Spatial habit competes with effort to determine human spatial organization

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners. I understand that my thesis may be made electronically available to the public.

ABSTRACT

Despite the important role that the physical environment plays in shaping human cognition, few studies have endeavored to experimentally examine the principles underlying how individuals organize objects in their space. The current investigation examines the idea that humans organize objects in their space in order to minimize effort or maximize performance. To do this, I devised a novel spatial organization task whereby participants freely arranged objects in the context of a writing task. Critically, the frequency with which each object was used was manipulated to assess participants' spontaneous placements. In the first set of experiments, participants showed a counterintuitive tendency to match pen pairs with their initial placements rather than placing pens in the less effortful configuration. However, in Experiment 2, where the difference in physical effort between different locations was increased, participants were more likely to reorganize the pens into the less effortful configuration. The current experiments suggest that the observed initial bias may represent a kind of spatial habit formation that competes with effort/performance considerations to shape future spatial organization.

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INTRODUCTION

From planning the layout of city streets to organizing the details of a working space, humans are capable of exceptional control over their physical environments. Yet, the reverse is also true: the structure of a physical environment can greatly impact human thinking and behaviour (Bub, Masson, & Bukach, 2003; Gibson, 1977; Norman, 1988; Till, Masson, Bub, & Driessen, 2014; Witt, Proffitt, & Epstein, 2005). Indeed, this reciprocal relation between humans and their environments has been argued to play a fundamental role in the success of our species (Laland & Brown, 2006). However, little is known about what motivates human spatial organization. To this end, I present the results of two experiments that use a novel paradigm to examine the mechanisms underlying individuals' arrangement of objects in their physical environment.

Despite the nearly infinite number of possible ways that objects could be arranged in a given environment, regularities in human spatial organization are ubiquitous (Gosling, 2009; Kirsh, 1995, 1996). For example, objects in a typical living space are placed according to their function (e.g., kitchenware is found in the kitchen) and, perhaps less obviously, on visible surfaces to promote attention (e.g., placing important documents at the top of a pile; Malone, 1983). What, ultimately, gives rise to these regularities in object arrangement? An intuitive and practical possibility is that individuals organize objects in space in order to more easily function, utilize, or navigate a given task environment (Kirsh, 1995, 1996; Knight & Haslam, 2010). In other words, given our control over the physical environment, individuals could organize space such that it minimizes the effort required for completing a goal or task (Chandrasekharan & Stewart, 2007; Kool, McGuire, Rosen, & Botvinick, 2010; Zipf, 1972). To provide an experimental examination of this hypothesis, I examined the straightforward prediction that, all else being equal, individuals will spontaneously place more frequently used objects closer than objects that are used less often (e.g., Zipf, 1972) such that task performance is maximized and physical effort is minimized.

The experiments reported here used a novel spatial organization task that afforded participants the freedom to structure their environment while allowing us to systematically examine factors that influenced object arrangement in space. In this task, participants copied symbols using different coloured pens that varied in their frequency of use throughout the experiment (e.g., one pen colour was used 90% of the time and the other only 10%). Critically, participants had to place each pen in one of two penholders located at different distances (i.e., close vs. far) at the beginning of each block of trials. By examining pen placements throughout this task, I could evaluate whether the frequency of object use influenced how participants spontaneously chose to structure their space. The straightforward prediction was that participants would choose to place the more frequently used pen closer in order to minimize effort and maximize performance.

EXPERIMENTS 1A & 1B

Method

How sample size was determined, all data exclusions (if any), all manipulations, and all measures in the study were reported for all experiments presented (Simmons, Nelson, & Simonsohn, 2011).

Participants

A total of 190 (100 in Experiment 1a and 90 in Experiment 1b) undergraduate students from the University of Waterloo completed the study for course credit. Data collection was stopped when there was a minimum of 16 participants who correctly completed the task in each counterbalanced cell. Forty-four participants (22 in Experiment 1a) were excluded (6 due equipment failure; 32 due to improper task completion, e.g., using their left hand when told not to; 6 did not complete the task). While this number seems large, it is important to point out that investigating natural behavior such as spontaneous spatial organization requires a degree of participant freedom that affords individuals the opportunity to violate experimental protocol. The mean age of the final sample (N = 146) was 20.0 (SD = 2.55) and was comprised of 109 females. Due to the setup of the task, all participants were preselected to be right-handed and must have normal or corrected-to-normal vision. Ethical approval for this study was obtained from the University of Waterloo Research Ethics Board. Participants provided their informed written consent prior to the experiment, and were orally debriefed upon completion of the study.

Apparatus & Stimulus

Participants were seated in front of a 23.6" Asus VN247H-P monitor. Two pen holders were placed to the right of the participants 18 cm apart horizontally (42 and 57 cm away from the participant respectively). Four black-inked ballpoint pens with different exterior colours – blue, orange, purple, and green – were placed on participants' left hand side. Stimuli were coloured symbols presented in 48 point Calibri font against a black background using E-Prime 2.0 (Psychology Software Tools, Inc.). Symbol colours matched those of the pens (e.g., blue, orange, purple, green).

Procedure

Participants were told that the purpose of the study was to copy familiar and unfamiliar symbols as quickly and as accurately as possible. Symbols were presented in colour and participants were asked to copy down a given symbol using the pen that corresponded to the colour of that symbol (see Appendix B for the complete set of symbols used). Critically, two pairs of pens (an experimental and a neutral pen set) were used, and the frequency with which they were used was manipulated. For the experimental set, pen use was unequal such that one of the pens was used in 90% of trials. For the neutral set, pens were used with equal frequency. Participants alternated between the experimental and neutral pen sets throughout the experiment. The neutral pen set primarily served to separate the experimental blocks and to provide an opportunity to examine participants' spontaneous pen placements for the experimental pen set in the following block.

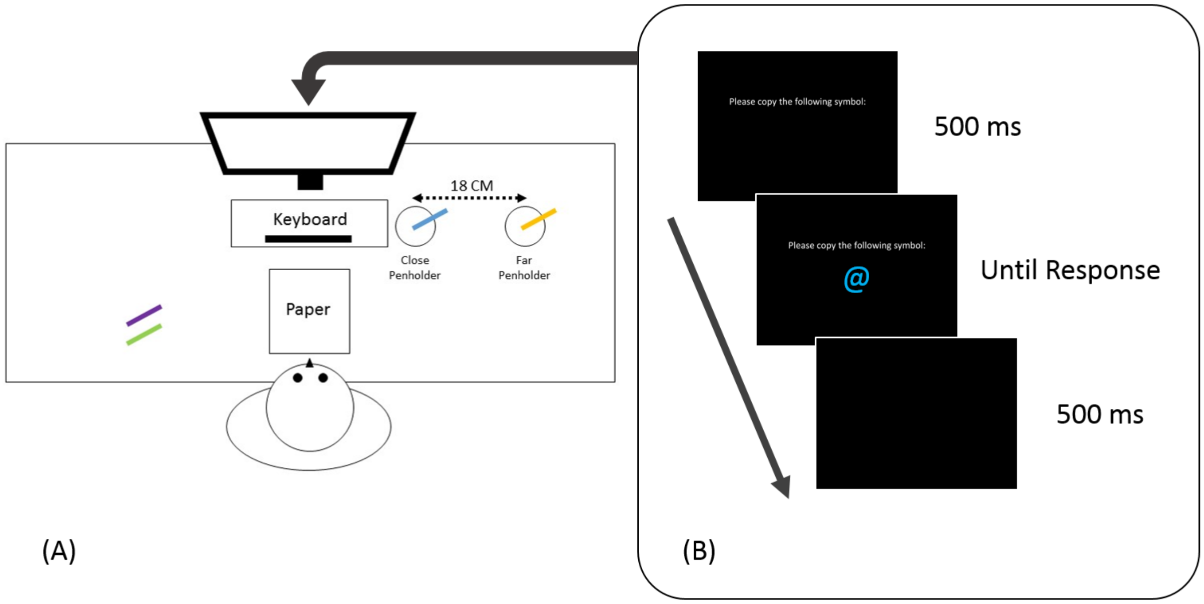

Figure 1. Illustration of the experimental setup (A) and procedure (B). Participants were presented with symbols on a monitor and were told to copy them onto the paper provided using coloured pens placed in the penholders to their right. The initial screen consisted of task instructions ("please copy the following symbol"), which was followed by the onset of target symbol. A 500 ms blank screen appeared before the next trial began.

At the beginning of each block, participants were instructed to pick out two pens and place one pen in each of the two pen holders (one located close to the participant and one far away; see Figure 1A for setup). They were told to freely place the pens in any configuration to help reduce any reluctance participants had towards changing the configuration of the pen throughout the task. In Experiment 1a, the four coloured pens were placed together in one container and the experimenter instructed participants which two pens they were to pick out initially (referred to by their colours). Since the experimenter was in the room in the first block in Experiment 1a, Experiment 1b was designed to eliminate this potential difference between blocks. In Experiment 1b, the experimental and neutral pen sets were placed in two separate containers labeled "Set A" and "Set B", and participants were instructed via the program regarding which pen set would be used for a given block. Whether participants started with the experimental or neutral pen set as well as the pen colours used for each participant was counterbalanced (see Appendix A for the full task instructions). Again, the frequency with which each colour in the experimental pen set was determined at random.

Trials began with a screen instructing participants to copy the symbol (see Figure 1B). The symbol was presented 500 ms after, and remained on the screen until participants finished copying the symbol and pressed the space bar to proceed. A 500 ms blank screen followed the space bar press before the next trial began. Participants were told to always put the pens back into the empty penholder after they finished copying the symbol and before they pressed the space bar. They were also instructed to not use their left hand during the experiment to prevent them from pressing the space bar before the pen was put back into the penholder. These instructions were meant to establish the physical cost of reaching for each location. Without these instructions, participants could, for example, hold on to the same coloured pen until a different coloured stimulus appeared. The experiment consisted of 10 blocks (5 using each pen set), with 20 trials in each block. At the end of block 10, participants switched the pen set again, but were not given the opportunity to complete the symbol copying task. Thus, depending on the counterbalance, a subset of our participants had an extra opportunity to decide the placement of the experimental set, while others did the same with the neutral set.

After the symbol copying task, participants were asked to estimate the proportion with which each coloured pen was used in a given set and how confident they were in their responses on a Likert scale ranging between 1 and 6. Participants were also probed regarding the purpose of the experiment as well as their strategies and intentions for completing the task (i.e., how they decided where to place the pens, and whether they were reluctant to move the pens around during the experiment) before they were debriefed.

Results

Results in Experiment 1a and 1b were qualitatively similar (when Experiment was included as a factor there was no main effect or interactions with other factors, all ps > .69) so data across the two experiments were combined. Effect size for the combined analysis, as well as separate effect size measures for each experiment, are provided. Random assignment resulted in uneven counterbalancing with respect to the starting configuration of the experimental pens (e.g., whether participants started the task in the frequent close-infrequent far or the frequent far-infrequent close configuration). However, truncating the data to match number of participants in each counterbalance did not affect the interpretation of our results. Additionally, there was no effect of pen set order (i.e., whether participants began the task with the neutral or experimental pen set) overall (ps > .31 across all analyses), so results were collapsed across that variable. Results are provided with 95% confidence intervals and, where appropriate, Loftus and Masson (1994) within-subject confidence intervals.

Manipulation Checks

First, the extent to which the frequency of object use manipulation was effective was assessed. Paired-sample t-tests indicated that participants perceived the frequent pen (M = 70.63, SD = 15.77, 95% CI [70.22, 71.04]) to have been used more than the infrequent pen (M = 28.61, SD = 15.23, 95% CI [28.20, 29.03]) for the experimental pen sets, $t(145)$ = 16.68, $p < .001$, d = 1.38 (E1a = 1.37; E1b = 1.38), whereas they perceived the pens in the neutral sets as being used equally frequently, $t(145)$ = .83, p = .41, d = .07 (E1a = .02; E1b = .17). Participants in Experiment 1a provided an overall confidence estimate of their frequency judgements (M = 3.95, SD = 1.03), while those in Experiment 1b provided judgements for the experimental (M = 4.19, SD = 1.05) and neutral pen sets (M = 3.71, SD = 1.15) separately. Lastly, participants' responses regarding whether they were reluctant to move the pens from their initial position was examined, and it was found that the majority (86%) of our participant did not feel reluctant to do so.

Next, participants' response times in trials completed using the close vs. far pen in the neutral blocks was assessed using a repeated-measures t-test. This served as an indirect measure of the costs in physical effort associated with reaching for different locations. Unsurprisingly, participants completed trials significantly more quickly when using the closer pen, M = 4946, SD = 1336, 95% CI [4903, 4989], than the farther pen, M = 5437, SD = 1267, 95% CI [5394, 5480], $t(145)$ = 15.92, $p < .001$, d = 1.32 (E1a = 1.47; E1b = 1.17). In addition, response times for the subset of our participants that placed the experimental pens in both the less effortful configuration and the more effortful infrequent close-frequent far configuration was also examined. Participants completed blocks (consisting of 20 trials) more quickly when pens were placed in the less effortful configuration, M = 98245, SD = 25473, 95% CI [97909, 98580], than the more effortful configuration, M = 106915, SD = 24178, 95% CI [106580, 107251], t(104) = 5.00 , p < .001, d = .49 (E1a = 0.50; E1b = 0.48).

Spontaneous Object Placement

Next, participants' pen placements throughout the task was examined. To see whether the more frequently used pen was placed in in the closer position overall, the data was coded such that if the participants placed the pens in the less effortful frequent close-infrequent far configuration in a given block, a value of 1 would be assigned (and 0 if they placed it in the alternative configuration). The proportion of blocks for which participants placed the experimental pens in the less effortful configuration was calculated and compared against a proportion of 0.5 separately for participants who began the experiment in the frequent close-infrequent far and the frequent far-infrequent close configurations. As shown in Figure 2A, participants who began the experiment with the frequently-used pen in the close position were significantly more likely than chance to place the pens in the less effortful configuration, M = 0.65, SD = .29, 95% CI [0.58, 0.71], t(79) = 4.43, p < .001, d = .50 (E1a = .45; E1b = .55). On the other hand, participants who began the experiment with the frequently-used pen in the far position were slightly less likely than chance to place the pens in the less effortful configuration, M = 0.43, SD = .32, 95% CI [0.35, 0.51], though this result was only marginal, t(65) = 1.71, p = .09, d = .21 (E1a = .21; E1b = .20). Figure 3 depicts the frequency of distribution of portions in which participants placed the more frequently used pen in the close position.

The results of Experiments 1 did not support the hypothesis that participants would spontaneously place the more frequently used object in the closer location. The pattern apparent in Figure 2A suggests an alternative hypothesis regarding individuals' spatial organization behaviour, namely, that individuals tend to place objects in their original locations. Critically, this predication can be tested by examining pen placement in the neutral blocks. To do so, the proportion of blocks on which the chosen configuration matched the initial configuration in neutral blocks was computed and compared against chance. Results are depicted in Figure 2B. Indeed, participants were more likely than chance to prefer the initial position for the neutral pen set, $M = 0.62$, $SD = .31$, 95% CI [0.57, 0.67], $t(145) = 4.93$, $p <.001$, $d = .41$ (E1a = .37; E1b = .45)1.

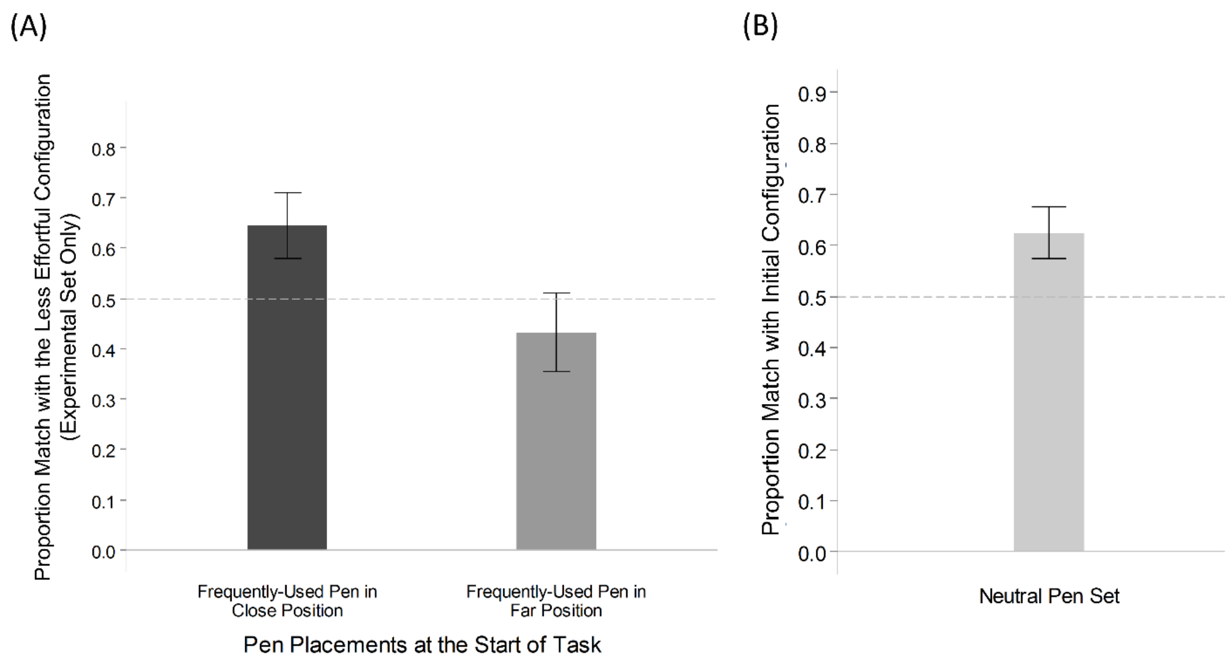

Figure 2. Proportion of blocks in which participants' pen placements matched the less effortful, frequent close-infrequent far configuration for the experimental pen set (A) and blocks in which participants' neutral pen placements matched the initial configuration (B). In Experiment 1a and

1b, participants were more likely than chance to place pens in the less effortful configuration if they began the experiment with the frequently close-infrequent far position. However, participants were slightly less likely to do so if they began the experiment with the infrequently close-frequent far position. Instead, participants were more likely to match subsequent pen placements with that of the initial pen configuration for neutral pen sets. Error bars represent 95% CI.

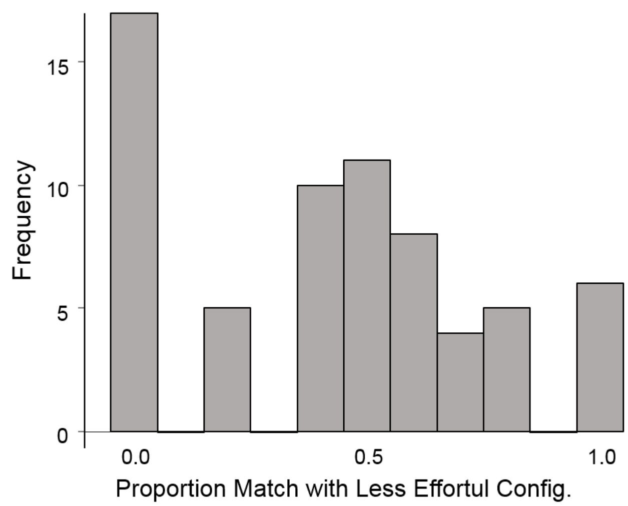

Figure 3. Frequency of distribution of portions in which participants' configurations match with the less effortful configuration in E1a and b.

Discussion

Altogether, Experiments 1a and 1b did not support the straightforward idea that individuals would organize their space in order to minimize physical effort or maximize performance. Despite participants' awareness of the differences in the frequency of object use, the associated costs in task efficiency, and their self-reported knowledge that they could move the pens, participants did not opt to place the pens in the less effortful configuration. Rather, object placements tended to match with their starting positions, which were determined by the participants at random at the beginning of the task. These results suggest that an object's past spatial history can have a strong influence on future spatial organization even when that spatial history leads to an "inefficient" spatial organization.

One interesting interpretation of the observed pattern is that individuals may have learned to associate a particular pen with its location early in the task (i.e., the first block). In this sense, individuals may be forming a kind of spatial habit that competes with a desire to minimize effort or maximize performance. This account makes an interesting prediction that is testable in the present data. Specifically, the likelihood that a given participant organizes objects in a particular arrangement should be related to how often that configuration had been used in the past. To test this idea, I analyzed the relation between the configuration participants used in the final block and the number of times that particular configuration had been used in the past. As predicted, frequency of past object configurations significantly influenced the object configuration in the final block for both the neutral set, $F(3, 142) = 8.08$, $p < .001$, $\eta2 = .15$ (E1a = .22; E1b = .10), and experimental set, $F(3, 142) = 8.57$, $p < .001$, $\eta2 = .15$ (E1a = .19; E1b = .19). Specifically, pen configuration in the last block was more likely to be in the initial configuration the more that participants placed the pens in the initial configuration in previous blocks (see Table 1).

Pen Set Used	Number of Previous Blocks Participants Placed Pens in Initial Configuration							
	1		2		3		4	
	Mean (SD)	Obs.	Mean (SD)	Obs.	Mean (SD)	Obs.	Mean (SD)	Obs.
Experimental	0.36 (0.5)	14	0.56 (0.5)	45	0.49 (0.51)	41	0.89 (0.31)	46
Neutral	0.36 (0.5)	14	0.65 (0.48)	40	0.48 (0.51)	40	0.87 (0.34)	52

Table 1. Likelihood of participants placing pens in the initial configuration in the final block of the task depending on the number of previous blocks that they placed the pens in the same configuration in Experiments 1a and 1b. The number of observation associated with a given cell is included.

EXPERIMENT 2

While the first experiment presents strong evidence that an object's spatial history influences spatial organization, this should not be taken to mean that effort does not. Rather, our putative spatial habits likely compete with effort/performance considerations in shaping how we organize space. Based on this idea, I predicted that participants would engage in effort minimization/performance maximization if the physical effort difference between the two locations was larger. To test this hypothesis, the distance between the two pen holders was increased in order to amplify the difference in effort between reaching for the far and close locations. In addition, to provide a strong test of our prediction, all participants began the experiment using the infrequent close-frequent far configuration. If participants are more likely to place the pens in the less effortful configuration in Experiment 2, then this would provide support for the idea that spatial habit and effort/performance are competing for expression in spatial organization.

Method

Participants

Twenty-five University of Waterloo students participated in this study for course credit or for pay. The same stopping rule in Experiments 1a and 1b was used (i.e., a minimum of 16 participants who correctly completed the task). Eight participants were excluded (3 due to equipment failure; 5 due to improper task completion). The mean age of the final sample ($N = 17$) was 21.23 ($SD = 1.89$); 15 identified as female. All participants were right-handed and had normal or corrected-to-normal vision.

Apparatus and Procedure

To increase effort, the closer pen holder was kept in the same location, but the far pen holder was moved 45 cm away from the closer pen holder horizontally (87 cm away from the participant). The experimental procedure was identical to that of Experiment 1b, except all participants began the task with the more frequently used pen in the far pen holder[1] and that participants completed one extra block to provide an even number of opportunities to configure both the experimental and neutral pen sets. In addition, participants were also asked to rate on a 6-point Likert scale how effortful they perceived the reaches to the close and far pen holders were.

Results

Manipulation Checks

Similar to the first experiment, participants perceived the frequent pen ($M = 78.24$, $SD = 11.85$ [75.28, 81.19]) to have been used more than the infrequent pen ($M = 21.76$, $SD = 11.85$, 95% CI [18.81, 24.72]) for the experimental pen sets, $t(16) = 9.82$, $p < .001$, $d = 2.38$; the neutral pens were perceived as being used equally frequently, $t(16) = .43$, $p = .67$, $d = .10$. Participants' confidence in their rating of the experimental and neutral pen frequencies were 4.71 ($SD = 1.05$) and 4.00 ($SD = 1.03$) respectively. Participants also completed neutral trials significantly more quickly when using the closer pen, $M = 4841$, $SD = 1017$, 95% CI [4784, 4899], than the farther pen, $M = 6426$, $SD = 1258$, 95% CI [6368, 6484], $t(16) = 14.12$, $p < .001$, $d = 3.42$. In addition, participants perceived reaching for the far pen holder ($M = 4.82$, $SD = .64$, 95% CI [4.75, 4.90]) to be more effortful than the close

[1] Participants were freely able to choose the initial configuration of the pens, but the experimenter manipulated the task such that whatever pen was placed in the far location would be used most frequently.

one ($M = 1.24$, $SD = .44$, 95% CI [1.16, 1.31]), $t(16) = 23.93$, $p < .001$, $d = 5.80$. Lastly, none of the participants expressed reluctance to move the pens from their initial positions.

Spontaneous Object Placement

Next, whether participants were more likely to place the more frequently used pen in the close pen holder for the experimental set was examined (see Figure 4). Indeed, a one-sample t-test revealed that participants were more likely than chance to place the pens in the less effortful configuration ($M = 0.72$, $SD = .27$ [0.58, 0.85]), $t(16) = 3.38$, $p = 0.004$, $d = 0.82$. A weighted contrast was conducted to examine differences in individuals' tendency to minimize effort in Experiment 1a/b and Experiment 2. To provide an accurate comparison, only participants in Experiment 1a and 1b that completed the same counterbalance as in Experiment 2 were selected for this analysis. It was found that participants in Experiment 2 were indeed more likely to place pens in the less effortful configuration compared to those in Experiments 1a and 1b, $t(47) = 3.43$, $p = .001$, $d = 1.06$ (Cohen's d is calculated based pooling equally-weighted standard deviations from all three samples). See Figure 5 for a distribution of the proportion of individuals who placed more frequently used pens in the less effortful configuration.

In addition, whether there was a tendency to place pens in the initial configuration for the neutral set was also examined. However, unlike Experiment 1a and 1b, there was no initial bias for the neutral set, $M = .41$, $SD = .22$, 95% CI [.30, .52], $t(16) = 1.67$, $p = .11$, $d = .41$. While not significant, the latter effect likely reflects the fact that the neutral blocks in Experiment 2 always followed the experimental blocks and the latter encouraged the pen locations to be reversed, since the difference in effort was more salient in the current experimental block. This issue will be further discussed in the General Discussion.

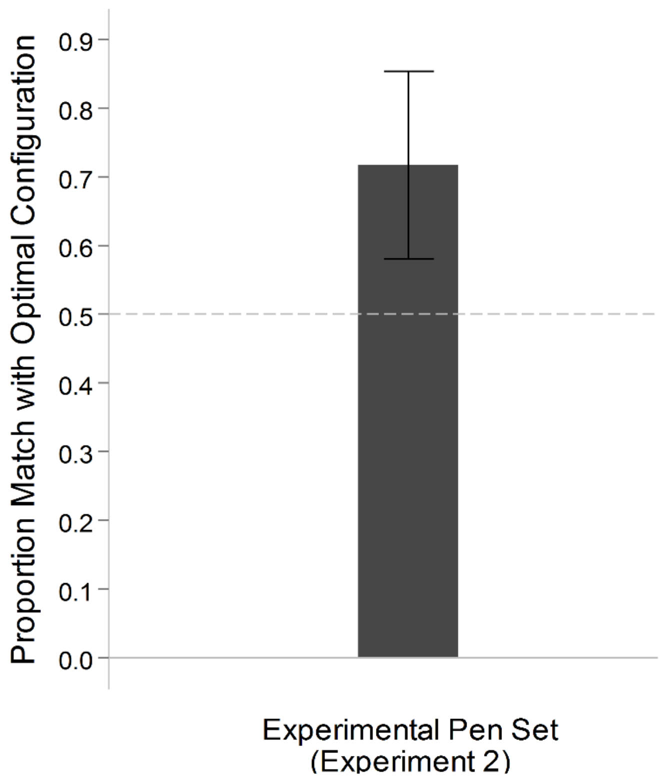

Figure 4. Proportion of blocks in which participants' pen placements matched the less effortful, frequent close-infrequent far configuration for the experimental pen set. With increased physical effort in Experiment 2, participants were more likely than chance to place pens in the less effortful configuration even when they began the task in the infrequent close-frequent far position. Error bars represent 95% CI.

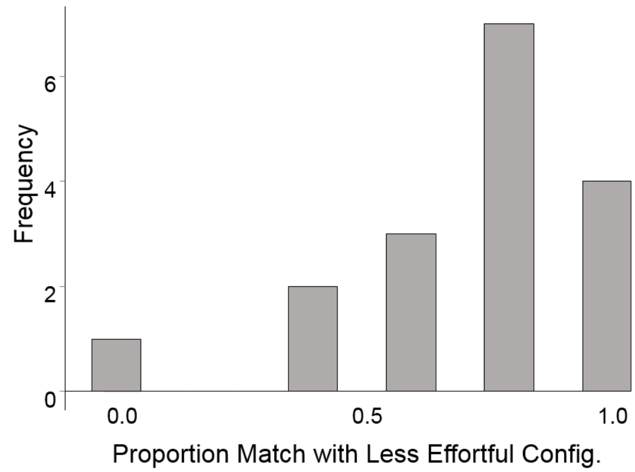

Figure 5. Frequency of distribution of portions in which participants' configurations match with the less effortful configuration in E2.

Discussion

Unlike Experiment 1, participants in Experiment 2 reconfigured the pens in a manner that would minimize physical effort (or maximize performance) when the distances between the object locations were increased. Critically, the only difference between Experiments 1a and 1b and Experiment 2 was the increased distances between the pens, which increased the difference in the effort required to reach to each location. Overall, these results are consistent with the idea that the effect of an object's spatial history competes with effort/performance considerations in the determination of spontaneous object placement.

GENERAL DISCUSSION

Despite the important role that the physical environment plays in shaping human cognition, few studies to date have endeavored to evaluate, experimentally, how individuals spontaneously organize their space. To bridge this gap, the present experiments tested the intuitive hypothesis that humans would organize their space in order to minimize effort or maximize performance. In Experiment 1a and 1b, I demonstrated that individuals were strongly influenced by an object's past spatial history; they maintained an object's original location despite the fact that this spatial configuration was physically more effortful and less time efficient for task completion. However, Experiment 2 demonstrated that this bias could be overcome when the physical effort to complete a task was increased. Together, the current experiments suggest that human spatial organization is likely driven by multiple – and potentially competing – factors, including (minimally) an object's spatial history and effort/performance considerations.

As discussed earlier, the influence of spatial history on object organization can be conceptualized as a kind of habit formation (Wood & Neal, 2007): a reflexive coupling between context (i.e., specific pen colours) and action (i.e., reaching far vs. near). A number of patterns support this idea. For example, once shaped, habits are robust and are consistently and reflexively triggered by the context associated with their initial acquisition (Wood, Quinn, & Kashy, 2002). Consistent with this notion, individuals in the present investigation maintained the initial configurations of objects despite it being more effortful for task execution. In addition, the strength of association between a given context and action can also influence habit formation (e.g., Goedert & Willingham, 2013) and, in Experiments 1a and 1b, the more individuals had used a given configuration prior to the final block, the more likely individuals were to place objects in that same configuration in the final block. Lastly, past experiments have shown that a formally learned context-action coupling can inhibit the formation of subsequent ones (Wood & Neal, 2007). This latter effect might help to explain the lack of an initial position bias in the neutral blocks of Experiment 2 when it was constrained to always follow the experimental blocks. In this sense, the colour-location association for the second pen pair (neutral set) may be weaker than the colour-location association formed in the very first block.

While the formation of habits when organizing objects in space may seem counterintuitive, Experiment 2 demonstrates clearly that these habits can be overcome. Specifically, individuals shifted toward a more efficient spatial organization when the cost for maintaining their spatial habits became more salient, presumably to increase the ease with which they functioned within the task space (Kirsh, 1995). Thus, the influence of spatial history can be overridden in the face of salient effort/performance costs.

CONCLUSION

Although the current experiments point to two factors that govern human spatial organization, this is likely not an exhaustive list. Further, the relation between these factors may be modulated by individual differences (Gosling, Craik, Martin, & Pryor, 2005; Gosling, 2009). Critically, the novel spatial organization paradigm developed here could be used as a simple tool to address these and other fundamental questions regarding how we structure our physical environments. Altogether, the current experiments mark an exciting first step towards a more systematic science of human spatial organization.

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APPENDIX A

Task Instructions

In this task, you will be writing down the symbols presented to you on this screen using the coloured pen that matches the colour of the symbol. For example, if the symbol is red, use the red pen to write down that symbol. You will be writing down your answers on the paper provided to you by the experimenter. Please note that some of the symbols will be familiar and others not. Try to copy the presented symbol as accurately and quickly as possible. At the beginning of each block, you will be instructed to place one set of pens in the pen holders (only ONE pen can be placed in each pen holder at one time). After you have finished writing down the symbol, you MUST put the pen back in the pen holder. Proceed to the next trial by pressing the space bar USING YOUR DOMINANT (RIGHT) HAND. You will be switching between TWO sets of pens in alternating blocks. The instructions on the screen will tell you when you will need to switch the pens. If you have any questions at this point, please ask the experimenter.

(next slide)

Before we begin the first block, please make sure that the pens from SET 'A' [colours of the pens in E1a] are in the pen holders. You may place them in any order you like, but make sure that only ONE pen goes in each pen holder. Remember:

1) NEVER use your LEFT HAND during the task

2) Always PUT THE PEN BACK IN THE PEN HOLDER after each trial

Try to copy the presented symbol as accurately and quickly as possible. When you are ready, press the SPACE BAR to begin.

APPENDIX B

Stimuli Used in Task

£	ƞ	9	M	あ
@	δ	2	Q	の
♂	β	3	k	よ
&	Ɛ	4	f	く