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# Visual Search With Varying Versus Consistent Attentional Templates: Effects on Target Template Establishment, Comparison, and Guidance

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Attentional templates can be represented in visual working memory (VWM) when the target varies from trial-to-trial and can be represented in long-term memory (LTM) when the target is consistent during trial runs. Given that attentional templates can be represented in either VWM or LTM, are there any differences in how these representations impact visual search when targets are consistent compared with varying? The current study tested the consistent template hypothesis, which predicts faster performance with a consistent target compared with a varying target. Experiment 1 examined whether consistent targets could lead to consistent templates that would improve template establishment, guidance, and/or comparison of the template to search items. Search response time was faster for consistent targets, and consistent targets produced faster comparison processes, but not more efficient guidance. Experiment 2 examined the consistent template restoration hypothesis, which predicts faster template establishment and comparison processes for a previously encountered consistent target. Experiment 2 replicated the consistent template hypothesis and supported the consistent template restoration hypothesis. These studies demonstrate that although attentional guidance is similar with varying and consistent attentional templates, consistent templates improve search performance by speeding template establishment and comparison processes.

***Public Significance Statement***

Throughout the day we are often searching for various items that we need to use. We may need to search for our car keys multiple times: at home, at work, and at a friend's place. Or we may have to search for the toy we just bought our child, the file we just received from our boss, and the mail right after we put it down. Is the search more efficient if we are searching for the same item multiple times (e.g., every morning I search for my daughter's favorite stuffed animal) as compared with when we search for a new item (e.g., searching for my daughter's new toy). Does the repetition of a search object improve our performance in the task compared with when the objects of our search keep changing? If it does improve our search performance, what aspect of search is improved: initiating search (target establishment), selecting items to search (guidance), or recognition of our target (comparison)? We addressed these questions by monitoring eye movements to isolate target establishment, guidance, and comparison for a visual search task with a repeated and/or changing target. The results showed that search was more efficient for repeated targets, in particular, search was initiated faster and the template was compared with search items more quickly. The selection of items (i.e., guidance) was not improved. These results suggest repeated targets improve performance, but not by improving guidance.

*Keywords:* attentional templates, eye tracking, visual search



When completing a visual search task for a known target, an attentional template (i.e., a mental representation of the target) can be created and used to bias attention to similar features in the visual environment and to aid recognition of potential targets (Bravo & Farid, 2009, 2012, 2014; Duncan & Humphreys, 1989). In a target preview visual search task, a target cue (i.e., a pictorial presentation of the target) is presented prior to a visual search array, and participants create a memory representation of the target (i.e., an attentional template). When the target cue changes on every trial, visual working memory (VWM) is used for attentional template maintenance (Carlisle, Arita, Pardo, & Woodman, 2011; Woodman & Arita, 2011). However, if the same target cue repeats across several trials, there is evidence that long-term memory (LTM) can maintain attentional templates (Carlisle et al., 2011; Gunseli, Olivers, & Meeter, 2014; Reinhart, Carlisle, & Woodman, 2014). What is not well understood is the degree to which changing versus repeated target cues lead to templates that function differently and/or lead to different effects on visual search

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Portions of these experiments can be found in Rebecca R. Goldstein's unpublished dissertation and were presented as a poster at the Object, Perception, Attention, & Memory, 2016 meeting in Boston, MA.

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performance. The present study used eye tracking to measure the effects of each type of attentional template representation on visual search processes.

There is evidence to support the storage of attentional templates in VWM. For example, neural activity that is thought to represent storage in VWM is present when attentional templates are needed for visual search tasks. Contralateral delay activity (CDA) is an event-related potential that appears 300 ms after the onset of a stimulus and has been found to index the contents of VWM (Vogel & Machizawa, 2004). The amplitude of the CDA increases as the number of items in VWM increases. The CDA is present following presentation of a target cue, demonstrating that VWM maintains the attentional template (Carlisle et al., 2011). Carlisle et al. (2011) presented participants with one or two targets prior to a visual search task. The CDA was found following target preview onset with one target, and the amplitude of the CDA increased when the target preview contained two targets. These data support the conclusion that a representation of a target, that is used to complete the search task, is stored in VWM following target preview.

Although studies support the use of VWM representations during visual search (Kumar, Soto, & Humphreys, 2009; Soto, Heinke, Humphreys, & Blanco, 2005), there is also evidence to support the use of LTM representations. When the target is the same from trial-to-trial (i.e., consistent target), the CDA nearly disappears as compared with when the target changes on every trial (i.e., varying target). The CDA is diminished in as few as three consistent trials and is nearly absent in seven consistent trials (Carlisle et al., 2011; Gunseli et al., 2014). This elimination of the CDA within three to seven consistent target trials has been interpreted as evidence of the passing of the attentional template from VWM to LTM (Carlisle et al., 2011; Gunseli et al., 2014; Reinhart et al., 2014). Therefore, VWM templates may not be needed for attention control when there is target repetition across trials.

Given that an attentional template can be represented in VWM or in LTM, is attentional guidance similar or different depending on the type of representation? The role of LTM in maintaining attentional templates is supported by a smaller/absent CDA with a consistent target compared with a varying target (Carlisle et al., 2011; Gunseli et al., 2014; Reinhart et al., 2014). However, there is not strong evidence to support differences in search behavior when a VWM versus LTM attentional template is used. In Carlisle et al. (2011) study, although consistent target trial reaction times (RTs) were faster as more consistent trials were completed, RTs averaged across all consistent target trials were not faster than RTs for varying target trials (Carlisle et al., 2011). Gunseli, Olivers, and Meeter (2014) reported that although overall RTs became faster with target repetition, RT $\times$ set size search slopes were not reduced with target repetition. Examining the effects of VWM versus LTM attentional templates on search performance may require a more sensitive search performance measure than RT.

Measuring eye movements during visual search can help determine the effect of target repetition on different processes involved in visual search: template establishment, guidance, and comparison. Using eye movement measures, the total RT on a search trial (i.e., the amount of time from when the search array is presented until a response is made) can be divided into multiple stages (Castelhano, Pollatsek, & Cave, 2008): preparation, navigation, and target verification. The preparation stage is the time it takes to begin the search and is measured by the duration of the first fixation before the first saccade is executed (Malcolm & Henderson, 2009, 2010). The efficiency of both template establishment and guidance processes can impact the length of this stage. Programming the first saccade may be delayed until a sufficient template is established. Information in the target template is then used along with peripheral visual information to guide attention to the first fixated item (Malcolm & Henderson, 2009, 2010). If the attentional template is not yet sufficiently established prior to executing the first saccade, establishment of the template can carry over into the navigation stage. The navigation stage includes the time from the first saccade on the display to the start of the first fixation on the target (Castelhano et al., 2008). During navigation, guidance occurs and can be measured by the number of distractors fixated. The comparison process also occurs during navigation in that each fixated distractor is compared with the target template, and this process can be measured by the dwell time on the distractors. The target verification stage is defined as the time from the start of the first fixation on the target until a response is made (Castelhano et al., 2008). During the target verification stage the comparison process for the target occurs and can be measured by the length of the verification stage and dwell time on the target. Measuring eye movements provides multiple measures (length of preparation, length of navigation, number of fixations on distractors, dwell time on distractors, length of verification and dwell time on target) to test hypotheses about how each process (template establishment, guidance and comparison) is affected by consistent and varying attentional templates.

Consistent and varying attentional templates may differ in the amount of time needed to establish the attentional template. A varying attentional template requires time to be fully formed before it is effective in guiding search (Vickery, King, & Jiang, 2005; Wolfe, Horowitz, Kenner, Hyle, & Vasan, 2004), and a consistent template may require less time. Wolfe et al. (2004) demonstrated that a 50-ms stimulus onset asynchrony (SOA) resulted in slower RTs for a varying target than for a consistent target, whereas a 200-ms SOA allowed for equivalent RTs for varying and consistent targets. This suggests that, after 200 ms, VWM templates are as established as LTM templates, but at 50 ms, LTM templates are more established than VWM templates. Differences in the time needed to establish consistent versus varying attentional templates may affect the preparation and/or navigation stages. If search is initiated prior to the template being completely set up, template establishment would continue into the navigation stage and prevent efficient guidance to the target. Neither Wolfe et al. (2004) nor Carlisle et al. (2011) measured eye movements, which would allow for the preparation and navigation stages to be measured. Furthermore, Carlisle et al. (2011) likely did not find an RT difference due to differences in the preparation or navigation stages because they used a 900-ms interstimulus interval (ISI) which is too long to detect a difference that occurs in less than 200 ms. Therefore, it remains unknown how establishing consistent attentional templates versus varying attentional templates affects preparation and navigation stages, especially for short ISIs between the target preview and the search array. In the current study, two ISIs are used: a long ISI (900 ms) and a short ISI (50 ms). The short ISI should encourage differences in preparation and/or navigation stages if varying templates require more time to be established than consistent templates (Establishment Hypothesis).

Varying versus consistent attentional templates may also differentially affect the process of guiding attention to items in the search array that are similar to the attentional template. Carlisle et al. (2011) may have not found RT differences between consistent and varying targets because the design of the search array lead to a very short navigation stage. When the search array contains distractors that share features of the target, RTs are generally slower because a longer attentional guidance process is needed (Duncan & Humphreys, 1989). Alternatively, targets that are distinct from the distractors result in very fast search, often referred to as pop-out search (Treisman & Souther, 1985). In the current study, the distractors were chosen such that a longer guidance process was necessary to detect the target. If the consistent attentional templates are more informative and allow for attention to be more efficiently guided to the target, then the navigation stage of search should be shorter with a consistent target (Guidance Hypothesis).

It is also unknown how consistent versus varying templates affect the process of comparing the attentional template to the targets and the distractors to decide whether a fixated item is the target. Both the navigation and target verification stages involve comparisons between the attentional template and items in the search array. Therefore, evidence for faster comparison with consistent templates may be found with (a) shorter target verification stage, (b) shorter dwell time on distractors during the navigation stage, and/or (c) shorter dwell time on the target during the target verification stage (Comparison Hypothesis).

The primary aim of the current study was to determine whether varying and consistent attentional templates lead to differences in search performance: the consistent template hypothesis. The consistent template hypothesis predicts that consistent target templates lead to faster performance (e.g., shorter RTs) as compared with varying target templates. Participants searched for a square of a specific color among 11 different colored squares. The search arrays contained multiple colors so that there would be no pop-out search and a longer guidance process would be required. The target cue was a square in the color of the target (a square with a gap on one side). The target cue color was either consistent across a block or varied across a block. Consistent targets repeated for 30 trials, and then a new target color was randomly chosen to repeat for the next 30 trials. For analysis, trials in each block were divided into bins of 6 trials and then performance for each bin was averaged across blocks. Based on previous research, the effects of a consistent target may be present within the first bin of 6 consistent trials and should be present by the second bin of 6 consistent trials (Carlisle et al., 2011; Gunseli et al., 2014).

Given that there is evidence to support the consistent template hypothesis, the current study monitored eye movements during the different stages of visual search (i.e., preparation, navigation, and target verification) to determine the specific processes (template establishment, guidance, and comparison) that are differentially impacted by consistent and varying attentional templates. Attentional templates require time to be established (Eimer, 2014; Malcolm & Henderson, 2009, 2010; Vickery et al., 2005; Wolfe et al., 2004), and this time may be longer for varying templates than for consistent templates. The establishment hypothesis predicts a longer preparation and/or a longer navigation stage for varying targets when there is a short ISI between the cue and the search array. Consistent templates may be more efficient for guiding attention. The guidance hypothesis would be supported by a shorter preparation or a shorter navigation stage due to fewer fixated distractors for consistent targets. Consistent templates may also improve the comparison process between the attentional template and the search items. The comparison hypothesis would be supported by longer dwell times on distractors and longer target verification stages for varying targets.

# Experiment 1

## Method

**Participants.** Participants were recruited from the Louisiana State University subject pool and received course credit for their participation. Analysis included 128 participants (32 consistent ISI 50, 32 consistent ISI 900, 32 varying ISI 50, and 32 varying ISI 900) from the 130 collected participants after two participants were excluded for performing below chance (50%). The analyzed sample included 100 females and 28 males with an average age of 19 years. Participants reported normal or corrected to normal vision and normal color vision (data were missing for 3 participants).

**Design.** The experiment was a 2 × 2 × 5 mixed model. The between subjects factors were target type (consistent vs. varying) and ISI (50 ms vs. 900 ms). The within subjects factor was bin (within each block of 30 trials, there were 5 bins of 6 trials each).

**Materials.** An EyeLink 1000 Plus tracker (SR Research LTD, Canada) was used to detect eye movements on a 24-in. Benq monitor with a resolution of 1920 × 1080 pixels. The eye tracker tracked the dominate eye of the participant. Head movements were stabilized with a chin rest positioned 93 cm from the monitor.

Search arrays consisted of 12 Landolt squares maintaining a visual angle of 0.33° × 0.33° with a line thickness maintaining a visual angle of 0.1° in a circular design. A gap sustaining a visual angle of 0.07° was located on either the right or left side of the square. Each square was a unique color that was randomly chosen from 14 possible colors (blue [RGB 0, 0, 225], light blue [RGB 0, 90, 255], brown [RGB 150, 98, 72], brown/red [165, 42, 42], gray [RGB 138, 138, 138], dark gray [RGB 70, 70, 70], green [RGB 0, 144, 0], olive green [RGB 114, 143,0], orange [RGB 250, 162, 0], pink [RGB 244, 0, 163], purple [RGB 97, 5, 226], red [RGB 255, 0, 0], red/orange [RGB 254, 110, 13], turquoise [RGB 0, 206, 209]). The target cue display consisted of one square without a gap.

**Procedure.** Informed consent was provided by the participants prior to starting the experiment. The instructions were presented on screen and read aloud to the participants. Participants were informed that a colored outlined square would be presented before the search array, and that their objective was to find the outlined square with the same color in the search array and report the location of the gap (left or right) by button press. During eye-tracker set-up, participants completed a 13-point calibration and validation procedure. Calibration and validation were deemed successful when average error is at or below .5 and max error is at or below 1. Following eye-tracker set-up, participants were reminded of the instructions and completed two practice trials. Participants completed 240 trials broken into eight blocks of 30 trials. After each block, the eye tracker was recalibrated.

To start each trial the participants completed a drift correct that was followed by a 200 ms target cue screen. The target cue screen contained an outlined square that provided the participant with the color of the target (see Figure 1). A blank ISI screen followed the target cue screen for either 50 or 900 ms depending on the condition. Following the ISI screen the search array was presented with 12 items randomly placed around a circle with a diameter of 6.8° visual angle in the positions of a clock face. One square was the target with the same color as the target cue and contained a gap on either the right or left side, and the remaining 11 squares were distractors with unique colors and a left or right gap position. The search array was removed once the participant reported the location of the gap in the target by button press.

The consistent and varying conditions differed only in the following ways. In the consistent target condition, the color of the target was the same on all 30 trials in a block. A new target color was chosen randomly without replacement for each block. A distractor in a given block could not be the color of the target in the previous block. In the varying target condition, the target color was randomly chosen on each trial with the constraint that none of the distractors in the trial could be the color of the target on the previous trial. In both conditions, the target location and the location of the gap were randomly determined on each trial.

**Power.** To determine the number of participants needed to find a difference between target types at each bin, a power analysis was conducted. Cohen's *d* for a dependent samples *t* test was calculated using the data in experiment one of Chun and Jiang (1998). This study was used because the data had the difference we would predict if consistent targets produce faster guidance than varying targets. In Chun and Jiang (1998), participants searched for a T among Ls. Configurations were old (distractors in the same locations) if the configuration appeared once per block. New configurations were seen once and never again for the rest of the experiment. A dependent samples *t* test at epoch 6 (5 blocks equal one epoch) between new and old contexts found old to be significantly faster. Using the sample size, standard error, and means, a Cohen's *d* was calculated, for a dependent samples *t* test, of 0.47 for the difference, which is approaching a medium effect. The effect size of 0.47 was entered in G*Power 3.1.7 (Faul, Erdfelder, Lang, & Buchner, 2007) for an independent samples *t* test. The results of this analysis called for 73 participants per group. Since the current design is not exactly the same as Chun and Jiang (1998), the *N* was set to 32 for each group and once each group had 16 participants the effect size for the current experiment was calculated. Cohen's *d* for an independent samples *t* test was calculated for target type (consistent, varying) at bin 5. The calculated Cohen's *d* was 0.54 which is a medium effect. The results of the analysis using G*Power call for 44 participants per group assuming a power of .80. In the present study comparison of interest is target type by bin at bin 5 and collapsing across ISI to make the comparison would create 64 participants in each group. For this reason, the number of participants in each group was kept at 32.

## Results

Participants' overall performance was good with 93.5% accuracy (consistent/50 ms = 94%, consistent/900 ms = 96%, varying/50 ms = 93%, and varying/900 ms = 91%). Inaccurate trials included incorrect responses (3.8%) and trials when the target was not fixated (2.7%). Trials were also excluded for RT more than three standard deviations above or below the participant's mean (1.6%).

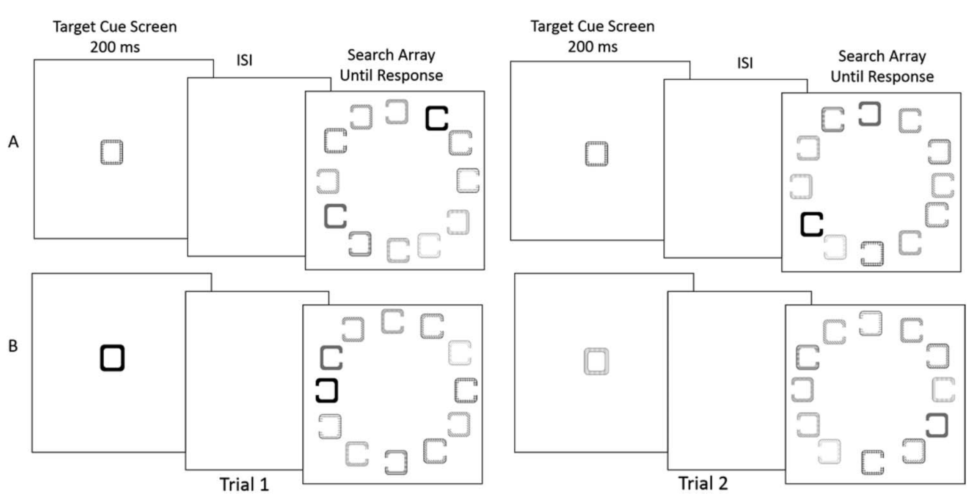


*Figure 1.* The trial sequence for both experiments presented the target cue screen followed by a blank ISI screen and ended with the search array screen that remained present until a response was made. The shades of gray and textures represent the different colors used for the stimuli. Each item in the search array was a unique color. In Experiment 1, the ISI between the target cue screen and the search array screen was 50 or 900 milliseconds depending on the condition. Row A shows the trial sequences for the consistent target condition. The target from Trial 1 is repeated as the target in Trial 2. Row B shows the trial sequences for the varying target condition. The target is different from Trial 1 to Trial 2 and the target color from Trial 1 does not appear in Trial 2. In Experiment 2, the ISI between the target cue screen and the search array screen was 50 milliseconds. Row A represents the first consistent target block, and row B represents block 2 which was the first varying target block. Participants completed 13 blocks starting and ending with a consistent target block.

For any instances in which the assumption of sphericity was violated when conducting an analysis of variance (ANOVA), Greenhouse-Geisser correction was used. ANOVAs were also analyzed using the BayesFactor package in R (Rouder, Morey, Speckman, & Province, 2012; Rouder, Morey, Verhagen, Swagman, & Wagenmakers, 2017). Each model's likelihood was calculated compared with the null and the model that was strongest compared with the null was used to calculate the reported Bayes Factors (BF) for the ANOVAs. For the ANOVA, $BF_x$ there is evidence that favors the alternative hypothesis and $1/BF_x$ means there is evidence that favors the null hypothesis. Along with every ANOVA, BFs are reported. All follow-up *t* tests (independent and paired) are scaled JSZ BFs. The Scaled JSZ BFs were computed with $BF_{10}$ values, in favor of the alternative hypothesis, and $BF_{01}$ values, in favor of the null hypothesis. BF less than 3 reported, but considered ambiguous evidence.

Dependent measures were first submitted to a 2 × 2 × 5 mixed factor ANOVA with target type (T, consistent vs. varying) and ISI (I, 50 vs. 900) as between subjects factors and with bin (B,1–5) as a within subjects factor. The 30 trials in each block were divided into 5 bins of 6 trials for analysis. That is, the first six trials of all the blocks were grouped together into the first bin, the next six trials of each block were grouped into the second bin, so on and so forth. A main effect of target type (T) or an interaction between bin and target type (T × B), with the consistent target leading to faster times at the later bins, is sufficient evidence for a consistent template leading to faster search processes than a varying template.

**Reaction time.** The model that best fit the RT data compared with the null contained target type, bin, and the target type by bin interaction. Consistent targets were found to produce faster RTs compared with varying targets, $F(1, 124) = 5.83$, $p = .017$, $\eta_p^2 = .045$, $BF_T > 1000$. Null hypothesis testing found no main effect of bin, $F(3.71, 460.42) < 1$, $p = .480$, $\eta_p^2 = .007$, however decisive evidence was found to support a bin effect ($BF_B > 1000$). More importantly, RTs appear to change across bins by target type as supported by decisive evidence for a target type by bin interaction, $F(3.71, 460.42) = 15.23$, $p < .001$, $\eta_p^2 = .109$, $BF_{T:B} > 1000$.

The decrease in RT across bins with a consistent target was supported by a linear trend, $F(1, 63) = 50.69$, $p < .001$, $\eta_p^2 = .446$. Bin 1 was slower than bin 5 with a consistent target ($p < .001$, $BF_{10} > 1000$). A linear trend was found with the varying targets, $F(1, 63) = 11.41$, $p = .001$, $\eta_p^2 = .153$, but contrary to the prediction a quadratic trend also fit the data, $F(1, 63) = 4.12$, $p = .047$, $\eta_p^2 = .061$. The varying target became slower from bin 1 to bin 5 ($p = .008$, $BF_{10} = 4.38$), however, bin 4 to bin 5 did not become slower ($p = .195$, $BF_{01} = 3.23$). RTs for the consistent condition were faster than the varying condition in the later bins (bin 2: $p = .041$, $BF_{10} = 1.28$; bin 3: $p = .01$, $BF_{10} = 4.21$; bin 4: $p = .002$, $BF_{10} = 15$; bin 5: $p = .002$, $BF_{10} = 17$), whereas there is substantial evidence for a lack of a difference in the earliest bin (bin 1 $p = .560$, bin 1 $B_{01} = 4.53$).

The only significant effect involving ISI was an interaction between ISI and bin, $F(3.71, 460.42) = 2.83$, $p = .028$, $\eta_p^2 = .022$, however the evidence was ambiguous to confirm the presence or absence of ISI by bin interaction ($1/BF_{B:I} = 2.24$). Strong evidence was found to confirm an absence of a three way interaction between target type, bin and ISI, $F(3.71, 460.42) = 1.61$, $p = .174$, $\eta_p^2 = .013$, $1/BF_{T:B:I} = 23.29$, but the evidence was ambiguous to confirm an absence of ISI effect, $F(1, 124) < 1$, $p = .738$, $\eta_p^2 = .001$, $1/BF_I = 1.63$.

The consistent template hypothesis was supported by the faster search exhibited by the consistent target compared with the varying target (see Figure 2). Eye movement data were used to calculate several variables (length of preparation, length of navigation, number of distractor fixated, dwell time on distractors, length of the target verification stage, dwell time on the target) to help

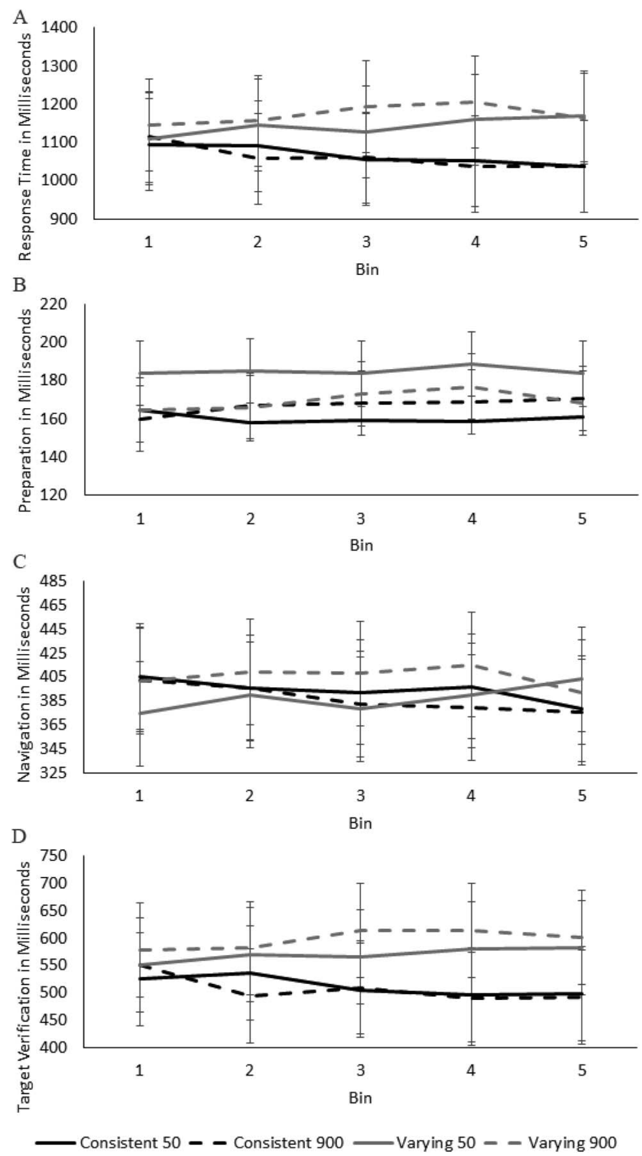


*Figure 2.* (A) Participants' response times in Experiment 1 for target type by interstimulus interval (ISI) in bin of six trials. (B) Preparation stage (ISI plus duration of the first fixation until the first saccade) for target type by ISI by bin of six trials. (C) Navigation stage (second fixation until the first fixation on the target) for target type by ISI by bins of six trials. (D) Target verification stage (from the first fixation on the target until a response is made) for target type by ISI by bins of six trials. Error bars denote confidence intervals based on the between-subjects factor target type (Masson & Loftus, 2003).

determine the search process or processes that produce faster search with a consistent target.

**Length of the preparation stage.** The establishment and guidance hypotheses predict an interaction between target type and ISI and/or a three-way interaction between target type, bin, and ISI during the preparation stage. Specifically, the preparation stage should be slowest with a varying target and 50 ms ISI. The model that best fit the preparation data compared with the null contained ISI, target type, bin, ISI by target type interaction, ISI by bin interaction, and target type by bin interaction. There was a significant interaction between ISI and target type, $F(1, 124) = 4.03$, $p = .047$, $\eta_p^2 = .031$, $BF_{T:I} = 1.67$, though evidence was weak. With the 50 ms ISI, consistent targets had a shorter preparation stage compared with varying targets ($p = .013$, $BF_{10} = 4.03$). With the 900 ms ISI, the preparation stage was similar between consistent and varying targets ($p = .605$, $BF_{01} = 3.49$). There was substantial evidence against a three way interaction, $F(2.59, 321.11) = 1.69$, $p = .177$, $\eta_p^2 = .013$, $1/BF_{T:B:I} = 5.09$.

There was substantial evidence for an effect of target type, $F(1, 124) = 6.32$, $p = .013$, $\eta_p^2 = .048$, $BF_T = 7.04$. There was also a significant interaction between target type and bin, $F(2.59, 321.11) = 2.92$, $p = .042$, $\eta_p^2 = .023$, $BF_{T:B} = 1.38$, though evidence was weak. A linear trend was not found with the consistent targets, $F(1, 63) = 3.37$, $p = .071$, $\eta_p^2 = .051$. For the varying targets a linear trend was found, $F(1, 63) = 5.39$, $p = .024$, $\eta_p^2 = .079$, however, contrary to predictions, quadratic, $F(1, 63) = 4.53$, $p = .037$, $\eta_p^2 = .067$, and cubic trends, $F(1, 63) = 5.23$, $p = .026$, $\eta_p^2 = .077$, were also found. Preparation remained the same from bin 1 to bin 5 ($p = .359$, $BF_{01} = 4.86$) with a varying target. The evidence comparing bin 1 to bin 4 ($p = .015$, $BF_{10} = 2.43$), and bin 4 to bin 5 ($p = .053$, $BF_{01} = 1.18$), was ambiguous. Taken together the evidence is not clear whether preparation became faster or remained the same across bins. Consistent targets had shorter preparation stages compared with varying targets for bins 1 through 4 (bin 1: $p = .023$, $BF_{10} = 2.05$; bin 2: $p = .022$, $BF_{10} = 2.11$; bin 3: $p = .011$, $BF_{10} = 3.74$; bin 4 = .009, $BF_{10} = 4.74$), but not for bin 5 ($p = .06$, $BF_{01} = 1.04$).

Looking beyond interactions of ISI with target type as evidence for the establishment hypothesis, it is worth noting that there is some evidence that bin and ISI independently affected the length of time before the first saccade (see Figure 2). There was very strong evidence for an effect of bin, $F(2.59, 321.11) = 3.94$, $p = .012$, $\eta_p^2 = .031$, $BF_B = 65.59$. Although there was no main effect of ISI, $F(1, 124) < 1$, $p = .434$, $\eta_p^2 = .005$, there was strong evidence supporting an ISI effect on preparation ($BF_I = 42$). An interaction was found between ISI and bin, $F(2.59, 321.11) = 5.22$, $p = .003$, $\eta_p^2 = .040$, $BF_{B:I} = 42$.

**Length of the navigation stage.** The guidance hypothesis predicts a main effect of target type and/or an interaction between target type and bin. None of the models fit the navigation data better than the null. There was no evidence for an effect of target type, $F(1, 124) < 1$, $p = .691$, $\eta_p^2 = .001$, $1/BF_T = 2.94$, and strong evidence was found for the absence of an effect of bin, $F(4, 496) = 1.39$, $p = .236$, $\eta_p^2 = .011$, $1/BF_B = 40.7$. Although there was an interaction between target type and bin, $F(4, 496) = 3.45$, $p = .009$, $\eta_p^2 = .027$, there was also strong support for the absence of this interaction ($1/BF_{T:B} = 54.31$). A linear trend was found for the consistent targets with navigation time decreasing across bins, $F(1, 63) = 16.57$, $p < .001$, $\eta_p^2 = .208$, and the navigation period became shorter from bin 1 to bin 5 with a consistent target ($p < .001$, $BF_{10} = 208$). A linear trend was not found with the varying targets, $F(1, 63) = 1.71$, $p = .196$, $\eta_p^2 = .026$. Furthermore, there is strong evidence that consistent and varying targets resulted in similar performance at each of the bins during the navigation stage (bin 1: $p = .314$, $BF_{01} = 3.33$: bin 2: $p = .793$, $BF_{01} = 5.13$: bin 3: $p = .703$, $BF_{01} = 4.95$; bin 4: $p = .385$, $BF_{01} = 3.75$; bin 5: $p = .216$, $BF_{01} = 2.62$). Guidance was not more efficient with a consistent target (see Figure 2).

A short ISI may not only delay the first saccade but may also lengthen navigation time due to inadequate template preparation or guidance preparation. Therefore, the establishment and guidance hypotheses predict an interaction between target type and ISI and/or a three-way interaction between target type, bin and ISI during the navigation stage. There is strong evidence for target establishment not having an effect on the navigation stage of search, as ISI had no effect on performance during navigation. There was no main effect of ISI, $F(1, 124) < 1$, $p = .683$, $\eta_p^2 = .001$, $1/BF_I = 2.9$, no interaction between ISI and target type, $F(1, 124) < 1$, $p = .386$, $\eta_p^2 = .006$, $1/BF_{T:I} = 15.58$, no interaction between ISI and bin, $F(4, 496) = 1.07$, $p = .372$, $\eta_p^2 = .009$, $1/BF_{B:I} > 1000$, and no three-way interaction between ISI, target type, and bin, $F(4, 496) = 1.90$, $p = .109$, $\eta_p^2 = .015$, $BF_{T:B:I} > 1000$.

**Number of distractors fixated.** The guidance hypothesis predicts fewer distractors will be fixated with a consistent target. The number of distractors fixated during navigation without replacement were analyzed (see Figure 3). The model that best fit the data compared to null contained bin. A main effect of target type was not found, $F(1, 124) < 1$, $p = .322$, $\eta_p^2 = .008$, $1/BF_T = 2.37$. Although a significant interaction between target type and bin was found, $F(4, 496) = 2.41$, $p = .048$, $\eta_p^2 = .019$, there was substantial evidence against the interaction ($1/BF_{T:B} = 6.53$). The evidence supporting fewer distractors fixated in bin 1 in the varying target condition versus the consistent target condition is mixed ($p = .027$, $BF_{10} = 1.78$). There is substantial evidence that the number of distractors fixated was similar for both target types at the remaining bins (bin 2: $p = .369$, BF01 = 3.66; bin 3: $p = .337$, $BF_{01} = 3.47$; bin 4: $p = .604$, $BF_{01} = 4.68$; bin 5: $p = .881$, $BF_{01} = 5.16$). There was very strong evidence to support a bin effect, $F(4, 496) = 8.43$, $p < .001$, $\eta_p^2 = .064$, $BF_B > 1000$), and substantial evidence points to an absence of an interaction between target type, bin, and ISI, $F(4, 496) < 1$, $p = .768$, $\eta_p^2 = .004$, $1/BF_{T:B:I} = 6.35$.

**Dwell time on distractors.** The comparison hypothesis predicts dwell time on distractors during the navigation stage will be shorter with a consistent target. The model that best fit the dwell time on distractors during navigation data compared with the null contained target type. Consistent targets produced shorter dwell times on distractors compared with varying targets, $F(1, 124) = 6.38$, $p = .013$, $\eta_p^2 = .049$, $BF_T = 8.98$. There was very strong evidence regarding no interaction between target type and bin, $F(4, 496) = 1.9$, $p = .109$, $\eta_p^2 = .015$, $1/BF_{T:B} > 1000$ (Figure 3) and no three way interaction between target type, bin, and ISI, $F(4, 496) < 1$, $p = .796$, $\eta_p^2 = .003$, $1/BF_{T:B:I} > 1000$.

**Length of the target verification stage.** The comparison hypothesis predicts a main effect of target type and/or an interaction between target type and bin during the target verification stage, because a consistent target will result in faster comparison

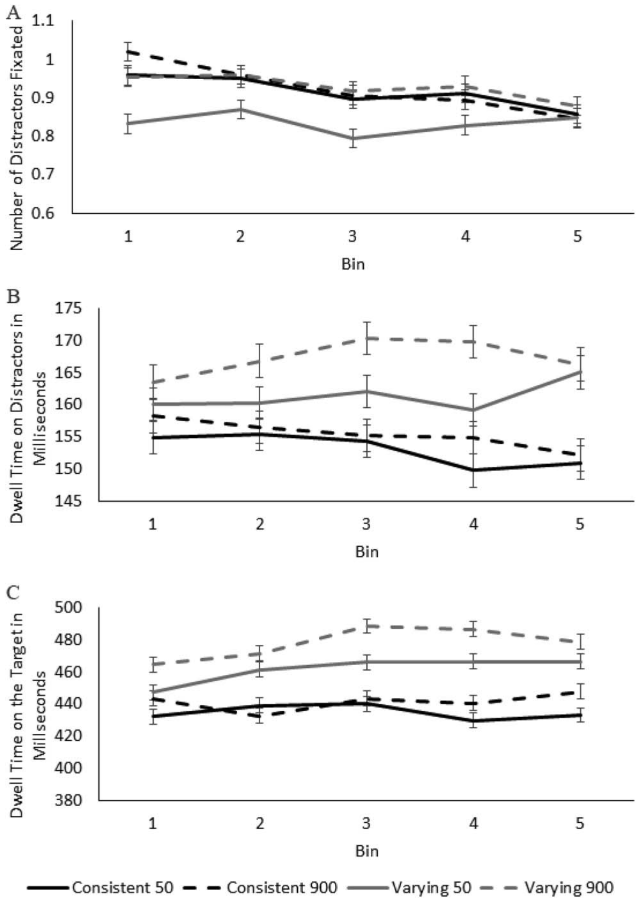


*Figure 3.* (A) Number of distractors fixated during the navigation stage without replacement for target type by interstimulus interval (ISI) in bins of six trials. (B) Dwell time on distractors during the navigation stage for target type by ISI in bins of six trials. (C) Dwell time on the target during the target verification stage for target type by ISI in bins of six trials. Error bars denote confidence intervals based on the between-subjects factor target type (Masson & Loftus, 2003).

processes. The model that best fit the target verification stage data compared with the null contained ISI, target type, bin, ISI by bin interaction, and a target type by bin interaction. Consistent targets produced a faster target verification stage (see Figure 2) compared with varying targets, $F(1, 124) = 7.10$, $p = .009$, $\eta_p^2 = .054$, $BF_T > 1000$, and an interaction was found between target type and bin, $F(3.38, 419.21) = 11.76$, $p < .001$, $\eta_p^2 = .087$, $BF_{T:B} > 1000$. A linear contrast was fit to the consistent target data across bins, $F(1, 63) = 32.3$, $p < .001$, $\eta_p^2 = .339$, however, contrary to predictions, a quadratic trend also fit the data, $F(1, 63) = 4.23$, $p = .044$, $\eta_p^2 = .063$. Verification time for consistent targets became shorter from bin 1 to bin 5, ($p < .001$, $BF_{10} > 1000$). A linear contrast also fit the varying target data cross bins, $F(1, 63) = 7.76$, $p = .007$, $\eta_p^2 = .110$. The evidence was ambiguous to determine if verification time for varying targets became slower from bin 1 to bin 5 ($p = .027$, $BF_{10} = 1.47$). The target verification stage was shorter with a consistent target compared with a varying target in the later bins (bin 2: $p = .032$ $BF_{10} = 1.56$; bin 3: $p = .006$, $BF_{10} = 6.21$; bin 4: $p = .001$ $BF_{10} = 45.11$; bin 5: $p = .001$ $BF_{10} = 33.35$), and evidence supports no difference in the duration of the verification stage for bin 1 ($p = .357$, $BF_{01} = 3.59$).

In addition to the effects important to support the comparison process, other effects found for the length of the target verification stage include the following: (a) the lack of a main effect of bin, $F(3.38, 419.21) < 1$, $p = .724$, $\eta_p^2 = .004$, but there was very strong evidence in favor of a bin effect ($BF_B > 1000$); (b) an interaction between bin and ISI, $F(3.38, 419.21) = 3.65$, $p = .01$, $\eta_p^2 = .029$, $BF_{B:I} = 1.67$, but the evidence was ambiguous; and (c) strong evidence in support of an absence of a three-way interaction, $F(3.38, 419.21) = 1.22$, $p = .302$, $\eta_p^2 = .010$, $1/BF_{T:B:I} = 10.79$.

**Dwell time on the target.** The shorter target verification stage may also be due to shorter dwell time on the target. The model that best fit the dwell time on the target compared with the null contains target type, bin, and target type by bin interaction. The main effect of target type was not significant, $F(1, 124) = 2.96$, $p = .090$, $\eta_p^2 = .023$, $BF_T = 2.30$. There was an interaction between target type and bin, $F(3.18, 393.87) = 3.42$, $p = .016$, $\eta_p^2 = .027$, $BF_{T:B} = 1.88$; Figure 3, but the evidence is weak. Strong evidence was not found to either confirm or reject speeded target rejection for consistent targets compared with varying targets at each bin (bin 1: $p = .325$, $BF_{01} = 3.4$; bin 2: $p = .096$, $BF_{01} = 1.49$, bin 3: $p = .069$, $BF_{01} = 1.16$; bin 4: $p = .034$, $BF_{10} = 1.51$; bin 5: $p = .092$, $BF_{01} = 1.43$). There was support for a main effect of bin, $F(3.18, 393.87) = 4.53$, $p = .003$, $\eta_p^2 = .035$, $BF_B = 15.71$, and very strong evidence against a three-way interaction between target type, bin, and ISI, $F(3.18, 393.87) < 1$, $p = .464$, $\eta_p^2 = .007$, $BF_{T:B:I} = 135.28$.

## Discussion

Experiment 1 supported the consistent template hypothesis; search for a consistent target was faster than for a varying target. The comparison process was faster for consistent templates, suggesting that consistent templates function differently than varying templates during the comparison processes. During the target verification stage, the time needed to verify and respond to consistent targets was reduced compared with varying targets. Given that consistent targets have been argued to be in LTM (Carlisle et al., 2011), this suggests that the process of comparison is more efficient with a LTM template than with a VWM template. A faster comparison process can allow for faster rejection of distractors and/or faster identification of the target. During the navigation stage, dwell times on distractors were shorter for consistent target searches, but there was not strong evidence to support shorter dwell times on the target with a consistent target (see Table 1).

There was also evidence to support the establishment hypothesis. Search initiation was slower for varying targets than for consistent targets. There was weak evidence to support that search was slowest for the varying target with a short ISI. Although both of these effects could also be attributable to slower guidance when planning the first saccade, there was no evidence of a consistent target effect on guidance during the navigation stage.

The guidance hypothesis predicts a shorter navigation period and fewer distractors fixated with a consistent target. However, the consistent targets did not provide more efficient guidance or reduce the number of distractors fixated compared with varying targets, suggesting that the guidance provided by consistent and

Table 1
*Support for Consistent Template Effects for Each Dependent Variable and Each Process in Experiment 1*

| Variable | Establishment | Guidance | Comparison |
|---|---|---|---|
| Length of the preparation stage | ✓ | ✓ | |
| ISI interaction with length of preparation stage | ✓(w) | ✓(w) | |
| Length of the navigation stage | | **x** | |
| Number of distractors fixated | | **x** | |
| Dwell time on distractors | | | ✓ |
| Length of the verification stage | | | ✓ |
| Dwell time on target | | | ✓(w) |

*Note*. The table above organizes results with regard to either a main effects of target type or an interaction between target type and bin. ✓indicates strong support from null hypothesis testing and Bayes. **x** indicates no support or strong evidence against. (w) beside a ✓ indicates a significant null hypothesis test with weak Bayes support.



varying targets is similar. This finding is in line with recent work demonstrating the N2 posterior-contralateral (an index of attention allocation, N2pc) activity produced by a LTM attentional template is similar to the activity produced by a VWM attentional template (Grubert, Carlisle, & Eimer, 2016). It is important to note that overall, participants' fixated less than one distractor per trial. A search task that required a more lengthy navigation period could reveal effects not evident in the current study.

In summary, Experiment 1 supported the consistent template hypothesis. RTs became faster with a consistent target and this finding was attributable to faster target verification and preparation stages. Experiment 1 also found evidence against the guidance hypothesis. Experiment 2 aimed to further investigate the benefits of consistent templates, particularly the effect of reencountering a previous consistent target was examined.

## Experiment 2

A LTM template has been postulated to reflect the automatization of the visual search task (Carlisle et al., 2011; Woodman, Luck, & Schall, 2007). A run of trials with a consistent target during a visual search task improves performance and decreases the CDA as evidence of the automatization. However, when there is an intervening new target color between runs of a consistent target (e.g., runs with a red target interrupted by runs with nonred targets), each time a previously consistent target run begins (e.g., another run with the red target), the automatization of the search task is absent as indexed by the presence of CDA activity. Previous research has suggested this automatization is not transferred to new encounters with a former consistent target (Carlisle et al., 2011). Instead, new encounters appear to recruit VWM again until automatization is restored. Experiment 2 examined the effects of restoration on the processes involved in visual search (target establishment, guidance, and comparison).

To examine the restoration of a previously used consistent template, participants completed alternating blocks of consistent and varying targets, and the consistent target color was the same for all consistent target blocks. In Experiment 1, a consistent target lead to faster RTs and a faster comparison process. In Experiment 2, if the automatization process is speeded when a previously consistent target is consistent again, the effect of target repetition should increase across blocks of consistent targets. On the other hand, if the benefits from a consistent target do not persist across blocks, then restoration of a previously used consistent template could produce the same results across blocks of consistent targets, suggesting that the process of achieving automatization starts over with each encounter with a previously consistent target. The consistent template restoration hypothesis predicts that reencountering a previously encountered consistent target will lead to stronger effects of consistent targets due to fewer target repetitions being needed for the effects to emerge and/or additive effects of the consistent target across blocks. The length of the blocks in Experiment 2 were reduced from 30 trials to 20 trials because the effect of the consistent target on RTs and comparison was present prior to or by bin 3 (18 repetitions of the target) in Experiment 1. Furthermore, because of the short ISI being optimal for testing target establishment effects, only the short ISI was used in Experiment 2.

### Method

**Participants.** Participants were recruited from the Louisiana State University subject pool and received course credit for their participation. Analysis included 32 participants from the 34 collected participants after two participants were excluded for performing below chance (50%). The analyzed sample included 29 females and 3 males with an average age of 20 years. The entire sample reported normal vision and normal color vision.

**Design.** The experiment design was a 2 × 6 × 5 repeated measures. Target type (consistent vs. varying), block (1–6), and bin (1–5) were within-subject factors.

**Materials.** The same equipment and stimuli (objects and colors) as in Experiment 1 were used in Experiment 2.

**Procedure.** Experiment 2 differed from Experiment 1 in the following ways. Participants completed both consistent and varying target blocks. At beginning of the experiment the consistent target's color was randomly chosen and remained the same for all consistent blocks. Participants completed 260 trials broken into 13 blocks containing 20 trials. Seven consistent target blocks alternated with six varying target blocks resulting in the first and last block being consistent target blocks. The consistent color never appeared as a distractor or as a target in the varying target blocks. Eye tracker recalibration occurred after every three blocks. An ISI of 50 ms between the target cue and the search array was used for all trials.

**Power.** The partial eta squared from the RT mixed ANOVA with target type (consistent, varying) and bin (1–5) from Experiment 1 was converted to an effect size using G*Power. The partial eta squared was .109 and the calculated effect size was .350. The effect size was used to estimate the number of participants in Experiment 2 to find the two-way interaction of target type and bin with 80% power. In Experiment 2, the target type variable is within subjects and not between subjects as it was in Experiment 1. Entering the effect size of .350 into G*Power for a mixed factor ANOVA within-between interaction produced a total sample size of 12 participants. Based on this information, the number of participants was kept at 32 because the number of trials per block was reduced.

## Results

To ensure an equal number of trials in each target type, data from the final block was excluded leaving data from the first 12 blocks for the analysis (6 consistent blocks and 6 varying blocks). Performance was good with an overall accuracy of 92.8%. Inaccurate responses included incorrect responses (3.7%) and when the target was not fixated (3.4%). Additional trials were removed for RTs more than three standard deviations above or below the participant's mean (1.9%). For each measure, only accurate trials for which the target was fixated were analyzed.

**Consistent template hypothesis.**

***Reaction time.*** To test the consistent template hypothesis and to see whether the establishment, guidance, and/or comparison hypotheses could explain the effects of the consistent target on RT, the dependent measures were submitted to a 2 × 5 repeated measures ANOVA with target type (T, consistent vs. varying) and bin (B, 1–5) as within subject variables. Data for each bin was collapsed across blocks (1–6) of the same target type.[1] For any instances in which the assumption of sphericity was violated, Greenhouse-Geisser correction was used. Bayes Factors are reported along with the ANOVA results. For the ANOVA, $BF_x$ indicates that there is evidence that favors the alternative hypothesis and $1/BF_x$ means there is evidence that favors the null hypothesis. Along with every ANOVA, BFs are reported. All follow-up *t* tests (independent and paired) are scaled JSZ BFs. The Scaled JSZ BFs were computed with $BF_{10}$ values, in favor of the alternative hypothesis, and $BF_{01}$ values, in favor of the null hypothesis. BF less than 3 reported, but considered ambiguous evidence.

The consistent template hypothesis was replicated. The model that best fit the RT data compared with the null contained target type. RTs were faster with consistent targets compared with varying targets, $F(1, 31) = 4.87$, $p = .035$, $\eta_p^2 = .136$, $BF_T > 1000$ (Figure 4). A significant interaction between target type and bin was found, $F(3.27, 101.31) = 4.7$, $p = .003$, $\eta_p^2 = .133$, there was evidence against the interaction ($1/BF_{T:B} = 11.46$). This interaction was caused by faster RTs for the later bins (bin 3: $p = .02$, $BF_{10} = 2.47$; bin 4: $p = .013$, $BF_{10} = 3.62$; bin 5: $p = .001$, $BF_{10} = 24.32$) for the consistent condition compared with the varying condition, but not in the earlier bins (bin 1: $p = .838$, $BF_{01} = 5.19$; bin 2: $p = .310$, $BF_{01} = 3.25$). RTs were found to become faster from bin to bin with a consistent target supported by a significant linear trend, $F(1, 31) = 28.53$, $p < .001$, $\eta_p^2 = .478$. With a consistent target, RTs became faster from bin 1 to bin 5 ($p < .001$, $BF_{10} > 1000$) and from bin 4 to bin 5 ($p = .02$, $BF_{10} = 2.42$). A linear trend was not found to fit the varying target RT data, $F(1, 31) < 1$, $p = .458$, $\eta_p^2 = .018$. Although the ANOVA also revealed a main effect of bin, $F(4, 124) = 2.49$, $p = .046$, $\eta_p^2 = .074$, decisive evidence was found against a bin effect ($1/BF_B > 1000$).

***Length of the preparation stage.*** The establishment hypothesis was supported during the preparation stage. Given that only a

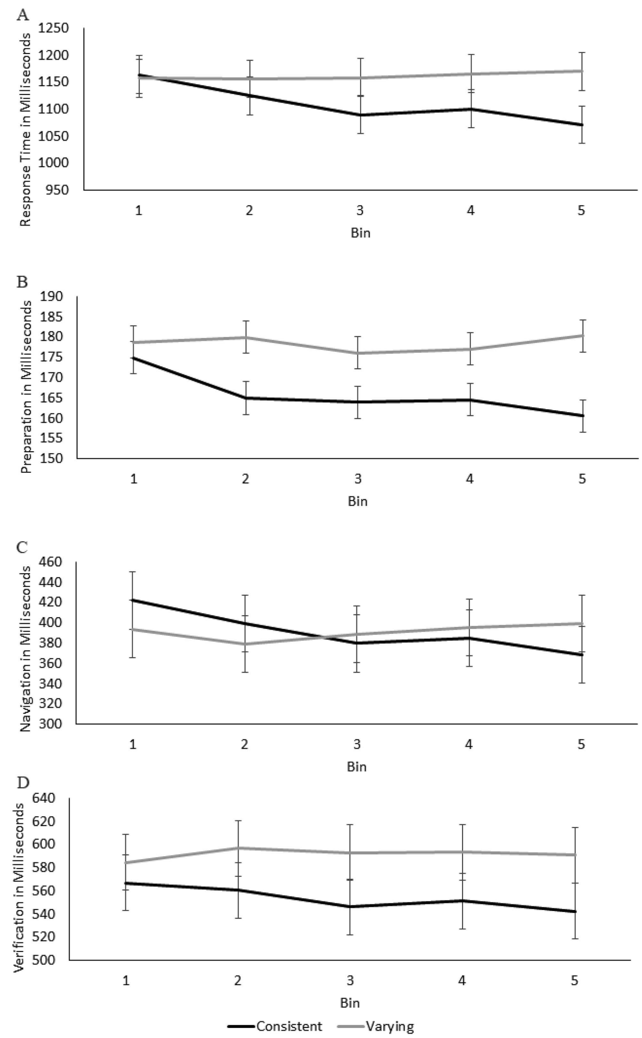


*Figure 4.* (A) Participants' response times in Experiment 2 for target type in bins of four trials. (B) Preparation stage for target type in bins of four trials. (C) Navigation stage for target type in bins of four trials. (D) Target verification stage for target type in bins of four trials. Error bars denote within confidence intervals (Masson & Loftus, 2003).

[1] In Experiment 2 results were examined in two ways: (a) results were collapsed across blocks and grouped into bins and (b) results were grouped by block. With the 20 trials in each block, bins contained 4 trials. With so few trials in each bin within each block, it was not possible to bin the analysis within a single block.

short ISI was used in Experiment 2, the establishment hypothesis predicts a main effect of target type or an interaction between target type and bin for the length of the preparation stage. The model that best fit the preparation data compared with the null contained target type, bin, and target type by bin interaction. Decisive evidence was found to support consistent targets produced shorter preparation stages compared with the varying targets, $F(1, 31) = 28.46$, $p < .001$, $\eta_p^2 = .479$; $BF_T > 1000$. An interaction between target type and bin was also present, $F(4, 124) = 4.33$, $p = .003$, $\eta_p^2 = .123$, $BF_{T:B} = 2.31$, though evidence was weak (see Figure 4). This interaction was caused by faster preparation stages for the consistent condition compared with the varying condition during the later bins (bin 2: $p < .001$, $BF_{10} = 114.37$; bin 3: $p = .004$, $BF_{10} = 10.61$; bin 4: $p = .001$, $BF_{10} = 30.78$; bin 5: $p < .001$, $BF_{10} > 1000$) but not for bin 1 ($p = .223$, $BF_{01} = 2.62$). A linear trend was found to fit the consistent target data, $F(1, 31) = 11.24$, $p = .002$, $\eta_p^2 = .266$. The preparation stage was longer in bin 1 compared with bin 5 with a consistent target, ($p < .001$, $BF_{10} = 118.17$), however, the change from bin 4 to bin 5 was not significant ($p = 168$, $BF_{01} = 2.15$). There was also a main effect of bin, $F(3.086, 95.667) = 3.72$, $p = .013$, $\eta_p^2 = .107$, $BF_B = 2.31$, though evidence was weak.

***Length of the navigation stage.*** None of the models fit the data better than the null. There was substantial evidence against a main effect of target type, $F(4, 124) = 1.28$, $p = .283$, $\eta_p^2 = .04$, $1/BF_T = 826$, and strong evidence against an effect of bin, $F(1, 31) < 1$, $p = .975$, $\eta_p^2 < .001$, $1/BF_B = 29$. There was an interaction between target type and bin, $F(4, 124) = 2.56$, $p = .042$, $\eta_p^2 = .076$, however, there was decisive evidence against an interaction ($1/BF_{T:B} > 1000$). The consistent and varying targets did not differ in performance at any of the bins, (bin 1: $p = .261$, $BF_{01} = 2.9$; bin 2: $p = .354$, $BF_{01} = 3.52$; bin 3: $p = .614$, $BF_{01} = 4.69$; bin 4: $p = .631$, $BF_{01} = 4.47$; bin 5: $p = .204$, $BF_{01} = 2.47$). Therefore, there is no evidence that the target template is more effective during the guidance stage for a consistent versus varying target.

***Number of distractors fixated.*** The guidance hypothesis also predicts that consistent targets will lead to fewer fixated distractors. For the number of distractors fixated, the model that best fit the data compared with the null contained target type. A main effect of target type was found, $F(1, 31) = 4.36$, $p = .045$, $\eta_p^2 = .123$, $BF_T = 368.49$. However, the effect was in the opposite direction of that predicted by the guidance hypothesis: Fewer distractors were fixated in the varying condition than in the consistent condition (varying $M = .84$, consistent $M = .95$; Figure 5). An interaction between target type and bin was not found ($F(4, 124) = 1.84$, $p = .126$, $\eta_p^2 = .056$, $1/BF_{T:B} = 33.83$). A main effect of bin was found, $F(4, 124) = 2.68$, $p = .035$, $\eta_p^2 = .080$, there was also evidence against a bin effect ($1/BF_B = 4.74$; Figure 4).

***Dwell time on distractors.*** The comparison hypothesis predicts shorter dwell time on the distractors in the consistent condition. The model that best fit the data was target type. Dwell time on distractors was shorter with a consistent target, $F(1, 31) = 14.31$, $p = .001$, $\eta_p^2 < .316$, $BF_T > 1000$ (Figure 5). The ANOVA did not reveal a main effect of bin, $F(4, 124) = 1.34$, $p = .260$, $\eta_p^2 = .041$, $1/BF_B = 27.59$, or an interaction between target type and bin, $F(4, 124) = 1.29$, $p = .276$, $\eta_p^2 = .040$, $1/BF_{T:B} = 358.48$.

***Length of the target verification stage.*** The comparison hypothesis also predicts a shorter target verification stage for the consistent target. For the length of the target verification stage, the model that best fit the data compared with the null contained target type. Consistent targets had faster target verification stages compared with varying targets, $F(1, 31) = 6.83$, $p = .014$, $\eta_p^2 = .181$, $BF_T > 1000$ (Figure 4). The evidence supports no interaction between target type and bin, $F(4, 124) < 1$, $p = .564$, $\eta_p^2 = .023$, $1/BF_{T:B} > 1000$, and no main effect of bin, $F(4, 124) < 1$, $p = .813$, $\eta_p^2 = .013$, $1/BF_B = 84.05$.

***Dwell time on the target.*** Consistent targets may also improve target comparison (e.g., shorter dwell time on the target). For target dwell time, the model that best fit the data contained the null. The ANOVA did not reveal a main effect of target type, $F(1, 31) < 1$, $p = .643$, $\eta_p^2 = .007$, $1/BF_T = 5.7$, a main effect of bin, $F(4, 124) < 1$, $p = .552$, $\eta_p^2 = .024$, $1/BF_B = 66$, or an interaction

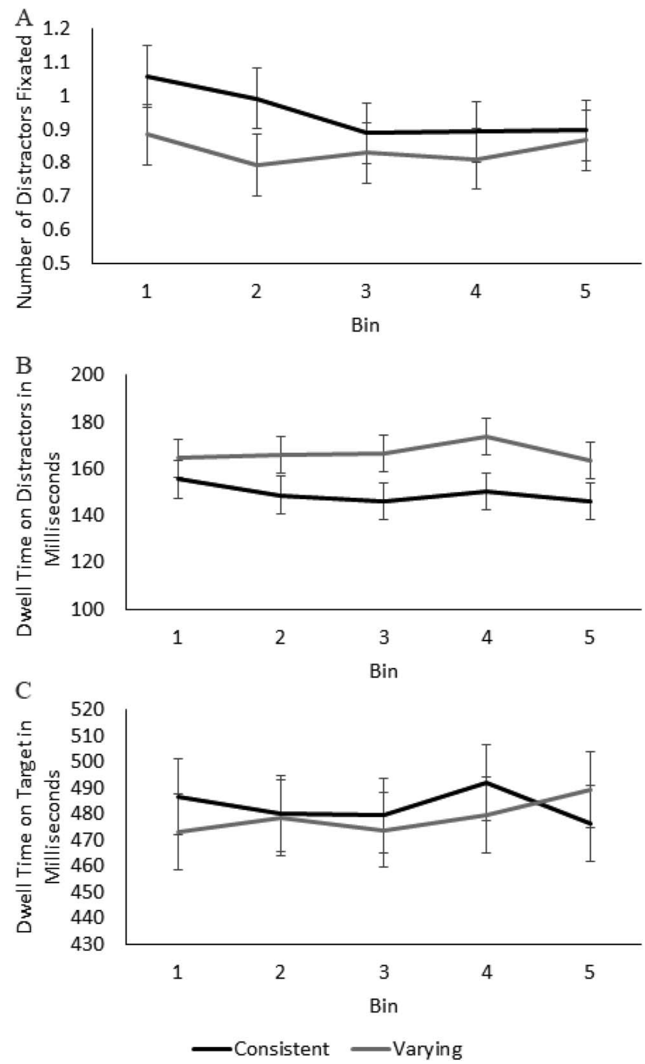


*Figure 5.* (A) Number of distractors fixated during the navigation stage without replacement for target type in bins of four trials. (B) Dwell time on distractors during the navigation stage for target type in bins of four trials. (C) Dwell time on the target during the target verification stage for target type in bins of four trials. Error bars denote within confidence intervals (Masson & Loftus, 2003).

between target type and bin, $F(2.91, 90.23) = 1.27$, $p = .287$, $\eta_p^2 = .039$, $1/BF_{T:B} > 1000$ (Figure 5).

The consistent template hypothesis was confirmed, with the faster search for consistent templates driven by faster search preparation and comparison for consistent targets. The following analysis will examine if reencountered consistent targets lead to stronger effects suggesting that there is carry over from previous consistent blocks. Therefore, we examined whether the effects increased across blocks, suggesting that the effects of a consistent target were stronger in the later blocks.

**Consistent template restoration hypothesis.** To test the consistent restoration hypothesis and to see if the establishment, guidance, and/or comparison effects increase across blocks of consistent trials, the dependent measures were submitted to a 2 × 6 repeated measures ANOVA with target type (T, consistent vs. varying) and block (BL, 1–6). The consistent restoration hypothesis predicts an interaction between target type and block with faster search performance in the later blocks with the consistent target. For any instances in which the assumption of sphericity was violated, Greenhouse-Geisser correction was used. Bayes Factors are reported along with the ANOVA's results. For the ANOVA, $BF_x$ there is evidence that favors the alternative hypothesis and $1/BF_x$ means there is evidence that favors the null hypothesis. Along with every ANOVA, BFs are reported. All follow-up *t* tests (independent and paired) are scaled JSZ BFs. The Scaled JSZ BFs were computed with $BF_{10}$ values, in favor of the alternative hypothesis, and $BF_{01}$ values, in favor of the null hypothesis. BF less than 3 reported, but considered ambiguous evidence.

***Reaction time.*** There was support for the consistent restoration hypothesis in the RT data. The model that best fit the RT data compared with the null contained target type, block, and target type by block interaction. An interaction was found between target type and block, $F(5, 155) = 7.09$, $p < .001$, $\eta_p^2 = .186$, $BF_{T:BL} = 6.13$ (Figure 6). Substantial evidence was found to support no difference between consistent and varying targets at the early blocks (block 1: $p = .399$, $BF_{01} = 3.78$; block 2: $p = .433$, $BF_{01} = 3.96$). There was substantial evidence for RTs with the consistent targets being faster than the varying targets during the middle blocks and last block (block 3: $p = .016$, $BF_{10} = 2.95$; block 4: $p < .001$, $BF_{10} > 1000$; block 6: $p = .006$, $BF_{10} = 6.4$). The evidence was ambiguous to determine differences between the consistent and varying target in the second to last block (block 5: $p = .173$, $BF_{01} = 2.2$). Consistent target RTs were found to become faster across blocks supported by a linear trend, $F(1, 31) = 43.39$, $p < .001$, $\eta_p^2 = .583$, but contrary to predictions a quadratic trend also fit the data, $F(1, 31) = 14.97$, $p = .001$, $\eta_p^2 = .326$. RTs were faster in block 6 compared with block 1 ($p < .001$, $BF_{10} > 1000$), with a consistent target and improved from block 3 to block 4 ($p < .001$, $BF_{10} > 1000$). However, RTs became slower from block 4 to block 5 ($p = .004$, $BF_{10} = 8.94$), and remained similar from block 5 to block 6 ($p = .391$, $BF_{01} = 3.74$). RTs also improved with varying targets across blocks supported by a significant linear trend, $F(1, 31) = 15.2$, $p < .001$, $\eta_p^2 = .329$. With a varying target RTs became faster from block 1 to block 6 ($p = .007$, $BF_{10} = 5.7$), and were similar from block 5 to block 6, ($p = .215$, $BF_{01} = 2.55$). RTs were faster with consistent targets compared with varying targets, $F(1, 31) = 4.83$, $p = .035$, $\eta_p^2 = .135$, $BF_T > 1000$. Decisive evidence supports a block effect, $F(3.12, 96.88) = 17.571$, $p < .001$, $\eta_p^2 = .362$, $BF_{BL} > 1000$. The stages of visual search were examined to determine the process or processes that could be leading to the faster search at the later consistent blocks.

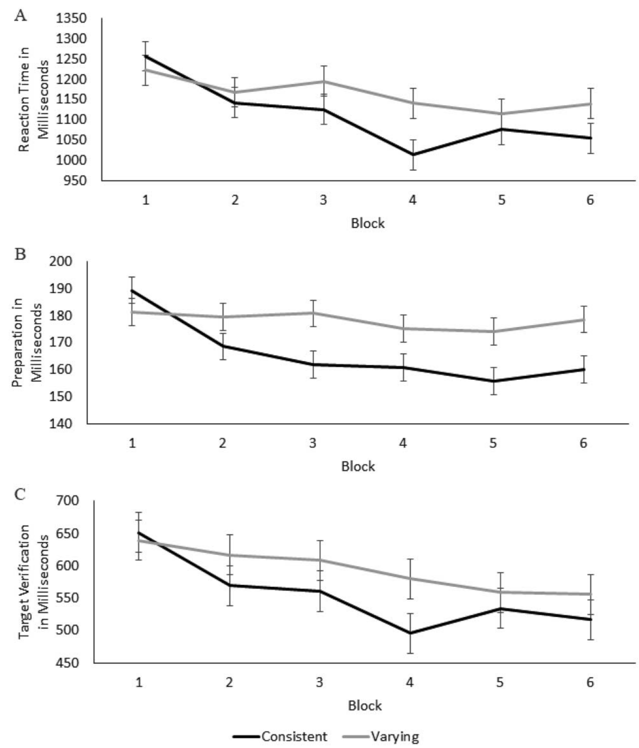


*Figure 6.* (A) Participants' response time in Experiment 2 for target type by block. (B) Preparation stage for target type by block. (C) Target verification stage for target type by block. Error bars denote within confidence intervals (Masson & Loftus, 2003).

***Length of the preparation stage.*** The restoration of establishment hypothesis predicts stronger effects on the preparation time for consistent targets for the later blocks. The model that best fit the preparation data compared with the null contained target type, block, and target type by block interaction. Decisive evidence was found for an interaction, $F(5, 155) = 10.19$, $p < .001$, $\eta_p^2 = .247$, $BF_{T:BL} > 1000$ (Figure 6). The preparation stage was shorter in the consistent condition for all the later blocks (block 2: $p = .006$, $BF_{10} = 7.05$; block 3: $p < .001$, $BF_{10} > 1000$; block 4: $p < .001$, $BF_{10} = 61.06$; block 5: $p < .001$, $BF_{10} = 922.61$; block 6: $p < .001$, $BF_{10} = 162.52$), but the evidence was weak in block 1 to support a shorter preparation stage with a varying target, (block 1: $p = .04$, $BF_{10} = 1.39$). The preparation time became shorter across blocks with a consistent target supported by a linear trend, $F(1, 31) = 78.92$, $p < .001$, $\eta_p^2 = .718$, however, contrary to predictions a quadratic trend fit the data, $F(1, 31) = 38.51$, $p < .001$, $\eta_p^2 = .554$. Preparation stage was shorter in block 6 compared with block 1 ($p < .001$, $BF_{10} > 1000$), with a consistent target and was similar between block 5 and block 6 ($p = .151$, $BF_{01} = 1.99$). A linear trend was not found to fit the varying target preparation stage data, $F(1, 31) = 1.23$, $p = .276$, $\eta_p^2 = .038$. There was also decisive evidence for consistent targets having a shorter preparation stage compared with varying targets, $F(1, 31) = 27.83$, $p < .001$, $\eta_p^2 = .473$, $BF_T > 1000$), and for a block effect, $F(3.33, 103.12) = 12.98$, $p < .001$, $\eta_p^2 = .295$, $BF_{BL} > 1000$.

***Length of the navigation stage.*** The model that best fit the length of navigation stage data was the null. There was decisive evidence against an interaction between target type and block, $F(5, 155) = 2.20$, $p = .057$, $\eta_p^2 = .066$, $1/BF_{T:BL} = 684.49$. There was also substantial evidence for no target type effect, $F(1, 31) < 1$, $p = .933$, $\eta_p^2 < .001$, $1/BF = 8.78$. Although there was a main effect of block, $F(5, 155) = 2.51$, $p = .033$, $\eta_p^2 = .075$, there was also substantial evidence against a block effect ($1/BF_{BL} = 8.79$).

***Number of distractors fixated.*** The model that best fit the number of distractors fixated during navigation was target type. The ANOVA revealed very strong evidence against an interaction between target type and block, $F(5, 155) = 1.97$, $p = .086$, $\eta_p^2 = .06$, $1/BF_{T:BL} = 57.43$). There was a main effect of block, $F(5, 155) = 2.58$, $p = .028$, $\eta_p^2 = .077$, however, there was also substantial evidence against the block effect ($1/BF_{BL} = 7$). The ANOVA did not reveal a main effect of target type, $F(1, 31) = 3.91$, $p = .057$, $\eta_p^2 = .112$, however, there was decisive evidence for the target type effect ($BF_T = 871.8$). Contrary to predictions, fewer distractors were fixated with a varying target compared with a consistent target (see Figure 7). However, on average less than one distractor was fixated per trial.

***Dwell time on distractors.*** The model that best fit the dwell time on the distractors during navigation data was target type. Decisive evidence was found against an interaction between target type and block, $F(4.05, 125.67) = 1.26$, $p = .288$, $\eta_p^2 = .039$, $1/BF_{T:BL} = 809.05$. Decisive evidence was found to support a target type effect, $F(1, 31) = 15.92$, $p < .001$, $\eta_p^2 = .339$, $BF_T > 1000$. Dwell times on distractors were shorter with a consistent target compared a varying target (see Figure 7). Very strong evidence was found against a block effect, $F(5, 155) = 1.34$, $p = .343$, $\eta_p^2 = .035$, $1/BF_{BL} = 50.04$.

***Length of the target verification stage.*** The model that best fit the length of verification data contained target type and block. The ANOVA revealed an interaction, $F(1, 155) = 3.232$, $p = .008$, $\eta_p^2 = .094$; Figure 6, however there was also evidence against the interaction ($1/BF_{T:BL} = 3.32$). The target verification stage was shorter for later blocks with a consistent target (block 2: $p = .048$, $BF_{10} = 1.21$; block 3: $p = .003$, $BF_{10} = 13.7$; block 4: $p < .001$, $BF_{10} = 301.05$; block 6: $p = .024$, $BF_{10} = 2.08$), but not for block 1 and 5 (block 1: $p = .700$, $BF_{01} = 4.93$; block 5: $p = .314$, $BF_{01} = 3.27$). The target verification period for the consistent target became shorter across blocks supported by a significant linear trend, $F(1, 31) = 25.1$, $p < .001$, $\eta_p^2 = .447$, but contrary to predictions a quadratic trend also fit the data, $F(1, 31) = 10.06$, $p = .003$, $\eta_p^2 = .245$. With a consistent target, the target verification period was shorter in block 6 compared with block 1 ($p < .001$, $BF_{10} = 620.23$), shorter in block 4 compared with block 3 ($p < .001$, $BF_{10} = 631.65$), longer in block 5 compared with block 4 ($p = .049$, $BF_{10} = 1.89$), and similar in blocks 5 and block 6 ($p = .368$, $BF_{01} = 3.6$). The target verification period also became shorter across blocks with a varying target supported by a linear trend, $F(1, 31) = 22.49$, $p < .001$, $\eta_p^2 = .420$. With a varying target the target verification period was longer in block 1 than block 6 ($p < .001$, $BF_{10} = 63.36$). The target verification stage was shorter in the consistent condition compared with the varying condition, $F(1, 31) = 6.59$, $p = .015$, $\eta_p^2 = .175$, $BF_T = 259.5$. Decisive evidence was found to support a block effect, $F(3.24, 100.56) = 12.245$, $p < .001$, $\eta_p^2 = .283$, $BF_{BL} > 1000$.

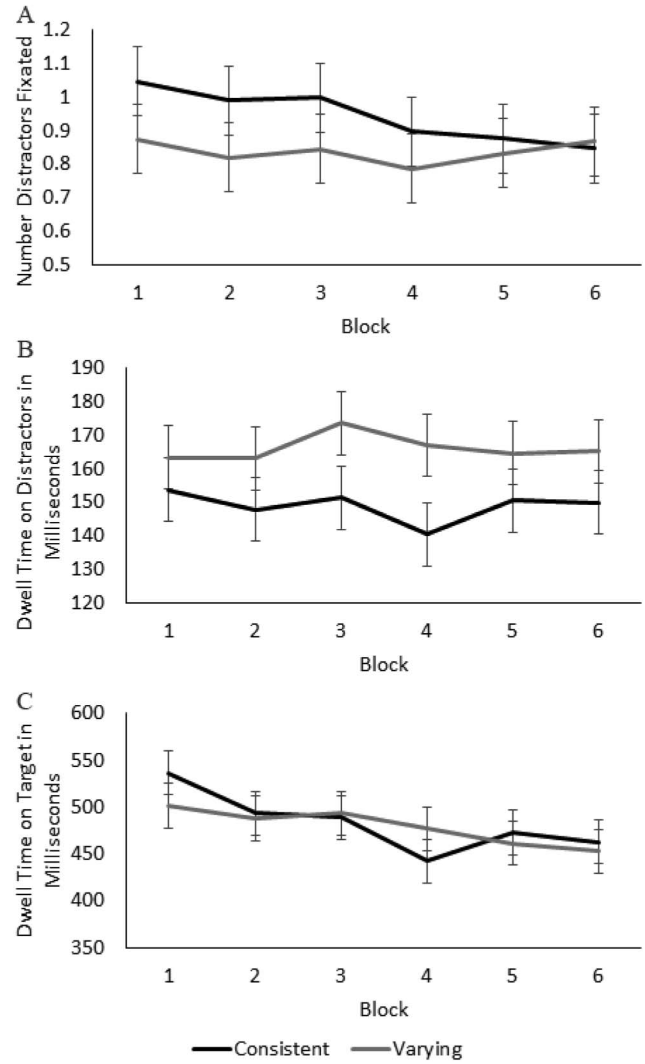


*Figure 7.* (A) Number of distractors fixated during the navigation stage for target type by block. (B) Dwell time on distractors during the navigation stage for target type by block. (C) Dwell time on the target during the target verification stage for target by block. Error bars denote within confidence intervals (Masson & Loftus, 2003).

***Dwell time on targets.*** The model that best fit the dwell time on the target data was block. The ANOVA revealed a significant interaction between target type and block, $F(3.68, 114.19) = 4.94$, $p = .001$, $\eta_p^2 = .138$; Figure 7, however, there was strong evidence against an interaction ($1/BF_{T:BL} = 13.43$). Dwell time on the target was shorter with a consistent target in block 4, ($p = .005$, $BF_{10} = 8.59$), but not for the remaining blocks, (block 1: $p = .058$, $BF_{10} = 1.04$; block 2: $p = .717$, $BF_{01} = 4.97$; block 3: $p = .621$, $BF_{01} = 4.71$; block 5: $p = .344$, $BF_{01} = 3.46$; block 6: $p = .286$, $BF_{01} = 3.09$). A linear trend was found to fit the consistent target data, $F(1, 31) = 16.7$, $p < .001$, $\eta_p^2 = .350$, and contrary to predictions a quadratic trend was also found to fit the data, $F(1, 31) = 6.53$, $p = .016$, $\eta_p^2 = .174$. With a consistent target dwell time on the target became shorter from block 1 to block 6 ($p < .001$, $BF_{10} = 68.91$) and from block

3 to block 4 ($p < .001$, $BF_{10} = 246.37$). Dwell time on the target became longer from block 4 to block 5 ($p = .015$, $BF_{10} = 3.14$) and was similar from block 5 to block 6 ($p = .444$, $BF_{01} = 4.01$). A linear trend was also found to fit the varying target data, $F(1, 31) = 10.77$, $p = .003$, $\eta_p^2 = .258$. With a varying target dwell time on the target became shorter from block 1 to block 6 ($p = .005$, $BF_{10} = 8.09$). There was decisive evidence in support of a block effect, $F(2.9, 89.94) = 7.05$, $p < .001$, $\eta_p^2 = .185$, $BF_{BL} > 1000$. A main effect of target type was not found, $F(1, 31) < 1$, $p = .670$, $\eta_p^2 = .006$, $1/BF_T = 7.62$.

## Discussion

In Experiment 2, evidence was found to replicate the consistent template hypothesis with a strong target type effect on RT. That is, a consistent target produced faster RTs compared with a varying target. Furthermore, a consistent target led to a faster comparison process. The faster comparison process was supported by shorter dwell time on distractors and by the length of the target verification stage, but not by dwell time on the target. Consistent targets also lead to a shorter preparation stage which could be due in part to longer target template establishment for varying targets (see Table 2). Consistent with Experiment 2, we also found no effect of target consistency on guidance during the navigation stage. Although there was an effect of target type on the number of distractors fixated, this effect was very small in the wrong direction (.84 distractors in the varying condition vs. .95 in the consistent condition).

There was evidence to suggest that the effects of a consistent target are additive across blocks of consistent targets. That is, when a consistent target is reencountered, the effect of the target consistency is stronger and/or arises more quickly. There is evidence to suggest that this is due primarily to a shorter preparation stage across blocks of consistent targets (see Table 3).

## General Discussion

Across two experiments, participants' visual search performance was faster with a consistent target than with a varying target. This provides support for the consistent template hypothesis, suggesting consistent attentional templates affect search differently than varying attentional templates. However, not every process involved in search benefits from a consistent target. Although there was evidence that the comparison process was more efficient and the preparation stage was speeded with a consistent target, there was no evidence for an improvement in the guidance process during the navigation stage. This is somewhat surprising because it is often assumed that the primary function of an attentional template is to guide attention toward the target (Chelazzi, Duncan, Miller, & Desimone, 1998; Duncan & Humphreys, 1989; Usher & Niebur, 1996). Furthermore, Experiment 2 demonstrated that the effects of a consistent target can carry over across trials of a variable target such that subsequent encounters with the consistent target lead to stronger effects on RT resulting from a faster preparation stage.

The current study demonstrates faster search for consistent targets, however other studies have not found differences in search behavior between consistent and varying targets (Carlisle et al., 2011). This discrepancy may be attributable to the degree to which the search task engages the search processes (template establishment, guidance, and verification). Carlisle and colleagues (2011) used an easy detection visual search task in which a red target among one green and 10 black distractors required a present/absent decision, whereas the present study used a harder search task in which multiple distractor colors were presented and a discrimination response was required. Previous attentional template research with a present/absent task comparing easy and hard visual search tasks found that with target repetition, RTs were speeded for both the hard and easy task, but the benefit was larger for the hard task condition (Gunseli et al., 2014). When the task is easy, guidance is strong and very quick and a less complete template can be effective. In addition, when a detection response is required, a less complete template can be established and the verification stage is less difficult. Therefore, search tasks that limit the need for complete template establishment, guidance, and comparison processes in search also limit the ability to test for effects during these stages. The present study attempted to solve this problem with the use of a more difficult search task requiring a discrimination response and allowed for evidence that using consistent templates can affect template establishment and comparison processes, but not the guidance process.

The effect of consistent targets on search RT, the preparation stage, and the comparison process in the current study suggest that templates stored in LTM can lead to faster search and more efficient search preparation and comparison processes. However,



Table 2
*Support for Consistent Template Effects for Each Dependent Variable and Each Process in Experiment 2*

| Variable | Establishment | Guidance | Comparison |
|---|---|---|---|
| Length of the preparation stage | ✓ | ✓ | |
| Length of the navigation stage | | **x** | |
| Number of distractors fixated | | **x** | |
| Dwell time on distractors | | | ✓ |
| Length of the verification stage | | | ✓ |
| Dwell time on target | | | **x** |

*Note*. The table above organizes results with regard to either a main effects of target type or an interaction between target type and bin. ✓indicates strong support from null hypothesis testing and Bayes. **x** indicates no support or strong evidence against. (w) below a ✓ indicates a significant null hypothesis test with weak Bayes support.

Table 3
*Support for Consistent Template Restoration Effects for Each Dependent Variable and Each Process in Experiment 2*

| Variable | Establishment | Guidance | Comparison |
|---|---|---|---|
| Length of the preparation stage | ✓ | ✓ | |
| Length of the navigation stage | | **x** | |
| Number of distractors fixated | | **x** | |
| Dwell time on distractors | | | **x** |
| Length of the verification stage | | | **x** |
| Dwell time on target | | | **x** |

*Note*. The table above organizes results in regards to interactions between target type and block as evidence for template restoration. ✓ indicates strong support from null hypothesis testing and Bayes. **x** indicates no null hypothesis testing support or Bays evidence against. (w) below a ✓ indicates a significant null hypothesis test with weak Bayes support or inconsistent effects across blocks.



in the present study we did not measure the CDA as has been done in previous studies, so the current data do not speak directly to whether the consistent targets were stored in LTM or the varying targets stored in VWM. Given that consistent target templates have been shown to result in less activation of VWM resources (Carlisle et al., 2011), it is likely that consistent target templates rely more heavily on LTM whereas varying target templates rely more on VWM.

## Preparation

Across both experiments, a consistent target led to shorter preparation stage. The preparation stage can be delayed in the varying target condition because of slower template establishment and/or slower guidance for the first saccade. There is a logical reason to predict that the preparation stage effect is attributable, at least in part, to faster template establishment for consistent targets. Once a consistent attentional template is being used, the target cue should confirm the same target for the trial, but there would be no need to encode the target template again given access to the representation of the consistent attentional template from the previous trial. This would allow for faster template establishment with a consistent target.

The faster preparation time could also be due to switching roles of targets and distractors (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977) across trials. When a target cue is the same color as a previous distractor or a distractor is the same color as a previous target the role assigned to the color must be updated. Target template establishment may be slower when a previously encountered distractor color appears on the target cue screen, because the previous distractor color must be marked as a target. The more times the color appears as a distractor compared with a target, the harder the process to override the distractor identity. We attempted to minimize the need for these identity updates or switches by not allowing the previous target color to be a distractor color in the subsequent block. In the consistent condition of Experiment 1, a new color was selected to be the repeated target color for each block, and this color was absent from the following $n + 1$ block and did not appear as a distractor until the $n + 2$ block. In the varying condition of Experiment 1, the target color on trial $n$ could not appear as a distractor on trial $n + 1$, but it could appear as a distractor on trial $n + 2$. The colors did not repeat as a target until all the colors had appeared as a target once across 14 consecutive trials. Overall, color had a stronger identity as a distractor than as a target. This identity could have produced more negative effects as the number of blocks increased. A distractor color from block $n$ could be a target on block $n + 1$. Therefore, it is possible that some of the delay in initiating the first saccade was due to the time needed to switch the identity from distractor to target. This delay should decrease across repetitions with the target color in the consistent blocks and may pose more of a delay for the varying blocks.

## Guidance During Navigation

Although guidance could have been more efficient for the consistent target during the preparation stage, the current study demonstrated that consistent and varying attentional templates do not differ in the efficiency of the guidance they provide during the navigation stage. This finding is consistent with previous research in which repeated and varied targets were presented in heterogeneous displays of six items (Grubert et al., 2016). A similar N2pc was produced when attention was allocated to features matching either the LTM or VWM templates (Grubert et al., 2016). Along similar lines, target repetition has not been found to result in a decrease in search slope, a hallmark of efficient guidance (Gunseli et al., 2014). The lack of a difference in guidance with consistent and varying templates in the current study is consistent with these findings. A consistent target did not decrease the number of distractors that needed to be fixated before the target was found. It is important to note that although the search task likely engaged guidance more than previous studies (Carlisle et al., 2011; Gunseli et al., 2014), on average only one distractor was examined before the target was found. It is possible that a search task that required a lengthier guidance process would reveal differences in guidance efficiency between consistent and varying targets.

The lack of a difference in guidance efficiency between consistent and varying targets in the current study may be due to the use of simple single-feature stimuli. When search involves multifeature targets, such as real-world objects, particular features can be weighted to guide attention over others (Duncan & Humphreys, 1989). Features such as color, orientation, and size can guide attention (Wolfe & Horowitz, 2004), and these features can be weighted based on the search context (Schmidt, MacNamara, Proudfit, & Zelinsky, 2014; Schmidt & Zelinsky, 2017). Repetition of a complex multifeature target may help with this weighting process, leading to more efficient guidance for consistent targets. Recent research on visual search for real-world objects suggests that changes in the CDA reflect pruning and addition of features prior to search (Schmidt et al., 2014; Schmidt & Zelinsky, 2017). However, in the present experiments, color was the only feature of the target that could guide attention for both the consistent and varying target conditions. Therefore, target repetition was unlikely to help guidance by improving feature weights in the template. In a visual search task for real world objects, consistent targets could lead to a more efficient guidance process, because the various features of a real-world object could be weighted or pruned to make the most effective template for guidance.

## Comparison

In the current study, there was evidence for a comparison benefit for consistent targets. With a consistent target, the verification stage was shorter and dwell time on distractors was shorter demonstrating that distractors were rejected faster. The presence of a comparison benefit combined with the lack of a guidance benefit may be attributable to the use of different template information for each process. Consistent with this idea, previous research on visual search with real world objects suggests that the template features used to guide search may be different than the template features used to verify the target (Schmidt & Zelinsky, 2017). The attentional template used during the comparison process could contain higher order information compared with the attention template used to guide search. As discussed above, the use of a simple single-feature template might limit this possibility. However, it is possible to have a highly specific template for the color of the target that is used for the comparison process (e.g., cherry red) and a less specific (e.g., red) template that is used for the guidance process. Therefore, the result from the present study could be due to the use of different templates during different search stages.

The comparison process for consistent targets may be speeded because of template information that aids in the response selection of the discrimination task (right gap or left gap). That is, the information in the consistent target template may be more precise or more specific to what is needed for determining the direction of the gap. A LTM representation could provide access to additional information regarding the target beyond what is provided by the target cue. For example, the LTM template my benefit from providing access to two representations, one for left gap targets and one for right gap targets whereas the VWM template may be limited to the solid square presented as the target cue. Therefore, the LTM template may be more precise allowing for a faster comparison process.

## Priming

It is possible that performance improved for consistent targets in some part because of intertrial priming. Intertrial priming effects are generally demonstrated by speeded RTs on repetition trials (consecutive trials with the same target) compared with switch trials (consecutive trials with different targets; Maljkovic & Nakayama, 1994, 1996). Intertrial priming could explain the improvement in RTs with a consistent target in the current experiment. The target repetition in the consistent blocks and the discrimination task that requires a response (left or right) that is separate from the target's defining feature (color) create a situation that can produce priming (Duncan, 1985). However, the color discrimination required in the present task could weaken priming effects (Olivers & Meeter, 2006). Although, it is possible priming aided in the faster performance with the consistent target, priming is likely not the sole cause of the consistent target effects.

One reason why priming is likely not the sole cause of the consistent target effects found in the current study is that the priming literature would predict an effect of target repetition on guidance (Kristjánsson & Campana, 2010; Maljkovic & Nakayama, 1994). A debate within the intertrial priming literature is whether priming facilitates finding the target or responding to the target (Becker, 2008a, 2008b; Huang & Pashler, 2005; Kristjánsson & Campana, 2010). In feature conjunction visual search tasks, target repetition results in less time between the onset of the array and the selection of the target (facilitation of finding the target or guidance) but does not result in shorter fixation durations on the target (responding to the target; Becker, 2008a, 2008b; Becker & Horstmann, 2009). Recently, Kruijne and Meeter (2016) have demonstrated that long-term priming, when bias is found on numerous trials after the bias inducement has been removed, can influence attentional guidance and target selection. However, in the present study, the strong evidence against consistent targets leading to more efficient guidance compared with varying targets is inconsistent with a priming explanation for the consistent target effects. Although it remains possible that priming could be involved in the consistent target effects for the establishment and comparison processes, this possibility lacks a simple explanation for why the effects would be found during establishment and comparison but not during guidance given that previous research supports an effect of priming on guidance.

## Interference

Using the same set of colors for target colors and distractor colors across trials could have caused interference. This interference results from having to change the identity for the color (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977). As previously discussed, this change in mark or rebranding is one possible explanation for why varying targets are slower at target establishment or search initiation. The target cue presentation triggers long-term representations that the color was previously marked as a distractor. This interference could impact search across all stages of the search process. It is possible each time the color is encountered other previous long-term representations will be triggered (Logan, 1988). This interference could have contributed to the slowing in RT across varying target bins during the comparison process. Interference can also explain why differences between consistent and varying targets can appear at later blocks, but not earlier blocks. As the number of target repetition trials increases with a previous distractor color, the interference by the old mark decreases and automatization for the new mark takes over (Logan, 1990; Woodman et al., 2007). Efforts were made to limit this interference in Experiment 1 by preventing a target in the consistent condition from being a distractor in the next block.

The present findings support an automatization account where the interference disappears after 20–30 trials (Logan, 1990; Woodman et al., 2007). In Experiment 2 the consistent target color never appeared in the varying target condition blocks. This color only had one mark as a target. The interference from the distractor colors can impact RTs and comparison separately from the preparation stage in Experiment 2. Different instances or memories can be retrieved when the search array is presented compared with the target cue screen (Logan, 1988). Even though the target is a distinct mark in the consistent condition, following a switch from varying to consistent condition the distractor colors could be providing interference as previous targets. There would still be interference present in the consistent condition in Experiment 2 and would require multiple repetitions for automatization to surpass the interference. By reducing the number of trials in a block from 30 to 20 contributes to the weaker effects seen in Experiment 2.

## Restoration

The effects of template consistency on search performance are larger when a previously encountered target template is reencountered. This supports the idea of a LTM effect for target repetition. Furthermore, the restoration effects were stronger for establishment than for comparison, supporting the idea that there may be different target templates used for these two stages and the template used for establishment may be more readily reactivated from LTM than the template used for comparison. Identifying the strength of the CDA in these circumstances may help clarify the interpretation of these effects. The current study establishes that the effects of consistent targets can carry over blocks of varying target trials.

## Time Course

The present study demonstrates that a consistent target leads to faster search, but does not clearly detail the time course of this effect. Studies investigating the attentional template passing from VWM to LTM maintain the number of target repetitions between 1 and 7 (Carlisle et al., 2011; Grubert et al., 2016; Gunseli et al., 2014). The present study had either 20 or 30 repetitions and bins of 6 (Experiment 1) or 4 (Experiment 2) trials were used for analysis to see whether the strength of the effects would increase with more repetitions. The design of the experiments does not permit looking at repetitions on a smaller scale than four or six repetitions. Therefore, it is possible that repetitions effects appeared with one or two repetitions. If this is the case, then there would be no Target Type × Bin interaction because the effect of repetition would be present starting in the first bin of the consistent block. However, for effects that can develop or increase over more than six repetitions, the current data are sufficient to look at the time course of development. Namely, in Experiment 1 there was evidence of an increasing effect of target repetition on RT and this effect was attributed to a decrease in verification time across bins of consistent targets. Therefore, it appears that the strength of the effect of a consistent target on the verification stage continues to increase over 6 to 30 target repetitions. This effect was not replicated in Experiment 2. In Experiment 2, participants switched between consistent and varying blocks and the consistent target was the same across all consistent blocks. These methodological differences may have led to a different time course for the effect of the consistent target on the verification process. In Experiment 2, there was some evidence (weak according to Bays statistics) to support an increase across bins in the effect of the consistent target on template establishment. Across these two experiments, the evidence for a strengthening of effects across bins is inconsistent. In addition, it is possible that effects develop very quickly (i.e., after 1 or 2 repetitions). Therefore, additional research will need to more closely examine the time course of these effects.

In sum, consistent templates lead to faster search than varying templates. Furthermore, the findings demonstrate that guidance efficiency is not necessarily effected differently when a template is consistent and versus varying. Therefore, if different templates are used for guidance in consistent versus varying search trials, these templates guide attention similarly. Alternatively, if the same template is used for guidance in varying and consistent trials, then different templates are accessed for other search processes that do show differences between consistent and varying trials (establishment and comparison processes). These findings help to understand guidance efficiency.

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