Supplemental material

Results of Experiment 2A

The results for Experiment 2A are presented in Table S1. Only data from trials for which the preceding trial was correct were included in the analysis. This excluded 5.9% of the trials in Experiment 2A. All response times are for correct trials. Table S2 presents results from the omnibus 3 x 2 x 2 (prime-type, cue duration, and previous response) within-subject ANOVA conducted on response times and accuracy for the conditions where the current trial involved a cue and target that were different (Go trials). For trials where the cue and target were the same, there are only two levels of priming (neither-primed or both cue- and target-primed). We excluded data from one participant because this person performed the task nearly at chance (accuracy 52%).

Accuracy. For NoGo-trials, accuracy was higher in the long cue duration conditions where the previous trial was a Go-trial [both-primed: $t(54) = 3.46$, $p < .001$; neither-primed: $t(54) = 4.06$, $p < .001$], but not when the previous trial was a NoGo-trial [$t(54) = 1.23$, $p = .226$]. Participants were more likely to correctly withhold their response when the previous trial was a correct NoGo-trial compared to when the previous trial was a correct Go-trial [aAbB vs. aBcC: $F(1,54) = 67.82$, $MSE = 0.007$, $p < .001$] and when the previous trial primed both the cue and the target compared to when the previous trial primed neither [aBbB vs. aBcC: $F(1,54) = 11.06$, $MSE = 0.007$, $p < .005$].

As shown in Table 5, for Go-trials, participants were more accurate in the long cue-duration conditions ($p < .001$) and when the previous trial was a Go-trial ($p < .01$). No other comparison reached significance.

Response times. As seen in Table S1, response times were slower for a Go trial that followed a NoGo-trial as compared to ones that followed a Go-trial (main effect of previous "response" $p < .001$). Critically for our hypothesis, there was a significant main effect of prime type ($p < .001$). Confirming our hypotheses, planned comparisons revealed that the cue-primed conditions were faster [following NoGo-trials: $F(1,54) = 50.03$, $MSE = 907.81$, $p < .001$; following Go-trials: $F(1,54) = 5.22$, $MSE = 871.85$, $p < .05$] than the neither-primed condition, and that the target-primed conditions were slower [following NoGo-trials: $F(1,54) = 14.03$, $MSE = 1150.81$, $p < .001$; following Go-trials: $F(1,54) = 21.94$, $MSE = 877.73$, $p < .001$] than the neither-primed condition.

Of the two-way interactions, only previous "response" x cue duration and previous "response" x prime-type reached significance. The former was due to a larger simple effect of previous "response" with short [$t(54) = 8.77$, $p < .001$] than with long cue duration [$t(54) = 3.25$, $p < .005$]. The latter interaction was due to a smaller, but still significant, simple effect of previous "response" for the cue-primed conditions [$t(54) = 2.36$, $p < .05$].

Although the predicted two-way interaction between prime-type and cue duration was not significant ($p = .092$), the significant three-way interaction ($p < .05$) can be interpreted as a two-way interaction (smaller effect of prime-type with long cue duration) only when the preceding trial required a Go-response [after NoGo: $p > .60$; after Go: $F(2,108) = 7.51$, $MSE = 918.53$, $p < .001$].

Table S1: Proportion correct and mean response times (in msec) for Experiment 2A. Standard deviations are given in brackets. The different conditions, using our notation are given in the top rows. Experiment 2A only had responses for Go-trials.

		Current trial				
		Go			NoGo	
Previous trial		Neither-primed	Cue-primed	Target-primed	Neither-primed	Both-primed
NoGo		aAbC	aAaB	aAbA	aAbB	-
Go		aBcD	aBbC	aBcB	aBcC	aBbB
NoGo	200	.98 (.06)	.99 (.04)	.99 (.03)	.93 (.08)	-
	1000	.99 (.02)	.99 (.03)	.99 (.02)	.92 (.08)	-
Go	200	.99 (.02)	.99 (.03)	.99 (.03)	.80 (.12)	.84 (.15)
	1000	1.0 (.01)	1.0 (0)	1.0 (0)	.86 (.12)	.90 (.11)
NoGo	200	457 (70)	425 (54)	471 (74)	-	-
	1000	441 (63)	416 (76)	462 (74)	-	-
Go	200	405 (52)	405 (59)	440 (61)	-	-
	1000	430 (67)	412 (60)	433 (66)	-	-

Table S2. Results of analysis of variance on mean correct response time and accuracy for Go-trials in Experiment 2A.

		Accuracy		Response time	
Effect	df	MSE	F	MSE	F
Duration	1,54	0.001	12.383***	2015.048	0.119
Previous	1,54	0.001	7.134**	1822.482	53.995***
Prime type	2,108	0.001	0.431	1014.288	73.606***
Dur x prev	1,54	0.001	0.050	1109.065	14.147***
Dur x prime	2,108	<0.001	0.119	894.288	2.437
Prev x prime	2,108	0.001	0.662	1114.695	5.875**
Dur x prev x prime	2,108	0.001	1.090	1103.673	4.644*

* $p < .05$, ** $p \leq .01$, *** $p \leq .001$

Results of Experiment 2B

The results for Experiment 2B are presented in Table S3. Only data from trials for which the preceding trial was correct were included in the analysis. This excluded 4.7% of the trials in Experiment 2B. All response times are for correct trials. Table S4 presents results from the omnibus 3 x 2 x 2 (prime-type, cue duration, and previous trial response) within-subject ANOVA conducted on response times and accuracy for the conditions where the current trial involved a cue and target that were different (different trials).

Accuracy. Contrary to the NoGo-trials in Experiment 2A, for the same-trials there was no difference in accuracy between short and long cue duration (all ps > .10). Participants were more likely to make a correct response if the previous trial was a correct same-trial compared to when the previous trial was a correct different-trial [aAbB vs. aBcC: $F(1,52) = 5.51$, $MSE = 0.007$, $p < .05$]. No other comparison reached significance.

For the different-trials, participants were more likely to make a correct response if the previous trial was a correct same-trial compared to when the previous trial was a correct different-trial [$F(1,52) = 8.99$, $MSE = 0.003$, $p < .001$]. No other comparison reached significance.

Response times. For same-trials, participants were faster on long cue duration trials compared to short cue duration trials [aAbB vs. aBcC: $F(1,52) = 4.04$, $MSE = 1722.42$, $p = .05$; aBcC vs. aBbB: $F(1,52) = 4.23$, $MSE = 2243.62$, $p < .05$]. Participants were also faster when the previous trial was a same-trial [aAbB vs. aBcC: $F(1,52) = 32.04$, $MSE = 1332.05$, $p < .001$] and when the previous trial primed both the cue and target [aBbB vs. aBcC: $F(1,52) = 18.25$, $MSE = 1254.45$, $p <.001$].

As seen in Table S3, for different-trials, response times were faster for trials that followed same-trials compared to trials that followed different-trials ($p < .001$). Replicating Experiment 2A, there was significant main effect of prime type ($p < .001$). Confirming our hypotheses, planned comparisons revealed that the cue-primed conditions were faster [following same-trials: $F(1,52) = 27.12$, $MSE = 1164.31$, $p < .001$; following different-trials: $F(1,52) = 10.70$, $MSE = 1893.43$, $p < .01$] than the neither-primed condition and that the target-primed conditions were slower [following same-trials: $F(1,52) = 5.87$, $MSE = 1252.02$, $p < .05$; following different-trials: $F(1,52) = 4.17$, $MSE = 865.74$, $p < .05$] than the neither-primed condition.

None of the two-way interactions reached significance, but we observed a significant three-way interaction ($p < .001$). This was due to the priming effects becoming larger (numerically, but not statistically) with long cue durations following same-trials and disappearing with long cue durations following different-trials ($ps > .24$). In other words, the expected duration x prime-type interaction (smaller effect of prime-type with long cue duration) was found only when the preceding trial was a different-trial [after same: $p > .10$; after different: $F(2,104) = 9.294$, $MSE = 1440.762$, $p < .001$].

Table S3: Proportion correct and mean response times (in msec) for Experiment 2B. Standard deviations are given in brackets. The different conditions, using our notation are given in the top rows.

		Current trial				
		Different			Same	
Previous trial		Neither-primed	Cue-primed	Target-primed	Neither-primed	Both-primed
Same		aAbC	aAaB	aAbA	aAbB	-
Different		aBcD	aBbC	aBcB	aBcC	aBbB
Same	200	.97 (.06)	.99 (.03)	.95 (.07)	.94 (.05)	-
	1000	.98 (.05)	.98 (.03)	.96 (.07)	.95 (.06)	-
Different	200	.96 (.07)	.98 (.05)	.96 (.08)	.91 (.12)	.93 (.09)
	1000	.97 (.06)	.97 (.05)	.97 (.05)	.93 (.08)	.93 (.08)
Same	200	481 (79)	466 (72)	492 (79)	482 (89)	-
	1000	481 (94)	448 (99)	495 (105)	470 (105)	-
Different	200	498 (90)	469 (80)	519 (99)	510 (93)	491 (96)
	1000	504 (112)	494 (92)	499 (107)	498 (109)	476 (111)

Table S4. Results of analysis of variance on mean correct response time and accuracy for different-trials in Experiment 2B.

		Accuracy		Response time	
Effect	df	MSE	F	MSE	F
Duration	1,52	0.003	1.853	7138.425	0.007
Previous	1,52	0.003	0.874	2824.979	22.616***
Prime type	2,104	0.003	8.992***	1486.788	38.192***
Dur x prev	1,52	0.003	< 0.001	2338.595	1.241
Dur x prime	2,104	0.002	1.732	1318.226	1.926
Prev x prime	2,104	0.003	1.184	1413.456	0.665
Dur x prev x prime	2,104	0.002	0.040	1521.252	9.272***

* $p < .05$, ** $p \leq .01$, *** $p \leq .001$

The main striking result of Experiments 2 is that priming the target produced slower-than-baseline responses, whereas priming the cue produced faster-than-baseline responses. This confirms a necessary prediction of the habituation model under the assumption that novelty rather than familiarity drives the change detection response, which is the main thrust of the current paper.

Results of simulations

Here we present the results of simulations that address the model's detailed predictions regarding the influence of cue duration on the effect of prime-type. To simplify the presentation, we focus on the difference between the cue-primed and target-primed conditions. Our initial (informal verbal) predictions were that with increased cue duration, change detection will be easier and thus all cueing conditions become similar. The data, however, revealed that it matters whether the previous trial was a same (or NoGo) trial or a different (or Go) trial. As discussed in the main text, the model captures this modulating effect of the previous trial type through a balance between the amount of depletion and recovery of synaptic resources, the effectiveness of which are increased with increased cue duration. Figure S1, shows the results of a systematic exploration of the values for the depletion and recovery parameters (16,016 simulations for each of the 12 conditions). For each condition, we calculated the novelty signal by measuring the height of the final peak and the height of the activation profile at the onset of the target stimulus (see Figure 3). The colored areas correspond to three patterns of results obtained in this dataset. In the red area are parameter combinations that produce the pattern we initially expected, that is a diminished effect of prime-type with long cue duration compared to short cue duration, irrespective of previous trial type. In the blue area are parameter combinations that produce the reversed pattern that is a diminished effect of prime type with short cue duration compared to long cue duration. Finally, in the green area are parameter combinations that produce the pattern we observe in the data, that is a diminished effect of prime-type with long cue duration compared to short cue duration when the previous trial was a different (or Go) trial and the reversed pattern when the previous trial was a same (or NoGo) trial. Near the boundary between the red and green areas are patterns where cue duration does not modulate the effect of prime-type when the previous trial was a same (of NoGo) trial, which is observed in Experiment 2A.

To provide some examples, we selected four representative parameter combinations that fall on a rectangle and are shown in Figure S1 by the colored dots. In Figure S2, we show the effect of prime-type (novelty signal for cue-primed condition minus novelty signal for target-primed condition) as a function of cue duration. When cue duration does not modulate the effect of prime-type (i.e., absence of an interaction), the lines are horizontal. We show the results from trials following a same trial with red lines. Only when the depletion and recovery are both high does longer cue duration decrease the effect of prime-type. The opposite is true for the blue lines, which depict the results for when the previous trial was a different trial. Only when both the depletion and recovery are low is there an increased effect of prime-type with longer cue duration.

The overall take-home message from these simulations is that the balance between depletion and recovery needs to be taken into account when considering the modulatory effect of temporal manipulations such as cue duration. In addition, the simulations point to a way forward to assess the balance of depletion and recovery at an individual level. For this to be viable, the model needs to be expanded to a full-fledged decision model that is able to account for entire response time distributions.

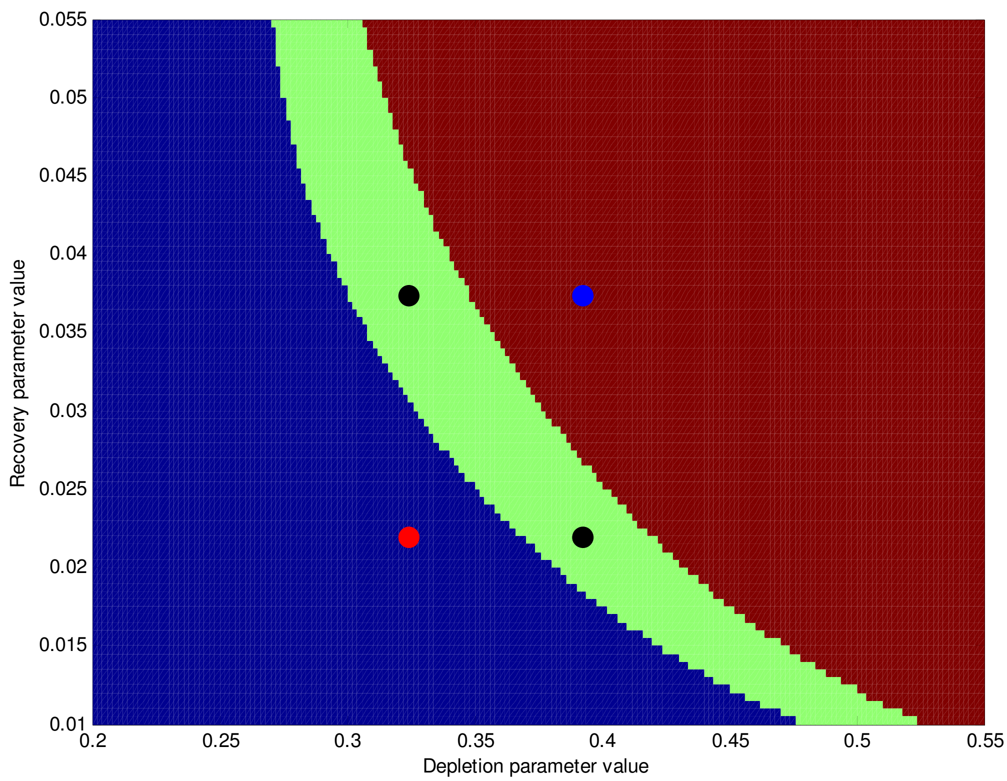

Figure S1. Results of systematically varying the depletion and recovery parameters in the model. The colored areas relates to the three patterns of result observed (see text). The dots are parameter combinations selected for presentation in Figure S2. The experimental data presented in main text has a pattern that falls within the green-colored area.

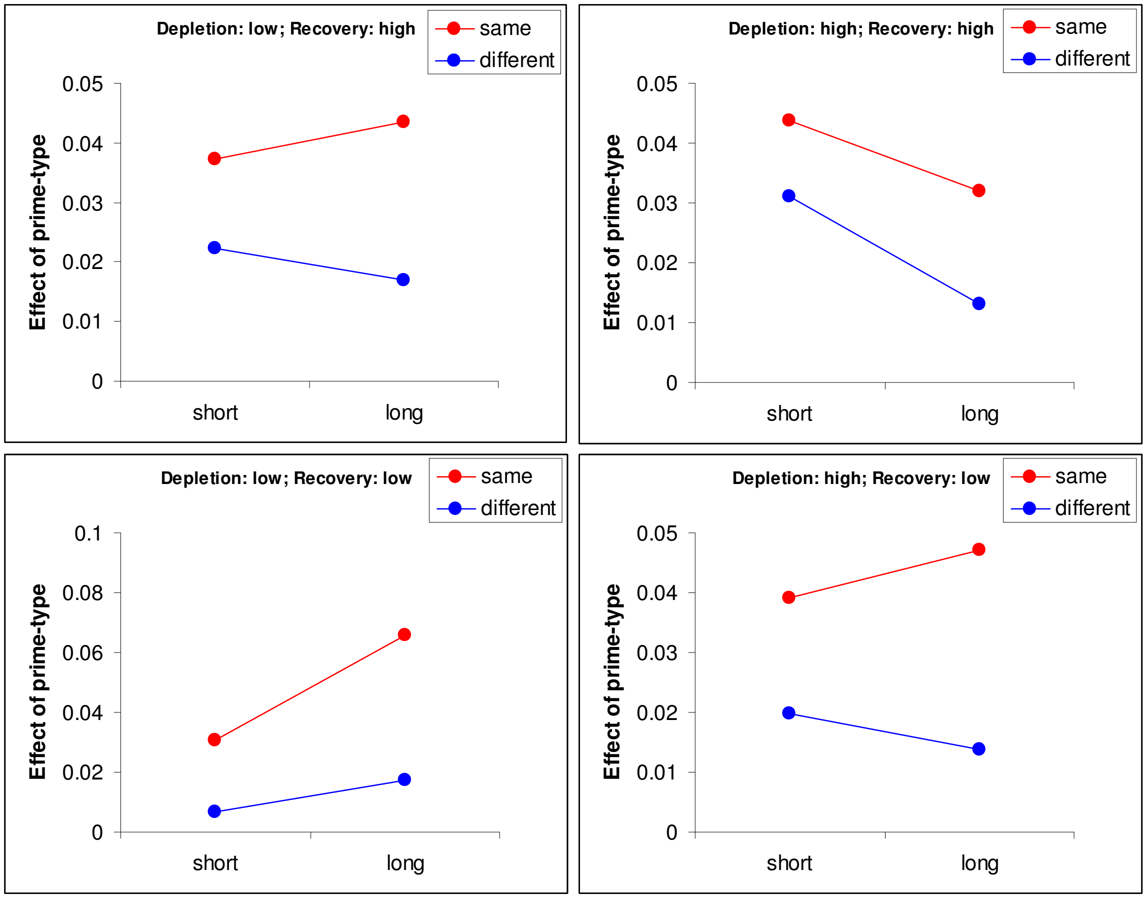

Figure S2. Representative examples from the simulation in Figure S1. Each dot represents an effect, i.e. a difference score. Non-horizontal lines therefore depict interactions between prime-type and cue duration (short, long). The exact values are adjusted for the overall mean.