Where Have You Been, What Did You See, and How Did You Get Here: Effects of Prior Trial History in the Context of Exogenous and Endogenous Spatial Cuing

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

Three spatial cuing experiments assessed whether the nature of the prior trial affects performance in a two choice target identification task. In Experiment 1 current trial RT was strongly affected by whether prior trial cue validity, prior trial target identity, and prior trial target location were the same as on the current trial when an exogenous spatial cue was 50% valid. Experiment 2 demonstrates that, with an endogenous cue, current trial RT was also affected by whether target identity or target location changed from the prior trial. Finally, in Experiment 3 when the cue was exogenous and cue validity was 75%, current trial RT was only affected by the target's identity on the prior trial. It is concluded that (a) the effects of prior trial history reflect yet another context in which the effects of exogenous and endogenous spatial cuing differ, and (b) the difference in RT to a target preceded by a valid or invalid cue does not reflect a pure measure of spatial attention. Instead, participants appear to weigh information from all dimensions on the previous trial when identifying the target on the current trial. An analysis of the RT distributions yielded significant differences with respect to where in the distribution each factor affected performance. Overall, these data demonstrate that both prior trial effects and analyses of RT distributions of such effects are a rich source of systematic variance that merits further investigation and theoretical consideration.

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Table of Contents

List of Tables

List of Figures

Introduction

Few would likely disagree with the contention that how we process events in our daily lives is strongly affected by both distant and more recent prior experience. Despite this consensus, prior trial history is ignored more often than not when considering data from many laboratory tasks. That said, some research has shown that prior trial history can have profound effects on timed performance, and that such history sometimes interacts strongly with context (see Masson & Kliegl, 2012 vs. Balota, Aschenbrenner, & Yap, 2013; O'Malley & Besner, 2013). Another line of research shows that congruency effects in flanker and Stroop tasks are sometimes affected by prior trial history (Gratton, Coles, & Donchin, 1992; Kerns et al., 2004; Peschke, Hilgetag, & Olk, 2013). The results of these studies demonstrate the importance of considering prior trial history if we wish to have a deeper theoretical understanding of mental processing. One obvious question concerns how broadly prior trial history matters in standard laboratory tasks. The three experiments reported here demonstrate that the nature of the prior trial affects performance in both exogenous and endogenous spatial cuing paradigms, and that an analysis of the RT distributions strongly constrains the interpretations that can be offered for these data.

Exogenous and Endogenous Spatial Cuing Paradigms

Two types of cues are standardly employed in the spatial cuing literature: exogenous and endogenous (Posner, 1980). Both types of spatial cuing involve the use of valid cues (cues that indicate the location of the target stimulus) and invalid cues (cues that do not indicate the location of the target stimulus) to capture attention. An exogenous spatial cuing paradigm typically involves the use of an abrupt onset peripheral cue (sometimes referred to as a "pull"

cue) to draw an individual's attention to the cued location. An exogenous cue need not provide any reliable indication of the potential location of the target stimulus in order to capture attention, therefore cue validity in this context is often 50% (Klein, 2004; Jonides, 1981; Posner, 1980).

In contrast, an endogenous spatial cuing paradigm often uses a central cue (sometimes referred to as a "push" cue) to inform participants of the possible location of the target. Such a cue generally requires some form of interpretation as to the location of the target (e.g. an arrow that points up or down). Endogenous cuing typically involves making the cue informative by having it be valid more often than chance. With both types of cuing, the target appears after the cue in one of the possible target locations. Both exogenous and endogenous cuing standardly yield robust effects of cue validity, in that participants are significantly faster and less error prone on valid as compared to invalid trials (Klein, 2004; Jonides, 1981; Posner, 1980).

These two spatial cuing paradigms are typically considered to provide an index of different forms of spatial attention, and have even been referred to as "modes of control over spatial attention" (e.g., Müller & Rabbitt, 1989). If prior trial factors modulate the effects of cue validity so as to affect current trial RTs, this implies that the difference in RT to a target preceded by a valid or invalid cue is not a pure measure of spatial attention. Our working hypothesis is that prior trial history will have a strong effect given the assumption that participants respond to *change* (cue status; target identity; target location) from the previous trial.

To anticipate the results, we found that all prior trial factors (cue validity, target identity, and target location) affected current trial RT in the context of an exogenous spatial cuing paradigm with 50% validity. With an endogenous spatial cue with 75% validity, RT was affected by a change in target identity or target location from the prior trial. Additionally, prior trial cue

validity interacted with the current trial's cue validity on RT. In the context of an exogenous spatial cuing paradigm with 75% validity, the only prior trial factor that affected RT was prior trial target identity. The differing results of these experiments are discussed in more detail below. Overall the data are consistent with the hypothesis that participants are responding to *change* from the prior trial in many instances.

Additionally, distributional analyses revealed that the size of the effect of a change from the prior trial varied as a function of position in the RT distribution. These patterns differed for the main effects. That is, some effects remained constant across the distribution, some were right shifted (i.e., the effect was larger when RT was longer), and some were left shifted (i.e., the effect was larger when RT was shorter). The results of these experiments suggest that not only do the effects of prior trial history differ as a function of type of cue and cue validity proportion, but also that the form that these effects take varies as a result of distribution position. Combined, these results support the notion that effects of prior trial history are dynamic and warrant further consideration.

Experiment 1: Exogenous Spatial Cuing (50% Validity)

Experiment 1 explored whether exogenous spatial cuing is susceptible to effects of prior trial history. The methods for this experiment were modeled after Risko and Stolz (2010).

Method

Participants. 36 University of Waterloo undergraduate students participated for course credit.

Design. The experiment was a within-subjects design with two cue conditions: valid and invalid.

Stimuli. The spatial cue was a white rectangle that measured 1 cm high by 2 cm wide and appeared 4.5 cm above or below fixation. The two target symbols consisted of "@" and "#". Each symbol measured 0.8 cm in height and 0.5 cm in width, and appeared 3.5 cm above or below fixation. The stimuli were presented in white Courier New font on a black background.

Procedure. The experiment consisted of 16 practice trials followed by a single block of 240 experimental trials (120 validly cued and 120 invalidly cued trials). On each trial a fixation cross (+) appeared in the centre of the screen for 500 ms. Participants' attention was then directed to one of two locations (above or below fixation) by the brief appearance of a rectangle (50 ms), which appeared as a flash of light to the participant. 100 ms after the offset of the cue, one of the two target stimuli appeared either above or below fixation. The location of the target stimulus corresponded to the location of the cue on 50% of trials (cues were 50% valid and 50% invalid). The target remained on the screen until participants indicated, via key press, which symbol was presented. There was an inter-trial interval of 750 ms following a response. The response keys used were "c" and "m", and participants used their index fingers to respond. The response key-target mappings were counterbalanced across participants based on order of arrival to the lab. Participants were instructed to indicate which target symbol they had seen as quickly and accurately as possible, and to do their best to keep their eyes on fixation.

Analysis. Data were analyzed using a repeated-measures ANOVA. The first prior trial factor that was considered was the *cue validity* on the previous trial. Given that this was a two choice target identification task, we also addressed whether the effect of a change in the target's *identity* (i.e. which of the two targets was presented) from the previous trial interacted with the

effect of cue validity on current trial RT. Finally, we asked whether the effect of a change in the *location* of the target stimulus from the previous trial interacted with the effect of cue validity on current trial RT.

Results

Of the 36 participants, data from 5 were removed from the analysis because at least 12% of their responses yielded an error. For the remaining 31 participants, trials on which an incorrect response was made were removed prior to data analysis, resulting in the removal of 4.5% of trials across participants. Trials following an incorrect response were also removed, resulting in the removal of 4.2% of trials across participants. Correct trial RTs that were over 2.5 standard deviations from the mean in each condition for each participant were also removed. This resulted in the removal of 1.8% of the trials with correct responses. Participants who had a mean RT over 2.5 standard deviations from the group mean were also removed. Two participants were outliers according to this criterion, leaving data from 29 participants for further analysis.

Effects on RT

We conducted a four-factor ANOVA consisting of the following factors: current trial cue validity (valid/invalid), whether cue validity changed from the prior trial (yes/no), whether target identity changed from the prior trial (yes/no), and whether the target location changed from the prior trial (yes/no). The results of this analysis can be found in Table 1. Significant interactions that do not include the current trial's cue validity do not have any theoretical value for the current discussion, and are therefore not unpacked. We first report the main effects. The mean RTs and percentage error for each of these main effects can be found in Figures 1-4.

Main effects. The standard effect of cue validity was observed; participants were significantly faster at identifying the target when the cue was valid (M = 580) than when it was invalid (M = 675), $F(1,28) = 146.93$, $p < .001$, $\eta_p^2 = .840$. This robust 95 ms cuing effect is close to the 90 ms effect reported by Risko and Stolz (2010).

There was a main effect of whether cue validity changed from the prior trial, $F(1,28) = 38.90$, $p < .001$, $\eta_p^2 = .581$. With both valid and invalid cues, participants were significantly faster to identify the target when the cue on the prior trial was of the same validity as the cue on the current trial (M = 613) than when it changed from the prior trial (M = 642).

There was also a main effect of whether the target identity changed from the prior trial, $F(1,28) = 13.25$, $p = .001$, $\eta_p^2 = .321$. Participants were significantly faster to respond when the target identity on the prior trial was the same as on the current trial (M = 615) than when the target identity changed from the prior trial (M = 640).

There was a marginal main effect of whether the target location changed from the prior trial, $F(1,28) = 3.14$, $p = .087$, $\eta_p^2 = .101$. Participants were slightly faster to respond when the target appeared in the same location as on the prior trial (M = 623) than when the target location changed from the prior trial (M = 632).

Four-way interaction. The four-way interaction was not significant (See Table 1).

Three-way interactions. There was a significant three-way interaction between the current trial's cue validity, whether the target identity changed from the prior trial, and whether the target location changed from the prior trial, $F(1,28) = 5.54$, $p = .026$, $\eta_p^2 = .165$. When the target identity was the same as on the prior trial, RTs on *validly* cued trials were more affected by whether the target location changed from the prior trial (13 ms) than when there was a change in target identity from the prior trial (5 ms). For *invalidly* cued trials, however, RTs were more

affected by whether the target location changed from the prior trial than when there was a change in target identity from the prior trial (13 ms) than when there was no change in target location from the prior trial (6 ms). The mean RTs and percentage error for this interaction can be found in Table 2.

With both validly and invalidly cued trials, participants had the shortest RTs when both the target identity and target location were the *same* as on the prior trial. In the case of invalidly cued trials, participants had the longest RTs when both the target identity and target location *changed* from the prior trial. This was not the case for validly cued trials, on which participants had the longest RTs when the target identity changed from the prior trial, but the target location did not.

There was also a significant three-way interaction on RT between whether the cue validity changed from the prior trial, whether the target identity changed from the prior trial, and whether the target location changed from the prior trial, $F(1,28) = 10.89$, $p = .003$, $\eta_p^2 = .280$.

None of the other three-way interactions were significant (See Table 1).

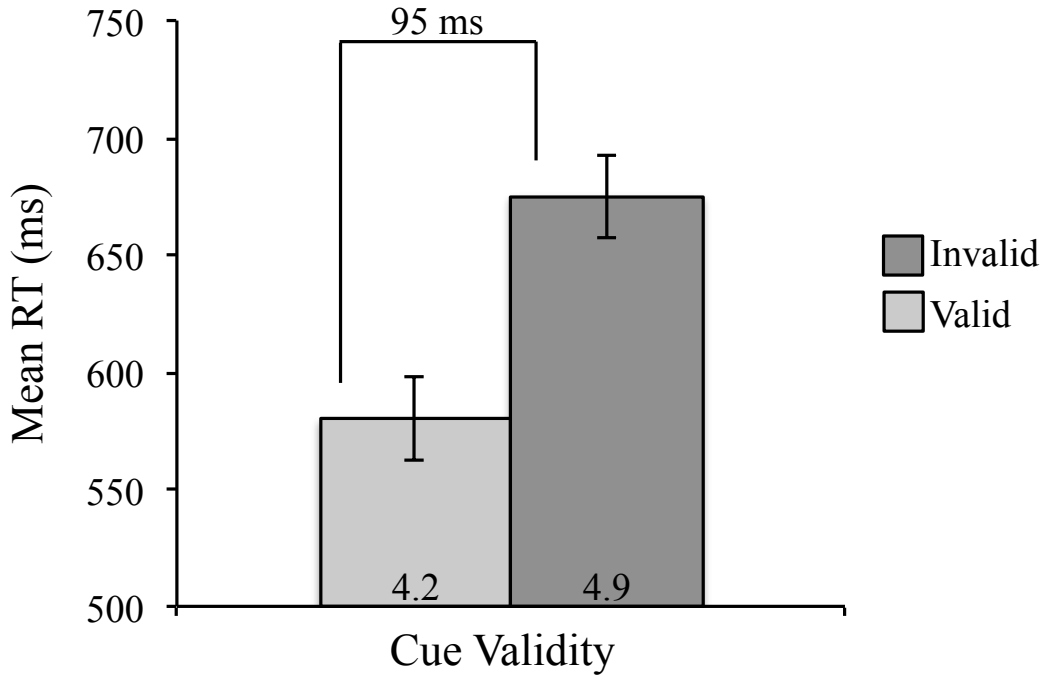
Two-way interactions. There was a significant two-way interaction between whether the cue validity changed from the prior trial and whether the target's identity changed from the prior trial, $F(1,28) = 15.73$, $p < .001$, $\eta_p^2 = .360$. There was also a significant two-way interaction between whether the cue validity changed from the prior trial and whether the target's location changed from the prior trial, $F(1,28) = 15.66$, $p < .001$, $\eta_p^2 = .359$. None of the other two-way interactions were significant (See Table 1).

Table 1. *Results of the within-subjects ANOVA on RTs for Experiment 1 (50% exogenous cuing).*

Effect	RT				
	F	*df*	*MSE*	*p*	η_p^2
Cue Validity (CV)	**146.93**	**1,28**	**7,270.74**	**.000**	**.84**
Prior Cue Validity (PCV)	**38.90**	**1,28**	**1,620.38**	**.000**	**.58**
Target Identity Switch (ID)	**13.25**	**1,28**	**2,244.23**	**.000**	**.32**
Target Location Switch (LOC)	3.14	1,28	2,265.01	.087	.10
CV x PCV	0.22	1,28	1,263.94	.642	.01
CV x ID	0.21	1,28	965.08	.651	.01
PCV x ID	**15.73**	**1,28**	**2,582.71**	**.000**	**.36**
CV x LOC	0.68	1,28	2,677.44	.416	.02
PCV x LOC	**15.66**	**1,28**	**1,212.37**	**.000**	**.36**
ID x LOC	0.87	1,28	2.541.64	.358	.03
CV x PCV x ID	2.00	1,28	1,815.82	.168	.07
CV x PCV x LOC	0.87	1,28	809.71	.359	.03
CV x ID x LOC	**5.54**	**1,28**	**1,342.13**	**.026**	**.17**
PCV x ID x LOC	**10.89**	**1,28**	**1,874.69**	**.003**	**.28**
CV x PCV x ID x LOC	0.41	1,28	1,982.85	.527	.01

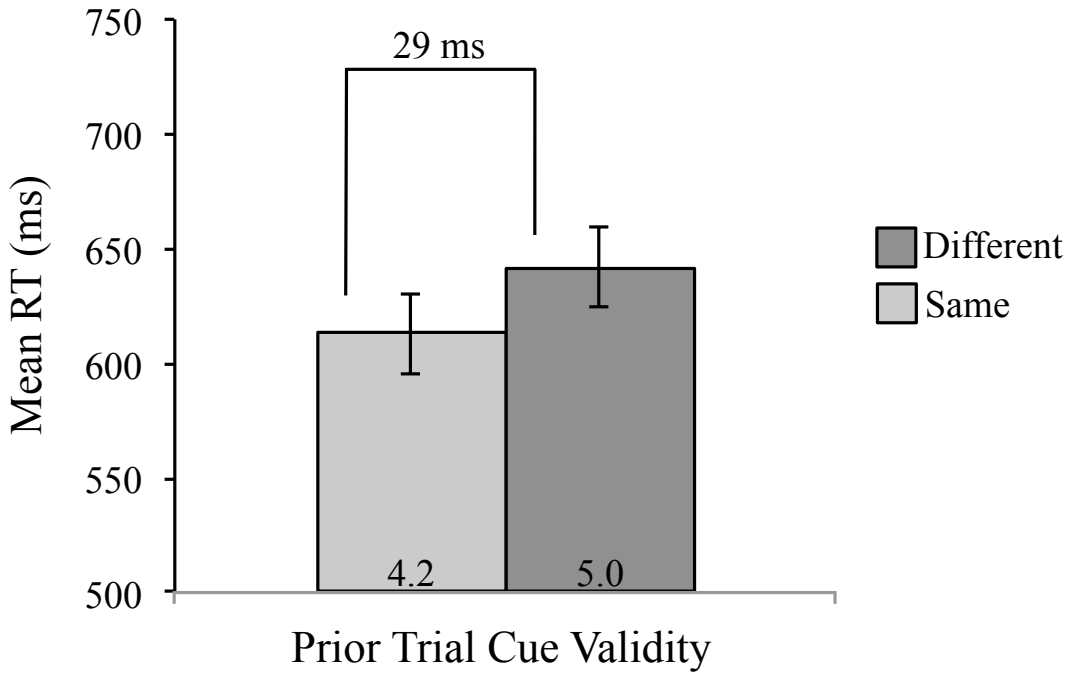
Note: Significant effects ($p < .05$) are bolded.

Figure 1. *Mean RT and percent error for Experiment 1 as a function of cue validity (Error Bars: 95% confidence intervals).*



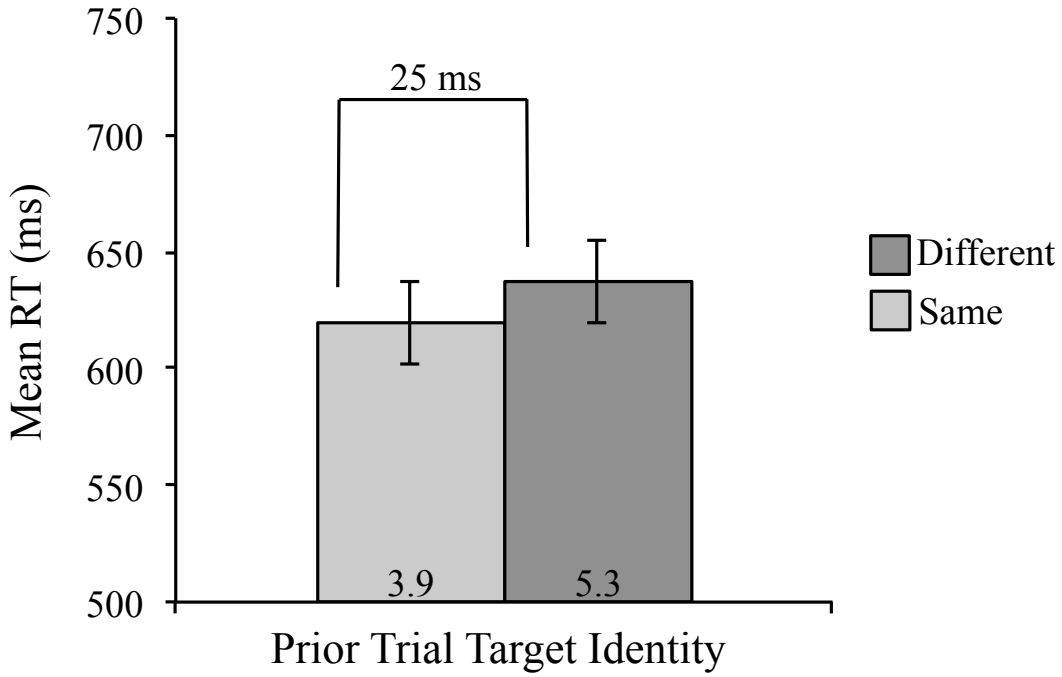
Note: Percentage errors for each condition are represented at the bottom of each column. 95% CI = 18 ms.

Figure 2. *Mean RT and percent error for Experiment 1 as a function of prior trial cue validity (Error Bars: 95% confidence intervals).*



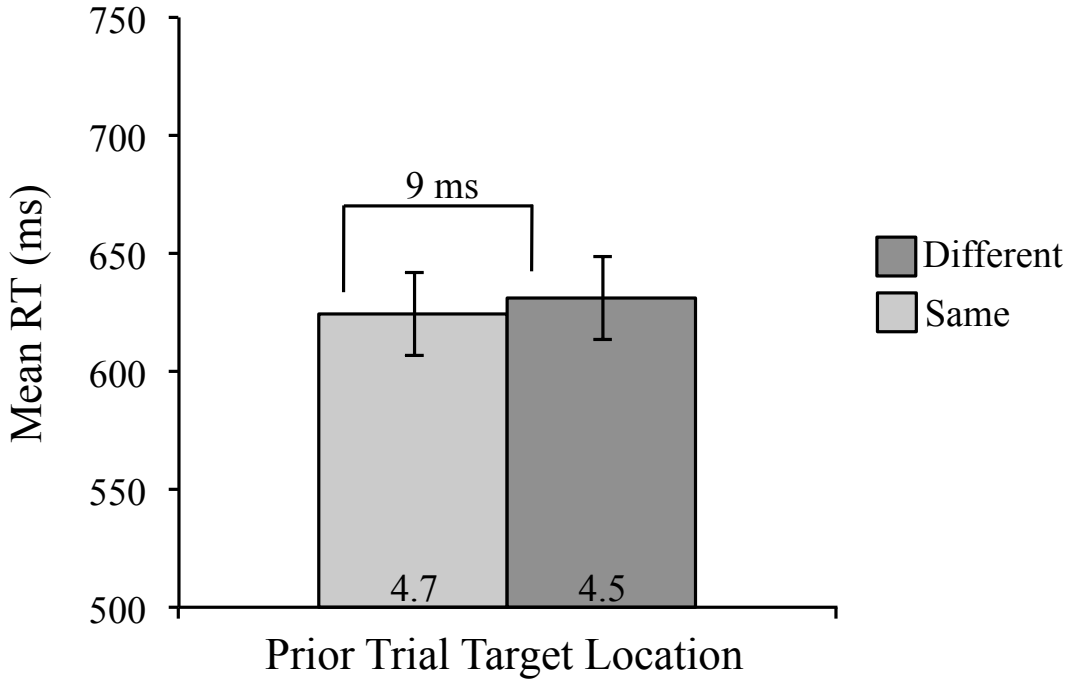
Note: Percentage errors for each condition are represented at the bottom of each column. 95% CI = 18 ms.

Figure 3. *Mean RT and percent error for Experiment 1 as a function of prior trial target identity (Error Bars: 95% confidence intervals).*



Note: Percentage errors for each condition are represented at the bottom of each column. 95% CI = 18 ms.

Figure 4. *Mean RT and percent error for Experiment 1 as a function of prior trial target location (Error Bars: 95% confidence intervals).*



Note: The main effect of prior trial target location was **marginal**. Percentage errors for each condition are represented at the bottom of each column. 95% CI = 18 ms.

Table 2. *Mean RT in Experiment 1 as a function of cue validity, prior target identity, and prior target location.*

	Same Identity		
	Same Location	Different Location	Mean Difference
Valid	564 (3.5)	577 (2.9)	**13**
Invalid	666 (4.0)	672 (5.1)	**6**
Validity effect	**102**	**95**	

	Different Identity		
	Same Location	Different Location	Mean Difference
Valid	592 (6.0)	587 (4.3)	**5**
Invalid	677 (5.6)	690 (5.0)	**13**
Validity effect	**85**	**103**	

Note: Percentage errors for each condition are represented in brackets.

Errors

The error data were also analyzed with a repeated-measures ANOVA. There was a main effect of whether the current trial's target identity changed from the prior trial, $F(1,28) = 14.65$, $p = .001$, $\eta_p^2 = .343$. Participants made significantly fewer errors when the current trial's target identity was the same as on the prior trial ($M = 3.9$) than when the target's identity changed from the prior trial ($M = 5.2$). There was a significant two-way interaction between the current trial's cue validity and whether the target identity changed from the prior trial, $F(1,28) = 4.33$, $p = .047$, $\eta_p^2 = .134$. Finally, there was a three-way interaction between whether the cue validity changed from the prior trial, whether the target identity changed from the prior trial, and whether the target location changed from the prior trial, $F(1,28) = 12.36$, $p = .002$, $\eta_p^2 = .306$. There were no other significant main effects or interactions on the error data. There was no evidence that error effects undermined any of the RT effects.

Vincentiles

Vincentizing refers to the creation of an RT distribution by averaging across the RT distributions of participants for the condition of interest. It is useful to look at Vincentiles because they provide more information than the means for each condition. Sometimes, the account for a dataset changes drastically as a result of information gleaned from the RT distribution. For example, Yap, Balota, Tse, and Besner (2008) reported that word frequency and stimulus quality had additive effects on mean RT in lexical decision, the level at which RT experiments for this paradigm (and many others) are typically analyzed. However, when the authors examined the RT distributions they found a three-way interaction between stimulus quality, word frequency, and RT bin, which called for a more complicated explanation.

We are unaware of any spatial cuing experiments that have been analyzed at the level of the RT distribution. It turns out that such analyses of the present experiment were informative. Indeed a consistent finding across all three experiments for one of the factors seen from an analysis of the RT distribution (a left shifted effect) has rarely been observed.

Vincentiles were calculated for each of the significant main effects found in Experiment 1 to determine whether the size of these effects varied as a result of the RT's location in the distribution. As is shown below, different factors produced different patterns in the distributional analysis. That is, whereas some effects remained constant throughout the distribution, other effects got larger or smaller as bin RT increased. The Vincentile analysis was restricted to the main effects, as there were a reasonable number of observations per bin for analysis. With two and three-way interactions, the number of observations per bin decreases dramatically, such that such effects tend to be less reliable.

To calculate the Vincentiles for a given factor, the RTs for each participant within each condition were rank ordered from fastest to slowest. These RTs were then divided into 10 bins, and the mean RT of each bin was calculated by averaging across the participant means in a bin. The resulting values were then plotted (Ratcliff, 1979; Vincent, 1912). The Vincentiles were analyzed with a repeated-measures ANOVA. The factors included in these analyses were the main effects (cue validity, prior trial cue validity, prior trial target identity, or prior trial target location) and RT bin (1-10). The results of this analysis can be seen in Table 3. As was expected, the main effects that were significant in Experiment 1 were significant in the current analyses. The main effect of bin was also significant for each analysis. The mean RTs for these analyses can be found in Figures 5-8.

Mauchly's test of sphericity indicated that the assumption of sphericity was violated for the interaction between cue validity and RT bin, $X^2(44) = 409.04$, $p < .05$. The degrees of freedom were therefore corrected using the Greenhouse-Geisser correction (E=.25). The interaction between cue validity and RT bin was significant, $F(2.21, 61.91) = 5.20$, $p = .007$, $\eta_p^2 = .157$. Figure 5 shows that the size of the **cue validity effect** was right shifted (smallest in the fastest bin and largest in the slowest bin). In other words, as RT increased, the size of the cue validity effect increased as well.

In contrast, Figure 6 shows that the **effect of a change in cue validity from the prior trial** did not differ in size as a function of position in the distribution. The assumption of sphericity was violated for the interaction between prior trial cue validity and RT bin, $X^2(44) = 425.96$, $p < .05$. The degrees of freedom were corrected using the Greenhouse-Geisser correction (E=.18). The interaction between prior trial cue validity and RT bin was not significant, $F(1.63,45.56) = 0.67$, $p = .485$, $\eta_p^2 = .024$. In short, bin RTs were equally affected by a change in cue validity from the prior trial regardless of response time.

The assumption of sphericity was also violated for the interaction between prior trial target identity and RT bin, $X^2(44) = 324.91$, $p < .05$. The degrees of freedom were corrected using the Greenhouse-Geisser correction (E=.24). The interaction between prior trial identity and RT bin was significant, $F(2.14, 59.82) = 8.353$, $p < .001$, $\eta_p^2 = .230$. Figure 7 shows that the size of the **effect of a change in target identity from the prior trial** was left shifted (largest in the fastest bin and reversed in the slowest bin). As RTs increased, the size of the effect of whether the target identity changed from the prior trial *decreased*. It is rare for an effect to be left shifted in the RT distribution, though it has been seen in the context of the Simon task (see Castel et al., 2007).

The assumption of sphericity was violated for the interaction between prior trial target location and RT bin, $X^2(44) = 370.90$, $p < .05$. The degrees of freedom were corrected using the Greenhouse-Geisser correction (E=.21). The interaction between prior trial target location and RT bin was not significant, $F(1.86,52.04) = 1.24$, $p = .297$, $\eta_p^2 = .042$. Figure 8 shows that the size of the **effect of a change in target location from the prior trial** remained constant across bins.

Table 3. *Results of the within-subjects ANOVA on bin RT for Experiment 1.*

	Cue Validity (CV)				
	F	*df*	*MSE*	*p*	η_p^2
CV	146.45	(1,28)	9074.67	.000	.839
Bin	526.79	(1.32,36.83)	12084.13	.000	.950
CV*Bin	5.20	(2.21,61.91)	2081.17	.007	.157
	Prior Trial Cue Validity (PCV)				
	F	*df*	*MSE*	*p*	η_p^2
PCV	48.48	(1,28)	1793.69	.000	.634
Bin	531.87	(1.36,38.06)	13708.76	.000	.950
PCV*Bin	0.67	(1.63,45.56)	2885.05	.485	.024
	Prior Trial Target Identity (ID)				
	F	*df*	*MSE*	*p*	η_p^2
ID	18.58	(1,28)	2381.21	.000	.399
Bin	581.79	(1.36,37.94)	12556.15	.000	.954
ID*Bin	8.35	(2.14,59.82)	1381.58	.000	.230
	Prior Trial Target Location (LOC)				
	F	*df*	*MSE*	*p*	η_p^2
LOC	4.40	(1,28)	2386.82	.045	.136
Bin	564.65	(1.36,38.05)	12065.95	.000	.953
LOC*Bin	1.24	(1.86,52.04)	2022.56	.297	.042

Note: Mauchly's test of sphericity indicated that the assumption of sphericity was violated for the main effect of bin in each analysis. The degrees of freedom were therefore corrected using the Greenhouse-Geisser correction.

Figure 5. *The main effect of cue validity in Experiment 1 as a function of RT bin. (Error Bars: 95% confidence intervals).*

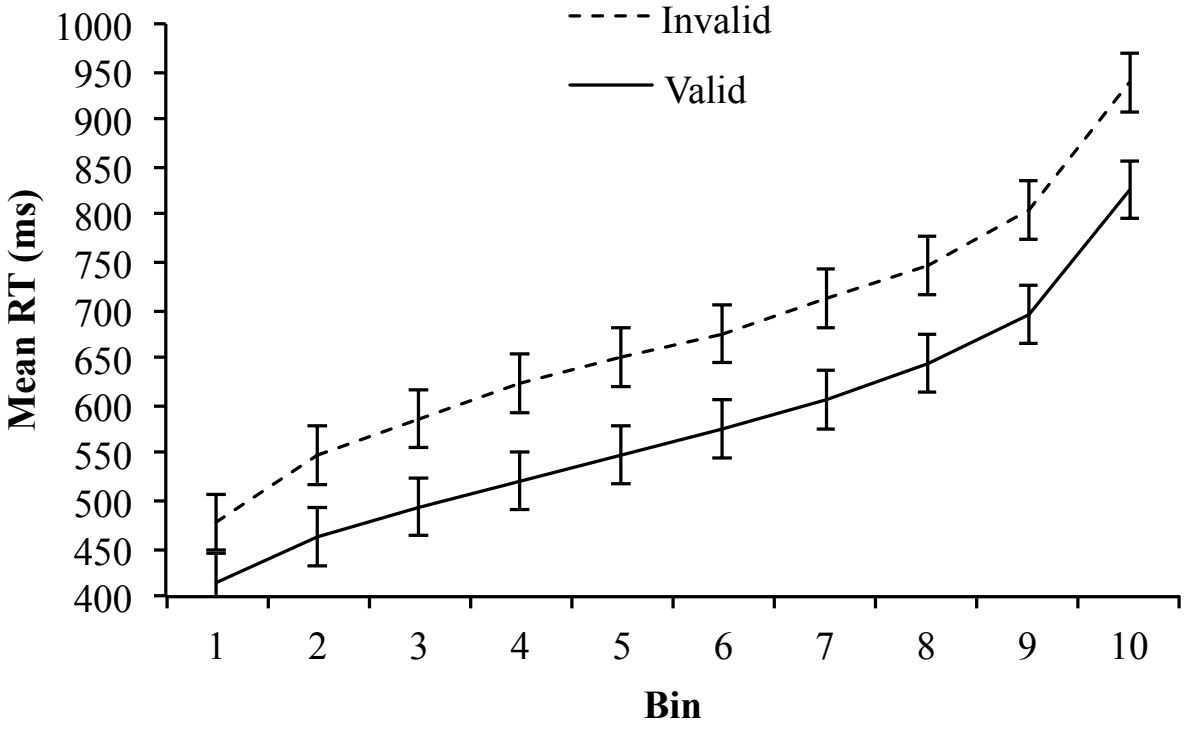


Figure 6. *The main effect of prior trial cue validity in Experiment 1 as a function of RT bin. (Error Bars: 95% confidence intervals).*

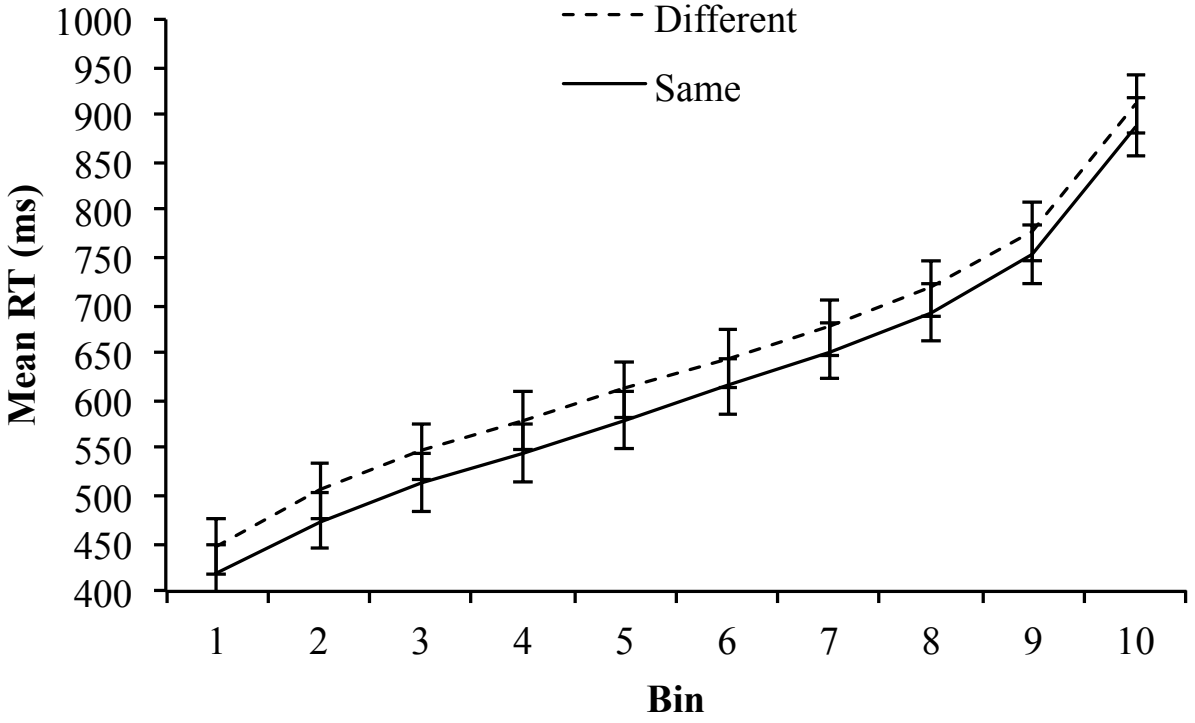


Figure 7. *The main effect of prior trial target identity in Experiment 1 as a function of RT bin. (Error Bars: 95% confidence intervals).*

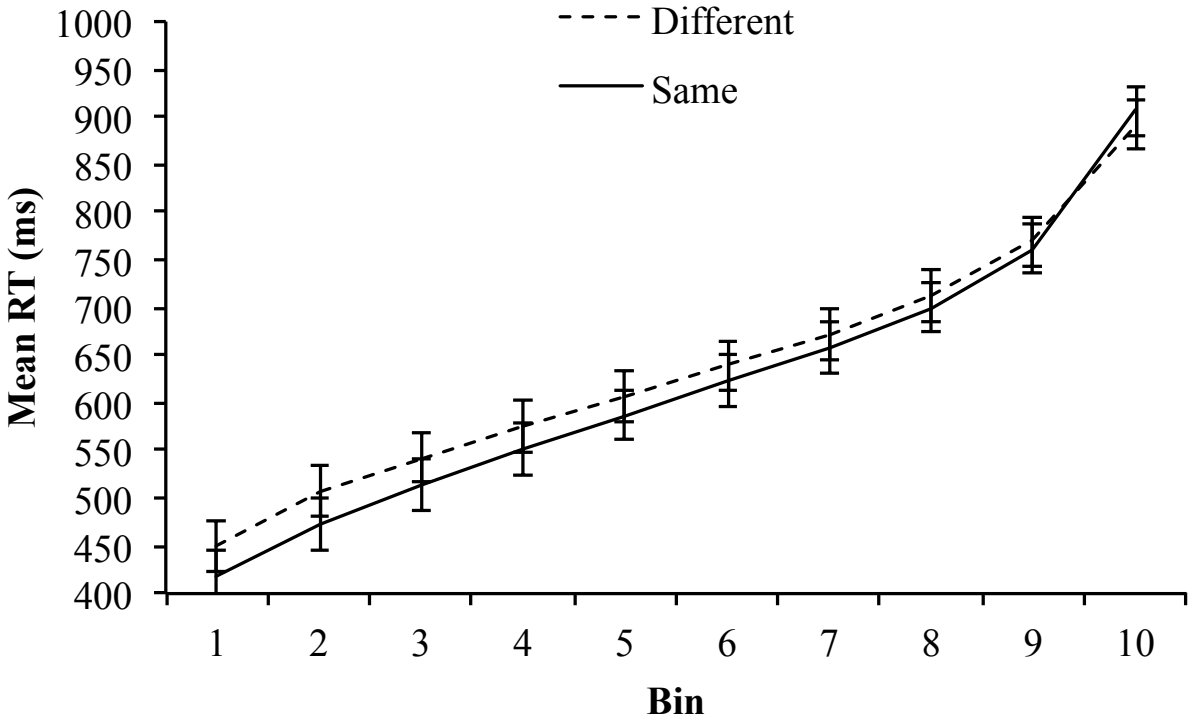
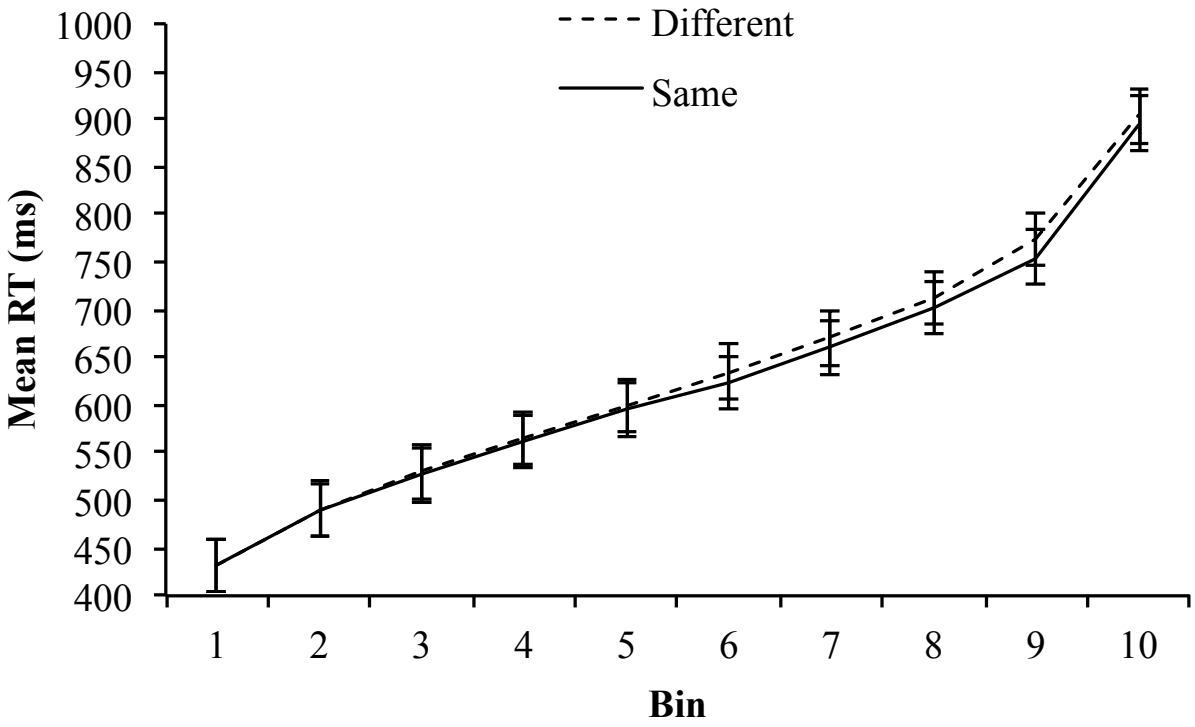


Figure 8. *The main effect of prior trial target location in Experiment 1 as a function of RT bin. (Error Bars: 95% confidence intervals).*



Note: The main effect of prior trial target location was **marginal**.

Discussion

The results of Experiment 1 demonstrate that all prior trial factors affect mean RTs when the cue is exogenous and cue validity is 50%. Participants were slower to identify the target symbol when any one of the three factors (cue validity, target identity, target location) changed from the prior trial.

Important new information comes from an analysis of the RT distribution. These analyses show that (1) the size of the cue validity effect increased as bin RT increased. In contrast, (2) the size of the effect of prior trial cue validity (same vs. different) remained constant across bins, and (3) the size of the effect of prior trial target identity (same vs. different) decreased as bin RT increased. In summary, these results demonstrate that different features of the prior trial affect performance in different ways across the distribution of RTs.

In terms of mean RT, an important finding is that prior trial target identity and prior trial target location interacted with the current trial's cue validity on RT. When the target symbol appeared in the same location as on the prior trial, and the target *identity* changed from the prior trial, participants showed a smaller cuing effect on the current trial as compared to when the target appeared in the same location as on the prior trial, and the identity was the same as on the prior trial. Further, the reverse pattern in the size of the cue validity effect was observed when the target *location* changed from the prior trial. The size of the cuing effect varied significantly as a function of prior trial history, implying that the cue validity effect with an exogenous spatial cue does not exclusively index spatial attention.

Experiment 2: Endogenous Spatial Cuing (75% Validity)

Experiment 2 explored whether endogenous spatial cuing is affected by prior trial history in the same way as exogenous spatial cuing. The target symbols were the same as in Experiment 1. The cue consisted of a coloured square (red or blue) presented at fixation, and was valid on 75% of trials. This cue was used instead of an arrow because of evidence that overlearned directional symbols (such as an arrow) may direct attention somewhat automatically (Hommel, Pratt, Colzato, & Godijn, 2001; Brignani, Guzzon, Marzi, & Miniussi, 2009).

Method

Participants. 36 University of Waterloo undergraduate students participated for course credit.

Design. The experiment was a within-subjects design with two cue conditions: valid and invalid.

Stimuli. The spatial cue was a coloured rectangle, presented in red [RGB (255, 0, 0)] or blue [RGB (0, 0, 255)], that measured 1 cm high by 2 cm wide and appeared in the same location as fixation. The two target symbols consisted of "@" and "#". Each symbol measured 0.8 cm in height and 0.5 cm in width, and appeared 3.5 cm above or below fixation. The stimuli were presented in white Courier New font on a black background.

Procedure. The experiment consisted of 32 practice trials followed by two blocks of 288 experimental trials each (216 validly cued and 72 invalidly cued trials). The two blocks were separated by a participant paced rest break. On each trial a fixation cross (+) appeared in the centre of the screen for 500 ms. Participants' attention was then directed to one of two locations

(above or below fixation) by the appearance of a coloured rectangle that appeared at fixation for 150 ms. The colour of the rectangle indicated the potential location of the target stimulus. Rectangle colour-target location mappings were counterbalanced across participants based on order of arrival to the lab. 100 ms after the offset of the cue, one of the two target stimuli appeared either above or below fixation. The location of the target stimulus corresponded to the location of the cue on 75% of trials (cues were 75% valid and 25% invalid). The target remained on the screen until participants indicated, via key press, which symbol was presented. There was an inter-trial interval of 750 ms following a response. The response keys used were "c" and "m", and participants used their index fingers to respond. The response key-target mappings were counterbalanced across participants based on order of arrival to the lab. Participants were instructed to indicate which target symbol they had seen as quickly and accurately as possible, and to do their best to keep their eyes on fixation.

Results

Of the 36 participants, data from 5 were removed from the analysis because at least 12% of their responses yielded an error. For the remaining 31 participants, trials on which an incorrect response was made were removed prior to data analysis, resulting in the removal of 5.4% of trials across participants. Trials following an incorrect response were also removed, resulting in the removal of 4.9% of trials across participants. Correct trial RTs that were over 2.5 standard deviations from the mean in each condition for each participant were also removed. This resulted in the removal of 2.6% of the trials with correct responses. Participants who had a mean RT over 2.5 standard deviations from the group mean were also removed. Four participants were outliers according to this criterion, leaving data from 27 participants for further analysis.

Effects on RT

We conducted a four-factor ANOVA consisting of the following factors: current trial cue validity (valid/invalid), whether cue validity changed from the prior trial (yes/no), whether target identity changed from the prior trial (yes/no), and whether the target location changed from the prior trial (yes/no). The results can be found in Table 4. We first report the main effects. The mean RTs and percentage error for each of these main effects can be found in Figures 9-12.

Main effects. The standard effect of cue validity was observed; participants were significantly faster at identifying the target when the cue was valid (M = 531) than when it was invalid (M = 540), $F(1,26) = 7.54$, $p = .011$, $\eta_p^2 = .225$. We looked at the Vincentiles to determine whether the small size of the cue validity effect was a result of participants only making use of the cue when processing was slow (discussed in more detail below).

There was no significant main effect of whether cue validity changed from the prior trial, $F(1,26) = 2.16$, $p = .153$, $\eta_p^2 = .077$.

There was a main effect of whether the target identity changed from the prior trial, $F(1,26) = 39.25$, $p < .001$, $\eta_p^2 = .602$. Participants were significantly faster to respond when the target identity on the prior trial was the same as on the current trial (M = 515) than when the target identity changed from the prior trial (M = 553).

There was also a main effect of whether the target location changed from the prior trial, $F(1,26) = 14.76$, $p = .001$, $\eta_p^2 = .362$. Participants were faster to respond when the target appeared in the same location as on the prior trial (M = 524) than when the target location changed from the prior trial (M = 543).

Neither the four-way interaction nor any of the three-way interactions were significant (See Table 4).

Two-way interactions. There was a significant interaction between the current trial's cue validity and whether cue validity changed from the prior trial, $F(1,26) = 5.51$, $p = .027$, $\eta_p^2 = .175$. RTs on invalidly cued trials were significantly slower when cue validity was the same as on the prior trial (i.e., invalid-invalid) than when cue validity changed from the prior trial (i.e., valid-invalid). RTs on validly cued trials did not vary significantly as a function of prior trial cue validity.

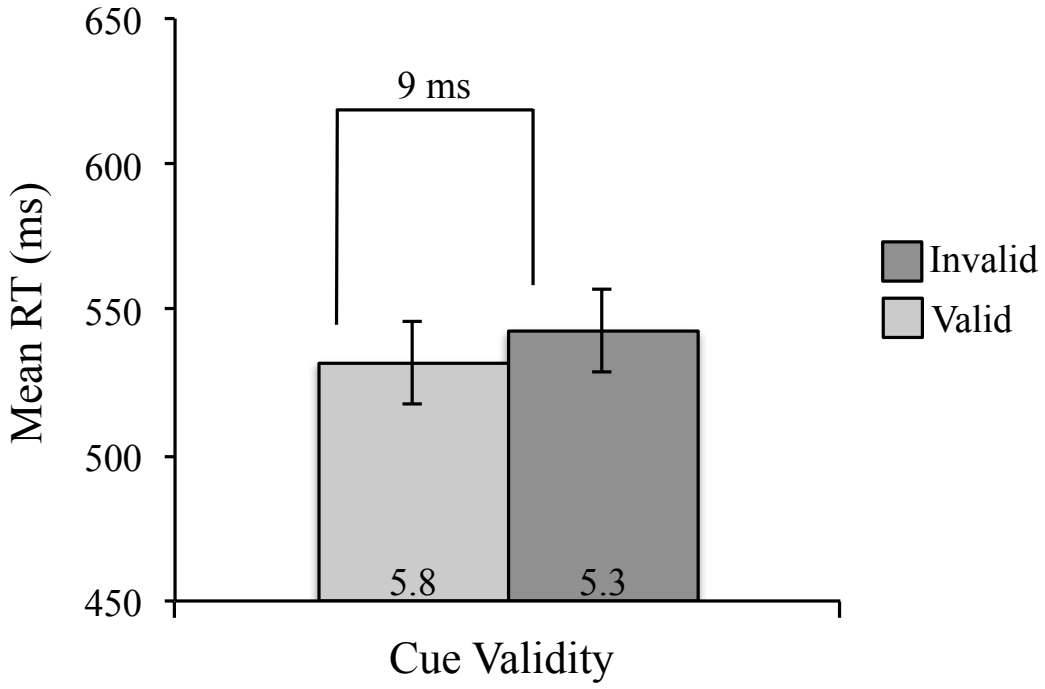
There was a significant interaction between whether cue validity changed from the prior trial and whether the target's location changed from the prior trial, $F(1,26) = 8.85$, $p = .006$, $\eta_p^2 = .254$, and between whether the target's identity had changed from the prior trial and whether the target's location had changed from the prior trial, $F(1,26) = 106.02$, $p < .001$, $\eta_p^2 = .803$. None of the other two-way interactions were significant (See Table 4).

Table 4. *Results of the within-subjects ANOVA on RTs for Experiment 2 (75% endogenous cuing).*

Effect	RT				
	F	*df*	*MSE*	*p*	η_p^2
Cue Validity (CV)	**7.54**	**1,26**	**1,265.74**	**.011**	**.23**
Prior Cue Validity (PCV)	2.16	1,26	601.88	.153	.08
Target Identity Switch (ID)	**39.25**	**1,26**	**3,942.83**	**.000**	**.60**
Target Location Switch (LOC)	**14.76**	**1,26**	**2,271.50**	**.000**	**.36**
CV x PCV	**5.51**	**1,26**	**1,157.28**	**.027**	**.18**
CV x ID	1.28	1,26	1,042.23	.269	.05
PCV x ID	0.17	1,26	925.56	.687	.01
CV x LOC	0.01	1,26	975.46	.922	.00
PCV x LOC	**8.85**	**1,26**	**799.22**	**.006**	**.25**
ID x LOC	**106.02**	**1,26**	**1,350.92**	**.000**	**.80**
CV x PCV x ID	0.13	1,26	1,180.66	.727	.01
CV x PCV x LOC	1.75	1,26	688.41	.197	.06
CV x ID x LOC	0.00	1,26	929.89	.955	.00
PCV x ID x LOC	2.49	1,26	1,589.81	.127	.09
CV x PCV x ID x LOC	0.41	1,26	1,035.32	.530	.02

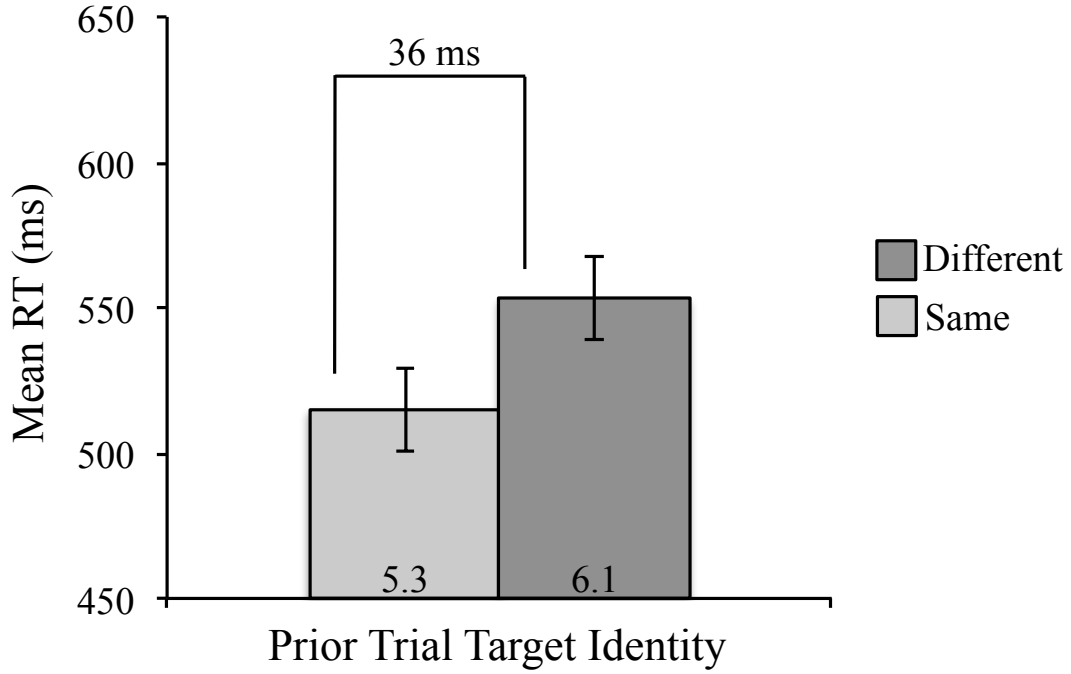
Note: Significant effects ($p < .05$) are bolded.

Figure 9. *Mean RT and percent error for Experiment 2 as a function of cue validity (Error Bars: 95% confidence intervals).*



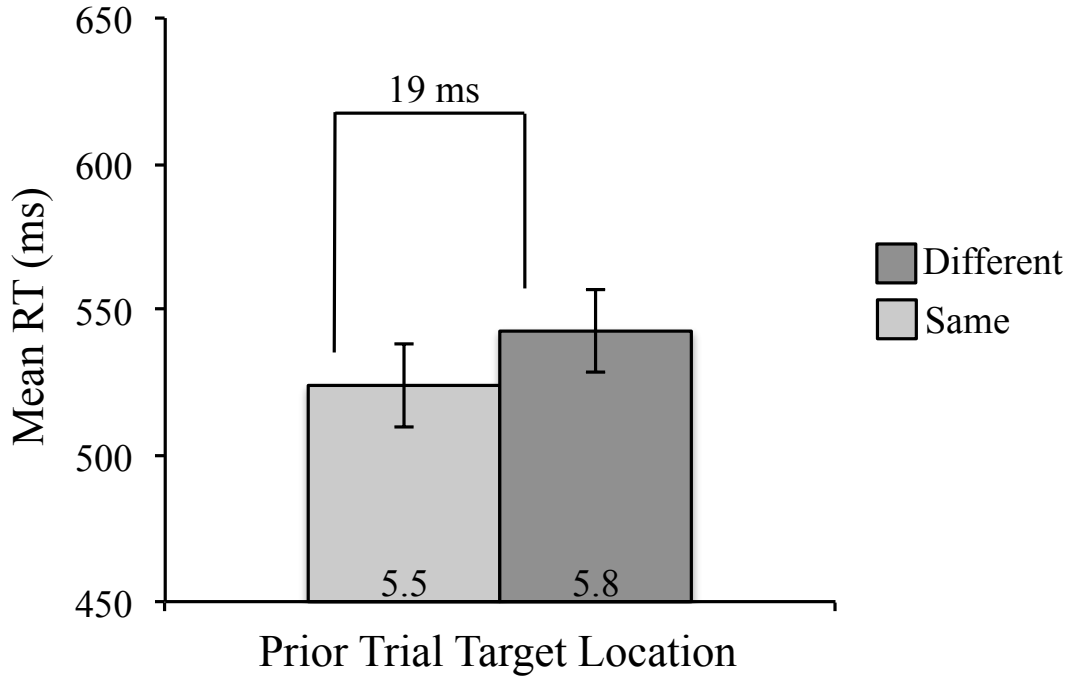
Note: Percentage errors for each condition are represented at the bottom of each column. 95% CI = 14 ms.

Figure 10. *Mean RT and percent error for Experiment 2 as a function of prior trial target identity (Error Bars: 95% confidence intervals).*



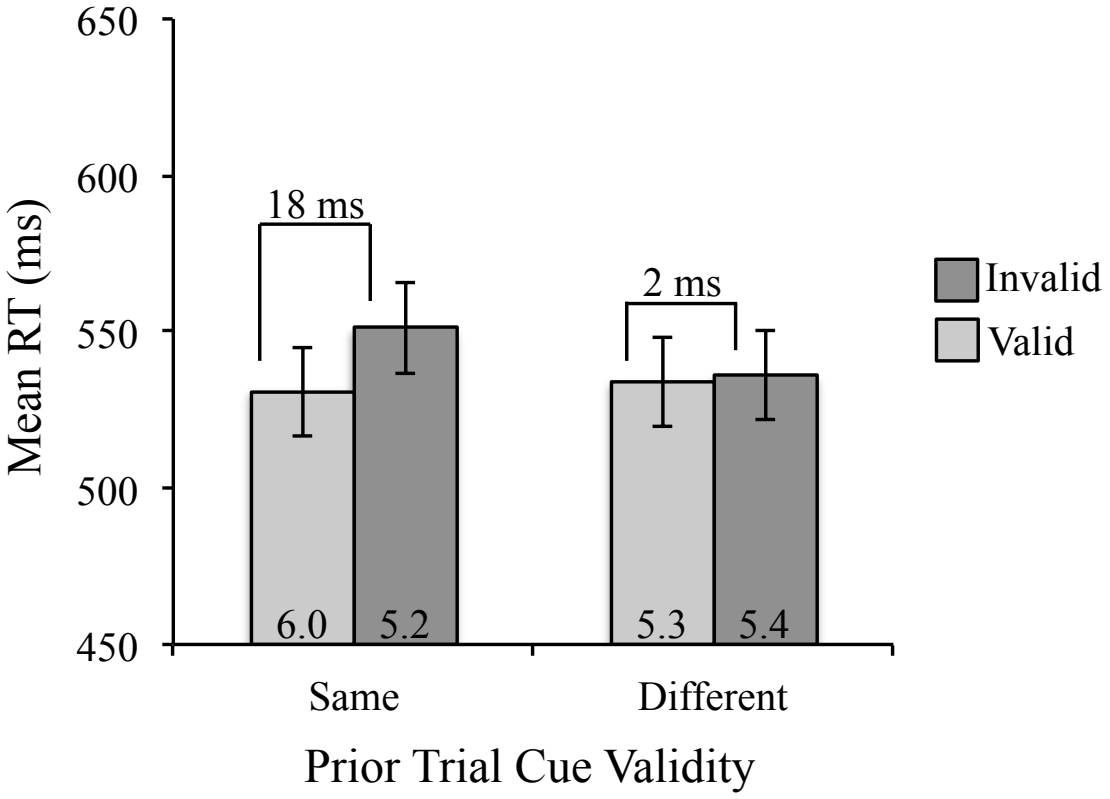
Note: Percentage errors for each condition are represented at the bottom of each column. 95% CI = 14 ms.

Figure 11. *Mean RT and percent error for Experiment 2 as a function of prior trial target location (Error Bars: 95% confidence intervals).*



Note: Percentage errors for each condition are represented at the bottom of each column. 95% CI = 14 ms.

Figure 12. *Mean RT and percent error for Experiment 2 as a function of cue validity and prior trial cue validity (Error Bars: 95% confidence intervals).*



Note: Percentage errors for each condition are represented at the bottom of each column. 95% CI = 14 ms.

Errors

The error data were analyzed with a repeated-measures ANOVA. There was a significant two-way interaction between whether the target identity changed from the prior trial and whether the target location changed from the prior trial, $F(1,26) = 52.17$, $p < .001$, $\eta_p^2 = .667$. There were no other significant main effects or interactions. There was no evidence that error effects undermined any of the RT effects (i.e., a speed-error trade-off).

Vincentiles

Vincentiles were again calculated for each of the significant main effects and analyzed with a repeated-measures ANOVA. The factors included in these analyses were the main effects (cue validity, prior trial cue validity, prior trial target identity, or prior trial target location) and RT bin (1-10). The results of this analysis can be seen in Table 5. As was expected, the main effects that were significant in Experiment 2 were significant in the current analyses. The main effect of bin was also significant for each analysis. Plots of these data can be found in Figures 13-15.

Mauchly's test of sphericity indicated that the assumption of sphericity was violated for the interaction between cue validity and RT bin, $X^2(44) = 506.35$, $p < .05$. The degrees of freedom were corrected using the Greenhouse-Geisser correction (E=.14). Figure 13 shows that as RTs increased across bins, the size of the **effect of cue validity** increased. However, unlike in Experiment 1, the interaction between cue validity and RT bin was not significant, $F(1.28,33.17) = 0.47$, $p = .541$, $\eta_p^2 = .018$. Though the effect of cue validity is larger at the slower end of the distribution, it is still only 15 ms at its largest. The small size of the cue validity effect

throughout the distribution suggests that this particular cue (a coloured rectangle) is a weak one compared to the cue from Experiment 1.

As is evident in Figure 14, the **effect of a change in target identity from the prior trial** mirrored the pattern found in Experiment 1, in that the effect was left shifted (largest in the fastest bin and smallest in the slowest bin). Mauchly's test of sphericity indicated that the assumption of sphericity was also violated for the interaction between prior trial target identity and RT bin, $X^2(44) = 482.46$, $p < .05$. The degrees of freedom were corrected using the Greenhouse-Geisser correction (E=.17). The interaction between prior trial target identity and RT bin was significant, $F(1.49,38.62) = 11.15$, $p = .001$, $\eta_p^2 = .300$.

Figure 15 shows that the **effect of a change in target location from the prior trial** also mirrored the pattern found in Experiment 1, in that the effect was approximately the same size throughout the RT distribution. Mauchly's test of sphericity indicated that the assumption of sphericity was also violated for the interaction between prior trial target location and RT bin, $X^2(44) = 414.86$, $p < .05$. The degrees of freedom were corrected using the Greenhouse-Geisser correction (E=.19). The interaction between prior trial target location and RT bin was not significant, $F(1.67,43.44) = 0.22$, $p = .763$, $\eta_p^2 = .008$.

Table 5. *Results of the within-subjects ANOVA on bin RT for Experiment 2.*

	Cue Validity (CV)				
	F	*df*	*MSE*	*p*	η_p^2
CV	6.98	(1,26)	1274.58	.014	.212
Bin	404.19	(1.41,36.72)	9577.32	.000	.940
CV*Bin	0.47	(1.28,33.17)	2377.92	.541	.018
	Prior Trial Target Identity (ID)				
	F	*df*	*MSE*	*p*	η_p^2
ID	41.86	(1,26)	4142.22	.000	.617
Bin	372.81	(1.37,35.49)	10056.07	.000	.935
ID*Bin	11.15	(1.49,38.62)	1897.90	.001	.300
	Prior Trial Target Location (LOC)				
	F	*df*	*MSE*	*p*	η_p^2
LOC	27.58	(1,26)	1844.30	.000	.515
Bin	377.95	(1.42,36.98)	9881.35	.000	.936
LOC*Bin	0.22	(1.67,43.44)	965.69	.763	.008

Note: Mauchly's test of sphericity indicated that the assumption of sphericity was violated for the main effect of bin in each analysis. The degrees of freedom were therefore corrected using the Greenhouse-Geisser correction.

Figure 13. *The main effect of cue validity in Experiment 2 as a function of RT bin. (Error Bars: 95% confidence intervals).*

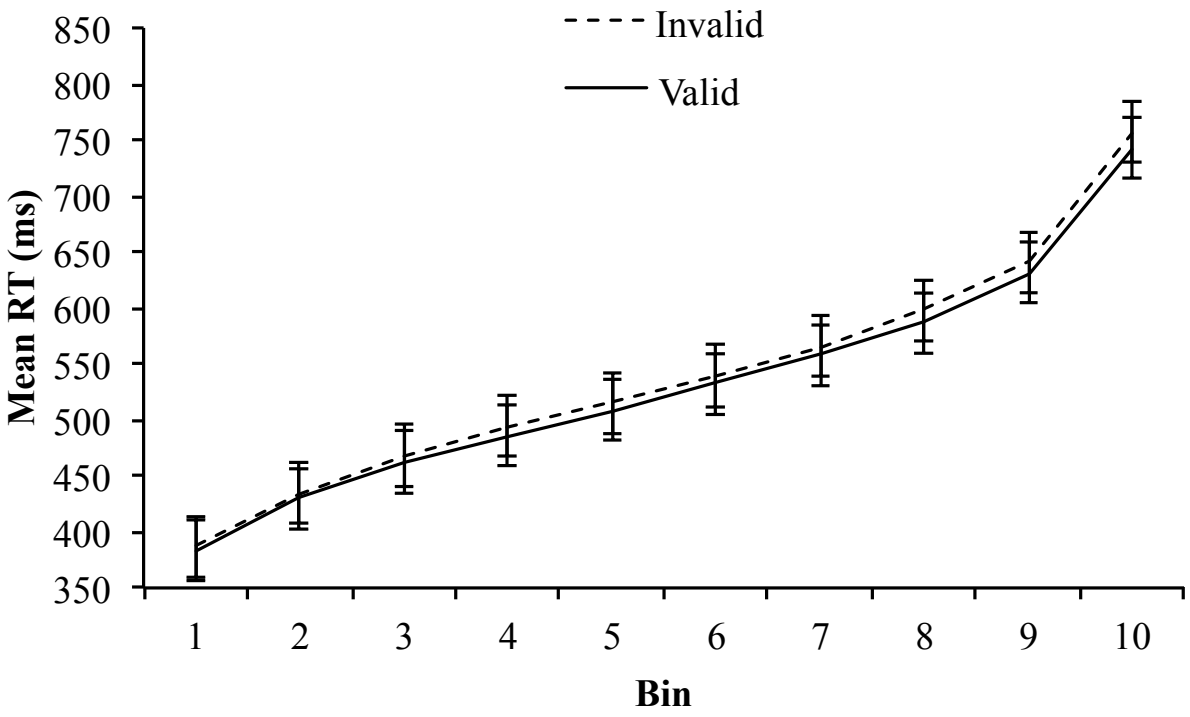


Figure 14. *The main effect of prior trial target identity in Experiment 2 as a function of RT bin. (Error Bars: 95% confidence intervals).*

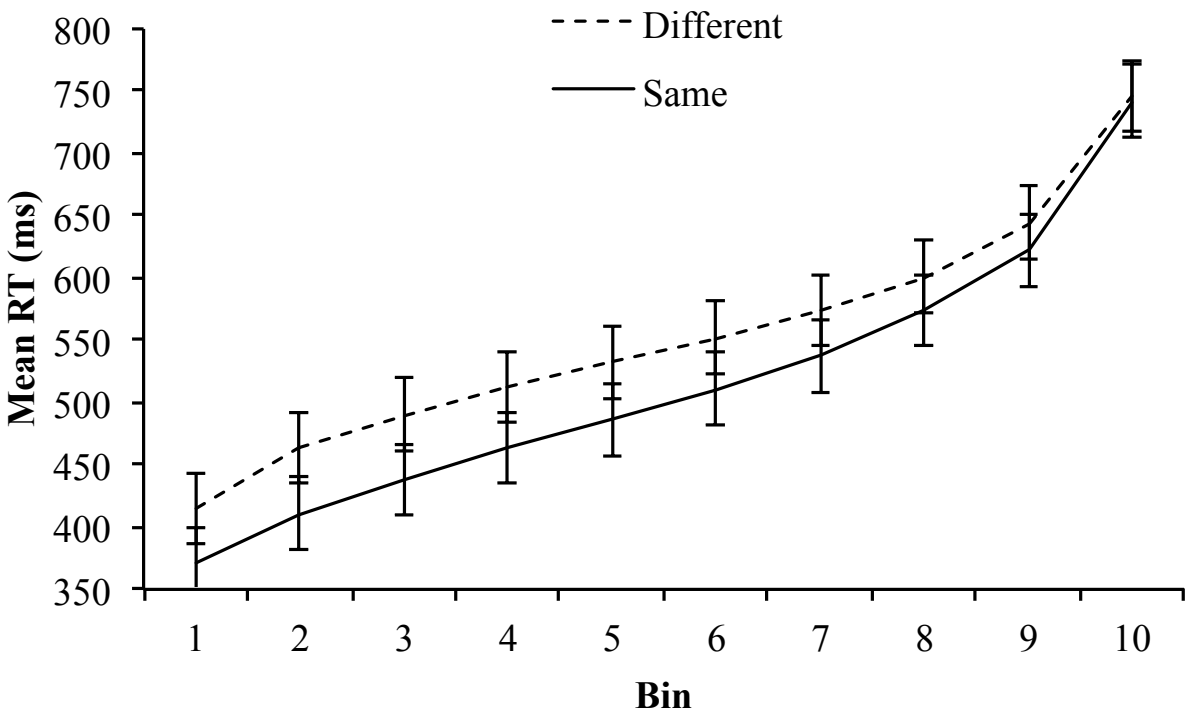
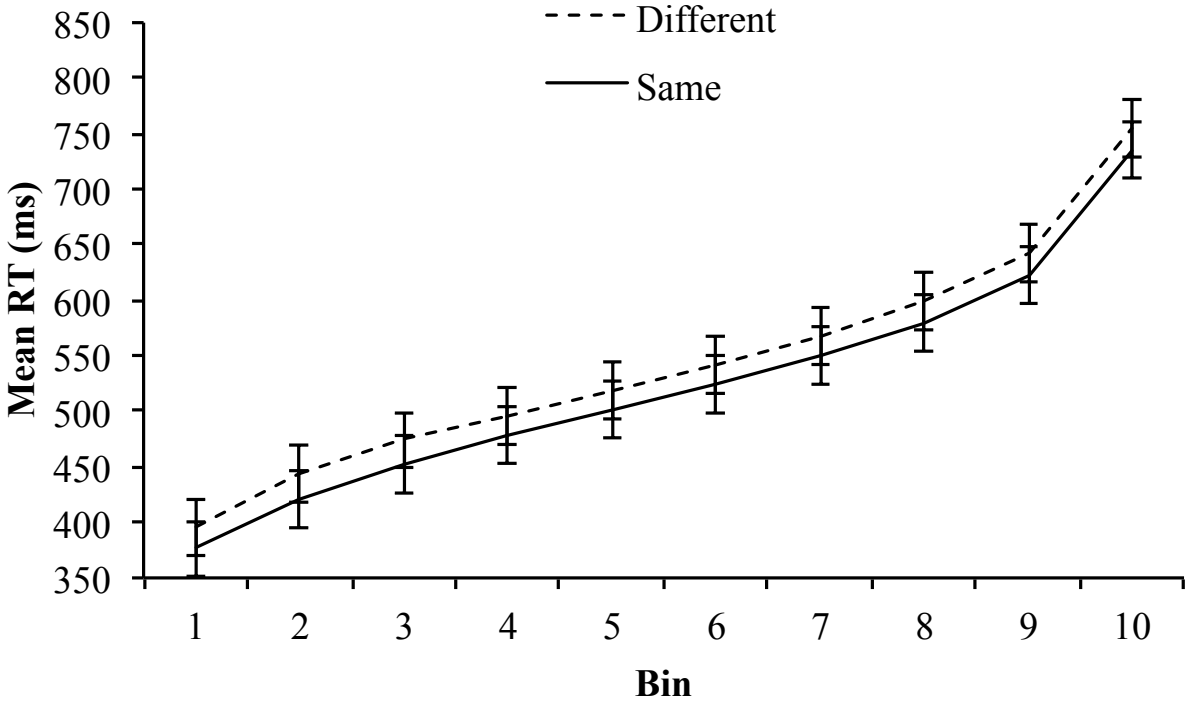


Figure 15. *The main effect of prior trial target location in Experiment 2 as a function of RT bin. (Error Bars: 95% confidence intervals).*



Discussion

Participants were slower to identify the target symbol when target identity or target location changed from the prior trial, mirroring the effects seen in Experiment 1. In contrast to Experiment 1, there was no significant main effect of whether cue validity changed from the prior trial. There was, however, a two-way interaction between the current trial's cue validity and whether cue validity changed from the prior trial. Validly cued trials were not affected by a change in cue validity from the prior trial, but invalidly cued trials were. Participants were slower on an invalidly cued trial when it was preceded by an invalidly cued trial (i.e., when cue validity did not change from the prior trial) than when it was preceded by a validly cued trial (i.e., when cue validity changed from the prior trial). These results differ from those in Experiment 1, in which participants were slower to respond on an invalidly cued trial when it was preceded by a validly cued trial than when it was preceded by a validly cued trial. This may have occurred because an invalid trial preceded by an invalid trial was a very rare event, as cue validity was 75%.

Unlike in Experiment 1, the size of the effect of cue validity was not significantly right shifted, though the size of the effect did consistently appear to increase across the distribution. The failure to see an interaction here may therefore be a Type 2 error. As in Experiment 1, the size of the effect of prior trial target identity (same vs. different) *decreased* as bin RT increased and the size of the effect of prior trial target location (same vs. different) remained constant across the distribution. These differing patterns for the main effects suggest that it is not the case that participants simply weigh all dimensions of the prior trial in the same way over time. Instead, it appears that different features of the prior trial influence performance at different points in time when the cue is endogenous and 75% valid.

In conclusion, the results of this experiment demonstrate that the size of the cue validity effect also varies as a function of prior trial history when an endogenous spatial cue is used. Further, these results differ from those in Experiment 1, suggesting that prior trial history has distinct effects depending on the type of spatial cue being used. The theoretical significance of these findings is deferred until the general discussion.

Experiment 3: Exogenous Spatial Cuing (75% Validity)

Experiment 3 made use of an exogenous spatial cue with 75% validity in order to assess whether the differential effects of prior trial history in the context of the first two experiments is a result of the type of cue used (exogenous vs. endogenous), and not simply how often the cue was valid (50% vs. 75%). The methods in Experiment 3 mirrored those in Experiment 2, with the exception that an exogenous spatial cue was employed.

Method

Participants. 37 University of Waterloo undergraduate students participated for course credit.

Design. The experiment was a within-subjects design with two cue conditions: valid and invalid.

Stimuli. The stimuli were the same as in Experiment 1.

Procedure. The procedure was the same as in Experiment 1, with the exception of the number of experimental trials. The experiment consisted of 32 practice trials followed by two

blocks of 288 experimental trials each (216 validly cued and 72 invalidly cued trials). The two blocks were separated by a participant paced rest break.

Results

Of the 37 participants, data from 5 were removed from the analysis because at least 12% of their responses yielded an error. For the remaining 32 participants, trials on which an incorrect response was made were removed prior to data analysis, resulting in the removal of 5.8% of trials across participants. Trials following an incorrect response were also removed, resulting in the removal of 5.4% of trials across participants. Correct trial RTs that were over 2.5 standard deviations from the mean in each condition for each participant were also removed. This resulted in the removal of 2.5% of the trials with correct responses. Participants who had a mean RT over 2.5 standard deviations from the group mean were also removed. Four participants were outliers according to this criterion, leaving data from 28 participants for further analysis.

Effects on RT

A four-factor ANOVA was conducted in which the factors were: current trial cue validity (valid/invalid), whether cue validity changed from the prior trial (yes/no), whether target identity changed from the prior trial (yes/no), and whether the target location changed from the prior trial (yes/no). The results of this analysis can be found in Table 6. We first report the main effects. The mean RTs and percentage error for each of these main effects can be found in Figures 16 and 17.

Main effects. The standard effect of cue validity was observed; participants were significantly faster at identifying the target when the cue was valid (M = 480) than when it was invalid (M = 581), $F(1,27) = 83.42$, $p < .001$, $\eta_p^2 = .755$.

There was no significant main effect of whether cue validity changed from the prior trial, $F(1,27) = 2.72$, $p = .110$, $\eta_p^2 = .092$.

There was a main effect of whether the target identity changed from the prior trial, $F(1,27) = 39.70$, $p < .001$, $\eta_p^2 = .595$. Participants were significantly faster at identifying the target symbol when the target identity on the prior trial was the same as on the current trial (M = 485) than when the target identity changed from the prior trial (M = 522).

There was no significant main effect of whether the target location changed from the prior trial, $F(1,27) = 1.08$, $p = .308$, $\eta_p^2 = .038$.

Neither the four-way interaction nor any of the three-way interactions were significant (See Table 6).

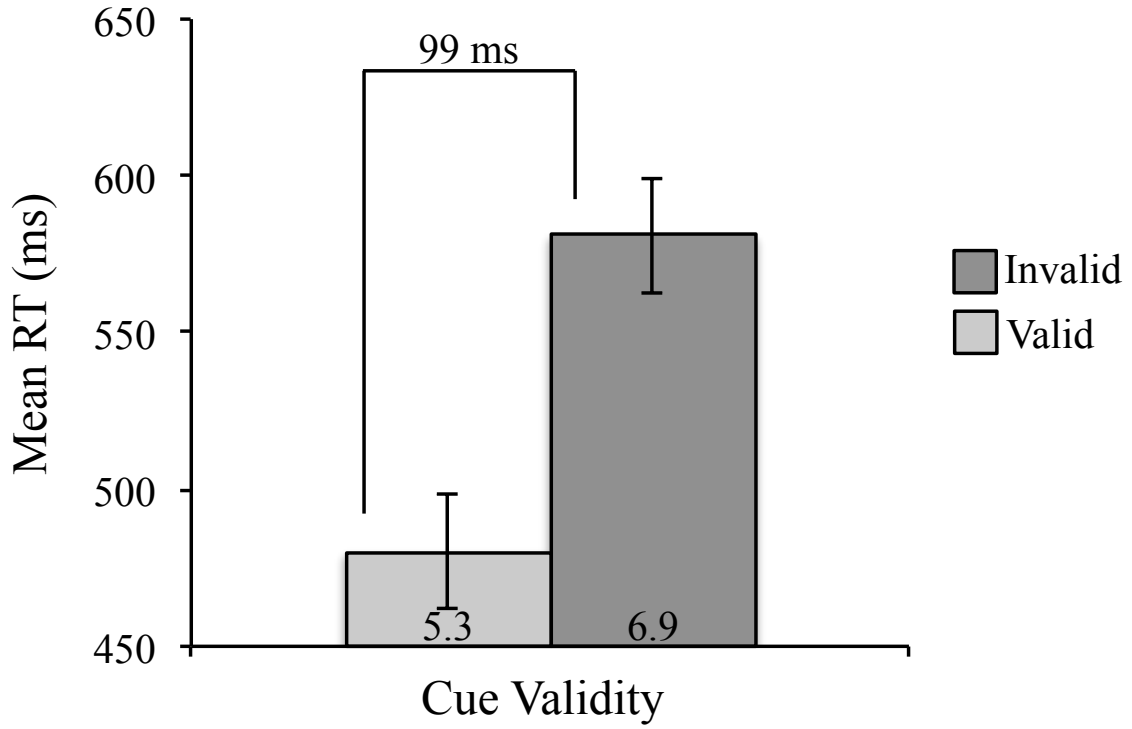
Two-way interactions. There was a significant interaction between whether the target's identity changed from the prior trial and whether the target's location changed from the prior trial, $F(1,27) = 99.05$, $p < .001$, $\eta_p^2 = .786$. None of the other two-way interactions were significant (See Table 6).

Table 6. *Results of the within-subjects ANOVA on RTs for Experiment 3 (75% exogenous cuing).*

Effect	RT				
	F	*df*	*MSE*	*p*	η_p^2
Cue Validity (CV)	**83.42**	**1,27**	**12,474.23**	**.000**	**.76**
Prior Cue Validity (PCV)	2.72	1,27	1.451.42	.110	.09
Target Identity Switch (ID)	**39.70**	**1,27**	**3,185.62**	**.000**	**.60**
Target Location Switch (LOC)	1.08	1,27	2,506.03	.308	.04
CV x PCV	1.16	1,27	1,109.69	.291	.04
CV x ID	2.16	1,27	1,895.26	.153	.07
PCV x ID	2.69	1,27	1,175.56	.113	.09
CV x LOC	1.97	1,27	985.42	.172	.07
PCV x LOC	0.80	1,27	1,226.97	.379	.03
ID x LOC	**99.05**	**1,27**	**1,115.98**	**.000**	**.79**
CV x PCV x ID	1.29	1,27	1,103.84	.267	.05
CV x PCV x LOC	1.62	1,27	1,361.19	.214	.06
CV x ID x LOC	1.97	1,27	1,453.30	.172	.07
PCV x ID x LOC	0.90	1,27	1,045.64	.351	.03
CV x PCV x ID x LOC	0.09	1,27	1,219.41	.763	.00

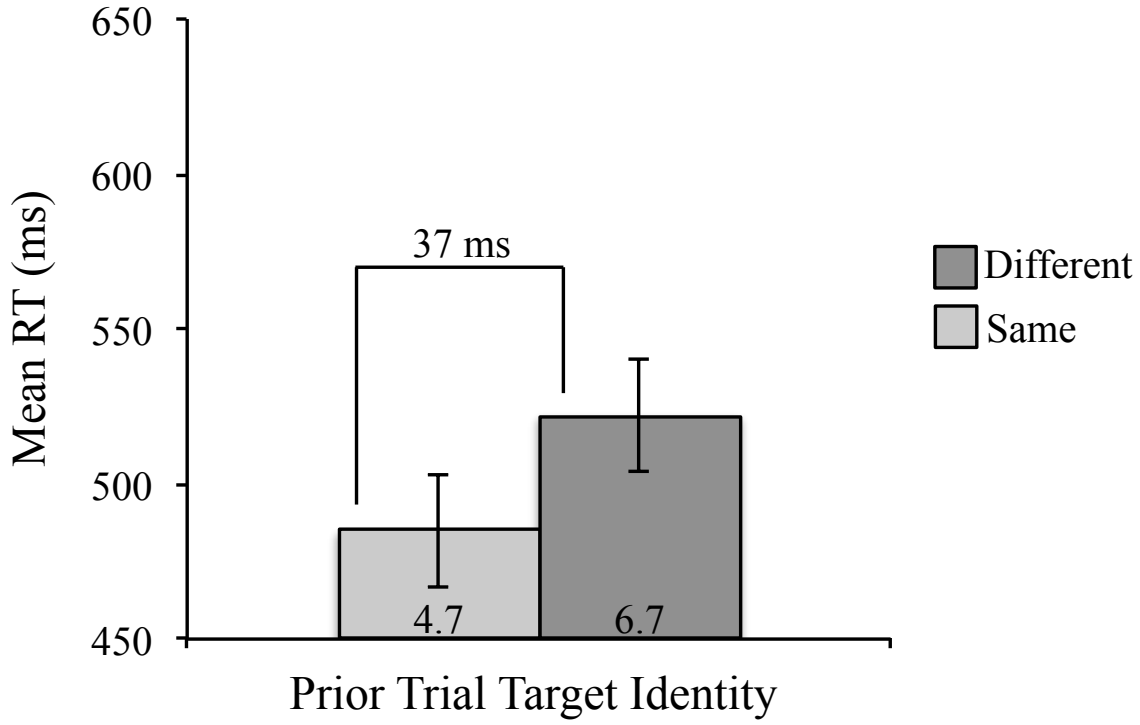
Note: Significant effects ($p < .05$) are bolded.

Figure 16. *Mean RT and percent error for Experiment 3 as a function of cue validity (Error Bars: 95% confidence intervals).*



Note: Percentage errors for each condition are represented at the bottom of each column. 95% CI = 18 ms.

Figure 17. *Mean RT and percent error for Experiment 3 as a function of prior trial target identity (Error Bars: 95% confidence intervals).*



Note: Percentage errors for each condition are represented at the bottom of each column. 95% CI = 18 ms.

Errors

The error data were analyzed with a repeated-measures ANOVA. There was a significant main effect of cue validity, $F(1,27) = 6.89$, $p = .014$, $\eta_p^2 = .203$. Participants made significantly fewer errors when the cue was valid than when it was invalid. There was also a significant main effect of whether the target's identity changed from the prior trial, $F(1,27) = 9.61$, $p = .004$, $\eta_p^2 = .262$. Participants made significantly fewer errors when the target's identity was the same as on the prior trial than when it changed from the prior trial.

There was a significant two-way interaction between whether the target's identity changed from the prior trial and whether the target's location changed from the prior trial, $F(1,27) = 30.45$, $p < .001$, $\eta_p^2 = .530$. There was a significant four-way interaction between the current trial's cue validity, whether cue validity changed from the prior trial, whether the target's identity changed from the prior trial, and whether the target's location changed from the prior trial, $F(1,27) = 5.85$, $p = .023$, $\eta_p^2 = .178$. There were no other significant main effects or interactions on the error data. There was no evidence that error effects undermined any of the RT effects.

Vincentiles

As in Experiments 1 and 2, Vincentiles were calculated for each of the significant main effects and analyzed with a repeated-measures ANOVA. The factors included in these analyses were the main effects (cue validity, prior trial cue validity, prior trial target identity, or prior trial target location) and RT bin (1-10). The results of this analysis can be seen in Table 7. As was expected, the main effects that were significant in Experiment 3 were significant in the current

analyses. The main effect of bin was also significant for each analysis. These plots can be seen in Figures 18-19.

Mauchly's test of sphericity indicated that the assumption of sphericity was violated for the interaction between cue validity and RT bin, $X^2(44) = 425.57$, $p < .05$. The degrees of freedom were corrected using the Greenhouse-Geisser correction (E=.22). The interaction between cue validity and RT bin was significant, $F(1.96,52.99) = 26.78$, $p < .001$, $\eta_p^2 = .498$. Figure 18 shows that the size of the **effect of cue validity** was again right shifted (smallest in the fastest bin and largest in the slowest bin).

Mauchly's test of sphericity indicated that the assumption of sphericity was also violated for the interaction between prior trial target identity and RT bin, $X^2(44) = 358.89$, $p < .05$. The degrees of freedom were corrected using the Greenhouse-Geisser correction (E=.26). The interaction between prior trial target identity and RT bin was significant, $F(2.37,64.06) = 8.54$, $p < .001$, $\eta_p^2 = .240$. As is evident in Figure 19, the size of the **effect of a change in target identity from the prior trial** increased as RT increased in the first 5 bins, and then decreased as RT increased in the final 5 bins. These results differ from Experiments 1 and 2, where the size of the effect of target identity decreased as RT increased across the entire distribution. Also important to note is that the effect of a change in target identity from the prior trial is still present in the slowest bin. This is different from the first two experiments, where the effect either reverses or disappears in the slowest bin.

Table 7. *Results of the within-subjects ANOVA on bin RT for Experiment 1.*

	Cue Validity (CV)				
	F	*df*	*MSE*	*p*	η_p^2
CV	88.54	(1,27)	15606.66	.000	.766
Bin	771.52	(1.63,44.05)	4710.99	.000	.966
CV*Bin	26.78	(1.96,52.99)	1329.08	.000	.498
	Prior Trial Target Identity (ID)				
	F	*df*	*MSE*	*p*	η_p^2
ID	57.04	(1,27)	3345.68	.000	.679
Bin	765.37	(1.49,40.10)	5514.52	.000	.966
ID*Bin	8.54	(2.37,64.06)	548.03	.000	.240

Note: Mauchly's test of sphericity indicated that the assumption of sphericity was violated for the main effect of bin in each analysis. The degrees of freedom were therefore corrected using the Greenhouse-Geisser correction.

Figure 18. *The main effect of cue validity in Experiment 3 as a function of RT bin. (Error Bars: 95% confidence intervals).*

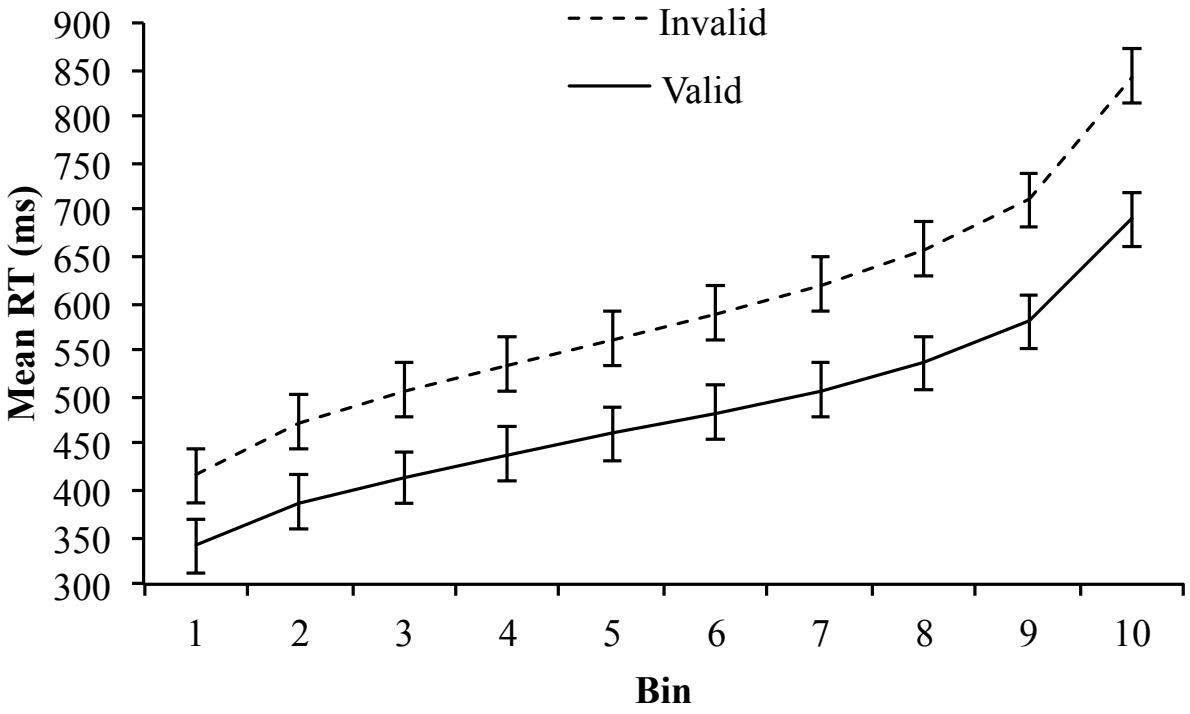
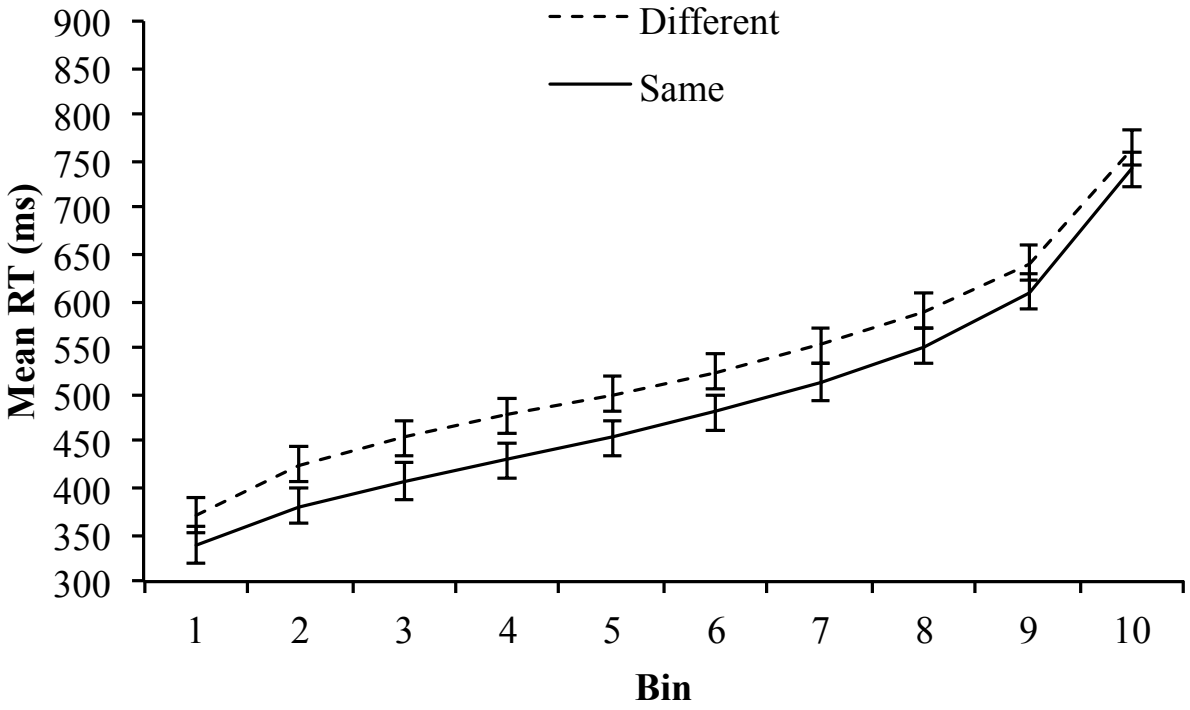


Figure 19. *The main effect of prior trial target identity in Experiment 3 as a function of RT bin. (Error Bars: 95% confidence intervals).*



Discussion

The pattern of the main effect of cue validity seen in the Vincentiles paralleled that seen in Experiments 1 and 2. In contrast, the pattern of the effect of prior trial target identity differed from what was seen in the first two experiments in that the size of the effect of a change in target identity from the prior trial increased as RT increased in the first 5 bins, and then decreased as RT increased in the final 5 bins (whereas it consistently decreased across the distribution in Experiments 1 and 2).

The only prior trial factor that affected performance in Experiment 3 was target identity. Participants were slower to identify the target symbol when the target identity changed from the prior trial. The results of this experiment differ from the results of both Experiments 1 and 2. This demonstrates that prior trial history has differential effects on performance as a result of both the type of cuing paradigm, as well as cue validity proportion. The theoretical significance of these findings is deferred until the general discussion.

General Discussion

The results of these three experiments suggest that the nature of the prior trial affects performance on the current trial in the context of both exogenous and endogenous spatial cuing. More specifically, these results support the hypothesis that participants are responding to change from the prior trial. When the cue was exogenous and cue validity was 50% (Experiment 1), participants were slower to respond when any one of the prior trial factors differed from the current trial. Additionally, the effects of the current trial's cue validity interacted with the effects of prior trial target identity and prior trial target location on RT. Participants responded to a

change in target identity differently depending on whether the target symbol appeared in the same location as on the prior trial.

The effects of prior trial history were different when the cue was endogenous (Experiment 2). Participants were slower to respond when the target identity or target location changed from the prior trial, but not when the cue's validity changed from the prior trial. There was also a significant two-way interaction between the current trial's cue validity and whether cue validity changed from the prior trial. When the current trial's cue was invalid, RTs were affected by whether the cue validity changed or not from the prior trial. This was not the case with validly cued trials, as RTs were around the same size regardless of the prior trial's cue validity.

Finally, target identity was the only prior trial factor that affected RT when the cue was exogenous and cue validity was 75% (Experiment 3). Participants were slower to respond on trials where the target identity changed from the prior trial than when it was the same as on the prior trial.

These results suggest that which prior trial information (i.e., cue validity, target identity, target location) is mainly attended to varies as a function of cue type (i.e., exogenous vs. endogenous) **and** validity (i.e., 50% vs. 75%). The effects of exogenous and endogenous cuing are well-known to differ in a variety of ways, such as the speed of visual orienting following the cue, the effect of memory load, and the effect of probability on cuing (Klein, 2004; Müller & Rabbit, 1989; Jonides 1981). The difference observed in the current studies indicates yet another way in which they differ. Table 8 summarizes which effects were significant in each experiment.

Table 8. *Significant main effects for Experiments 1-3.*

Experiment	Effect					
	CV	PCV	ID	LOC	CV*PCV	CV*ID*LOC
Exogenous (50% Valid)	**YES**	**YES**	**YES**	**MARGINAL**	NO	**YES**
Endogenous (75% Valid)	**YES**	NO	**YES**	**YES**	**YES**	NO
Exogenous (75% Valid)	**YES**	NO	**YES**	NO	NO	NO

Note: Cue validity (CV), prior trial cue validity (PCV), prior trial target identity (ID), and prior trial target location (LOC).

The effects of prior trial history also varied as a function of bin RT. A Vincentile analysis of the significant main effects in each experiment showed that effects of prior trial history differed depending on the RT's position in the distribution. In all three experiments, the size of the cue validity effect increased as RT increased (though it was not significantly right shifted in Experiment 2). In contrast, the size of the effect of whether target identity changed or not from the prior trial was left shifted (i.e., it decreased as RT increased). Finally, the size of the effect of whether cue validity changed or not from the prior trial, and the size of the effect of whether target location changed or not from the prior trial, remained constant across the distribution. These results demonstrate that the characteristics of the prior trial that are salient when a response is being made vary depending on processing speed. Table 9 summarizes the patterns that the significant main effects took in the RT distribution.

Table 9. *The main effects in Experiments 1-3 as a function of bin RT.*

Experiment	Effect			
	CV	PCV	ID	LOC
Exogenous (50% Valid)	**Right shifted**	**Constant**	**Left shifted**	**Constant**
Endogenous (75% Valid)	**Constant**	ns	**Left shifted**	**Constant**
Exogenous (75% Valid)	**Right shifted**	ns	**Left shifted**	ns

Note: Cue validity (CV), prior trial cue validity (PCV), prior trial target identity (ID), prior trial target location (LOC), non-significant main effects (ns).

The effect of cue validity was present in all experiments, thus replicating what is standardly reported in the literature. More importantly for present purposes, the magnitude of the cuing effect varied as a function of prior trial history. In Experiments 1 and 2, the effects of the current trial's cue validity interacted with prior trial factors on RT. This change in RT in turn led to a change in the size of the cue validity effect. These results suggest that the difference between responses to validly and invalidly cued trials does not exclusively reflect a pure measure of spatial attention. Instead it is jointly determined by all factors considered here (i.e., prior trial cue validity, prior trial target location, and prior trial target identity). These data suggest that participants behave dynamically in response to different sources of information from prior trials.

In short, participants appear to weigh the prior trial information differently depending primarily on the type of cuing that is being used, as well as on how valid the cue is. Additionally, prior trial effects varied across the RT distribution (in particular, one left shifted effect was seen in all three experiments, a finding that to date, appears rare in the literature). We conclude that prior trial history can have powerful effects in the context of both exogenous and endogenous spatial cuing paradigms. If our goal is to provide a deeper theoretical understanding of such data,

then it is important to consider such effects. The development of a computational model that can simulate these effects may well be called for.

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