experimental and theoretical article which questions the implicit nature of contextual cuing.

Anderson, B. A., Kim, H., Kim, A. J., Liao, M.-R., Mrkonja, L., Clement, A., & Grégoire, L. (2021). The past, present, and future of selection history. *Neuroscience & Biobehavioral Reviews, 130,* 326-350. doi: 10.1016/j.neubiorev.2021.09.004

Britton, M. K., & Anderson, B. A. (2020). Specificity and persistence of statistical learning in distractor suppression. *Journal of Experimental Psychology: Human Perception and Performance, 46*(3), 324-334. doi: 10.1037/xhp0000718

Chen, M., Wang, C., Sclodnick, B., Zhao, G., & Liu, X. (2019). Executive working memory involved in the learning of contextual cuing effect. *Experimental Brain Research*, *237*(11), 3059-3070. doi: 10.1007/s00221-019-05643-7

Chun, M. M., & Jiang, Y. H. (1998). Contextual Cueing: Implicit Learning and Memory of Visual Context Guides Spatial Attention. *Cognitive Psychology, 36*, 28-71. doi: 10.1006/cogp.1998.0681

Colagiuri, B., & Livesey, E. J. (2016). Contextual cuing as a form of nonconscious learning: Theoretical and empirical analysis in large and very large samples. *Psychonomic Bulletin & Review*, *23*(6), 1996-2009. doi: 10.3758/s13423-016-1063-0

Gao, Y., & Theeuwes, J. (2020). Learning to suppress a distractor is not affected by working memory load. *Psychonomic Bulletin & Review, 27*(1), 96-104. doi: 10.3758/s13423-019-01679-6

Gaspelin, N., & Luck, S. J. (2018). 'Top-down' does not mean 'voluntary'. *Journal of Cognition, 1*, 1-4. doi: 10.5334/joc.28

Geyer, T., Rostami, P., Sogerer, L., Schlagbauer, B., & Müller, H. J. (2020). Task-based memory systems in contextual-cueing of visual search and explicit recognition. *Scientific Reports, 10*(1), 1-13. doi: 10.1038/s41598-020-71632-4

Giménez-Fernández, T., Luque, D., Shanks, D., & Vadillo, M. A. (2020). Probabilistic cuing of visual search: Neither implicit nor inflexible. *Journal of Experimental Psychology: Human Perception and Performance, 46*(10), 1222-1234. doi: 10.1037/xhp0000852

Giménez-Fernández, T., Luque, D., Shanks, D. R., & Vadillo, M. A. (2022a). Is probabilistic cuing of visual search an inflexible attentional habit? A meta-analytic review. *Psychonomic Bulletin & Review, 29*, 521-529. doi: 10.3758/s13423-021-02025-5

Giménez-Fernández, T., Vicente-Conesa, F., Luque, D., & Vadillo, M. A. (2022b). The role of working memory in probabilistic cuing of visual search. *Journal of Experimental Psychology: Learning, Memory, and Cognition.* Advance online publication. doi: 10.1037/xlm0001193

Golan, A., & Lamy, D. (2023). Attentional Guidance by Target-Location Probability Cueing Is Largely Inflexible, Long-Lasting, and Distinct From Inter-Trial Priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition.* Advance online publication. doi: 10.1037/xlm0001220

Hong, I., & Kim, M. S. (2022). Habit-like attentional bias is unlike goal-driven attentional bias against spatial updating. *Cognitive Research: Principles and Implications, 7,* 1-10. doi: 10.1186/s41235-022-00404-7

Jiang, Y., & Leung, A. W. (2005). Implicit learning of ignored visual context. *Psychonomic Bulletin & Review, 12,* 100-106. doi: 10.3758/s13423-020-01722-x

Jiang, Y. V., Swallow, K. M., & Rosenbaum, G. M. (2013). Guidance of spatial attention by incidental learning and endogenous cuing. *Journal of Experimental Psychology: Human Perception and Performance, 39*, 285-297. doi:10.1037/a0028022

Jiang, Y. V., & Sisk, C. A. (2019). Habit-like attention. *Current Opinion in Psychology, 29*, 65-70. doi:10.1016/j.copsyc.2018.11.014

Jiang, Y. V., Won, B., & Swallow, K. M. (2014). First saccadic eye movement reveals persistent attentional guidance by implicit learning. *Journal of Experimental Psychology: Human Perception and Performance, 40*, 1161-1173. doi:10.1037/a0035961

Moors, A., & De Houwer, J. (2006). Automaticity: A Theoretical and Conceptual Analysis. *Psychological Bulletin, 132*, 297-326. doi: 10.1037/0033-2909.132.2.297

Newell, B. R., & Shanks, D. R. (2023). *Open minded: Searching for truth about the unconscious mind*. MIT Press.

Pollmann, S. (2019). Working memory dependence of spatial contextual cuing for visual search. *British Journal of Psychology, 110*(2), 372-380. doi: 10.1111/bjop.12311

Shanks, D. R., Malejka, S., & Vadillo, M. A. (2021). The challenge of inferring unconscious mental processes. *Experimental Psychology, 68*(3), 113-129. doi: 10.1027/1618-3169/a000517

Shanks, D. R., & St. John, M. F. (1994). Characteristics of dissociable human learning systems. *Behavioral and Brain Sciences, 17*(3), 367–447. doi: 10.1017/S0140525X00035032

Smyth, A. C. & Shanks, D. R. (2008). Awareness in contextual cuing with extended and concurrent explicit tests. *Memory & Cognition, 36*(2), 403-415. doi: 10.3758/mc.36.2.403

Theeuwes, J., Bogaerts, L., & van Moorselaar D. (2022). What to expect where and when: how statistical learning drives visual selection. *Trends in Cognitive Sciences, 26*(10), 860-872. doi: 10.1016/j.tics.2022.06.001

Travis, S. L., Mattingley, J. B., & Dux, P. E. (2013). On the role of working memory in spatial contextual cuing. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *39*(1), 208-219. doi: 10.1037/a0028644

Vadillo, M. A., Konstantinidis, E., & Shanks, D. R. (2016). Underpowered samples, false negatives, and unconscious learning. *Psychonomic Bulletin & Review, 23,* 87-102. doi: 10.3758/s13423-015-0892-6

Vadillo, M. A., Linssen, D., Orgaz, C., Parsons, S., & Shanks, D. R. (2020). Unconscious or underpowered? Probabilistic cuing of visual attention. *Journal of Experimental Psychology: General, 149,* 160-181. doi: 10.1037/xge0000632

Vadillo, M. A., Malejka, S., Lee, D. Y. H., Dienes, Z., & Shanks, D. (2022). Raising awareness about measurement error in research on unconscious mental processes. Psychonomic Bulletin & Review, 29, 21–43. doi: 10.3758/s13423-021-01923-y

Valsecchi, M., & Turatto, M. (2021). Distractor filtering is affected by local and global distractor probability, emerges very rapidly but is resistant to extinction. *Attention, Perception, & Psychophysics, 83*(6), 2458-2472. doi: 10.3758/s13414-021-02303-3

Vicente-Conesa, F., Giménez-Fernández, T., Luque, D., & Vadillo, M. (2022). Learning to suppress a distractor may not be unconscious. *Attention, Perception, & Psychophysics,* Advanced online publication. doi: 10.3758/s13414-022-02608-x

Vicente-Conesa, F., Giménez-Fernández, T., Shanks, D. R., & Vadillo, M. A. (2022b). The role of working memory in contextual cueing of visual attention. *Cortex, 154*, 287-298. doi: 10.1016/j.cortex.2022.05.019

Wang, B., & Theeuwes, J. (2018). Statistical Regularities Modulate Attentional Capture. *Journal of Experimental Psychology: Human Perception and Performance, 44*(1), 13-17. doi: 10.1037/xhp0000472

Wang, B., & Theeuwes, J. (2020). Implicit attentional biases in a changing environment. *Acta Psychologica*, *206,* 1-10. doi: 10.1016/j.actpsy.2020.103064

Watson, P., Pavri, Y., Le, J., Pearson, D., & Le Pelley, M. E. (2022). Attentional capture by signals of reward persists following outcome devaluation. *Learning & Memory, 29*, 181-191. doi: 10.1101/lm.053569.122.

Wolfe, J. M. (2021). Guided Search 6.0: An updated model of visual search. *Psychonomic Bulletin & Review, 28,* 1060-1092. doi: 10.3758/s13423-020-01859-9

Won, B.-Y., & Jiang, Y. V. (2015). Spatial working memory interferes with explicit, but not probabilistic cuing of spatial attention. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 41*(3), 787-806. doi: 10.1037/xlm0000040

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