

Experiments 1 and 2

This chapter describes the first two experiments of the research work. In both these experiments, the sequential mode of presentation was compared with simultaneous presentation, whilst locations were either random or unchanged, from study to test in the swap detection task. The difference between the two experiments was in the sequential mode of presentation. In Experiment 1, the study display was gradually built up by presenting the stimuli one by one, whereas in Experiment 2, the previous stimulus vanished as the next one was presented. These two types of sequential presentation are depicted in Figure 4.1. The rationale of these experiments, their design, procedure, and results are explained in this chapter.

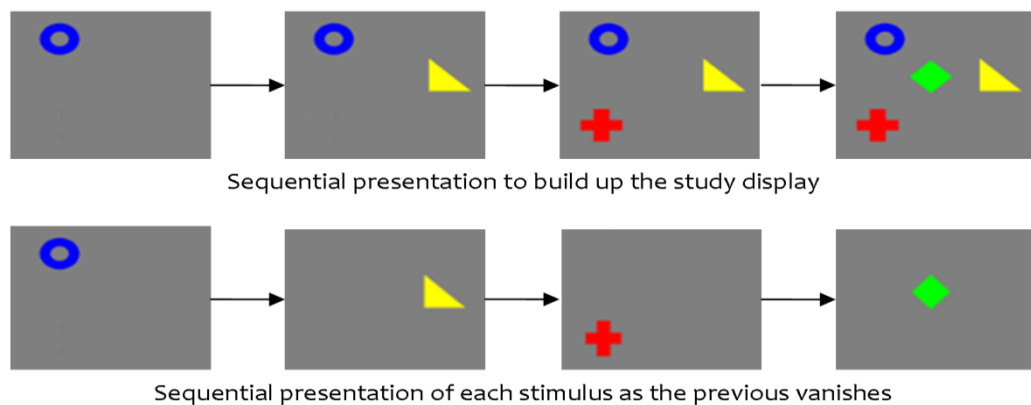


Figure 4.1: Two kinds of sequential presentation

Earlier, Jaswal and Logie [2011] have studied these two kinds of sequential presentations, and simultaneous presentation, in three separate experiments using the change detection task to test color-shape binding with six stimuli. In all experiments, they also manipulated locations to be unchanged or random from study to test. With simultaneous presentation, performance was significantly better with unchanged locations than random locations. With sequential presentation in which the study display was gradually built up, performance decreased somewhat in the unchanged locations condition. With sequential presentation in which the previous stimulus vanished as the next was presented, performance was very low, even when locations remained unchanged. They attributed these differences to configural encoding of stimuli which is maximum with simultaneous presentation, somewhat reduced but still available, as stimuli remain on the screen to build up the study display; but completely precluded when one stimulus vanishes as the next is presented, as all stimuli are never seen together by the participants. Thus, the present experimenter also expects differences in the performance of participants in the simultaneous and sequential mode of presentation

tested in the present work, in the same experiments. Differences in the level and pattern of performance are also expected between Experiment 1 and 2, as they use different types of sequential presentation.

4.1 EXPERIMENT 1

The experiment aimed to study the effect of mode of presentation and locations on feature binding, using a change detection paradigm. The feature binding performance was compared in the change detection task, with simultaneous and sequential presentation of stimuli in the study display; and with unchanged and random locations from study to test.

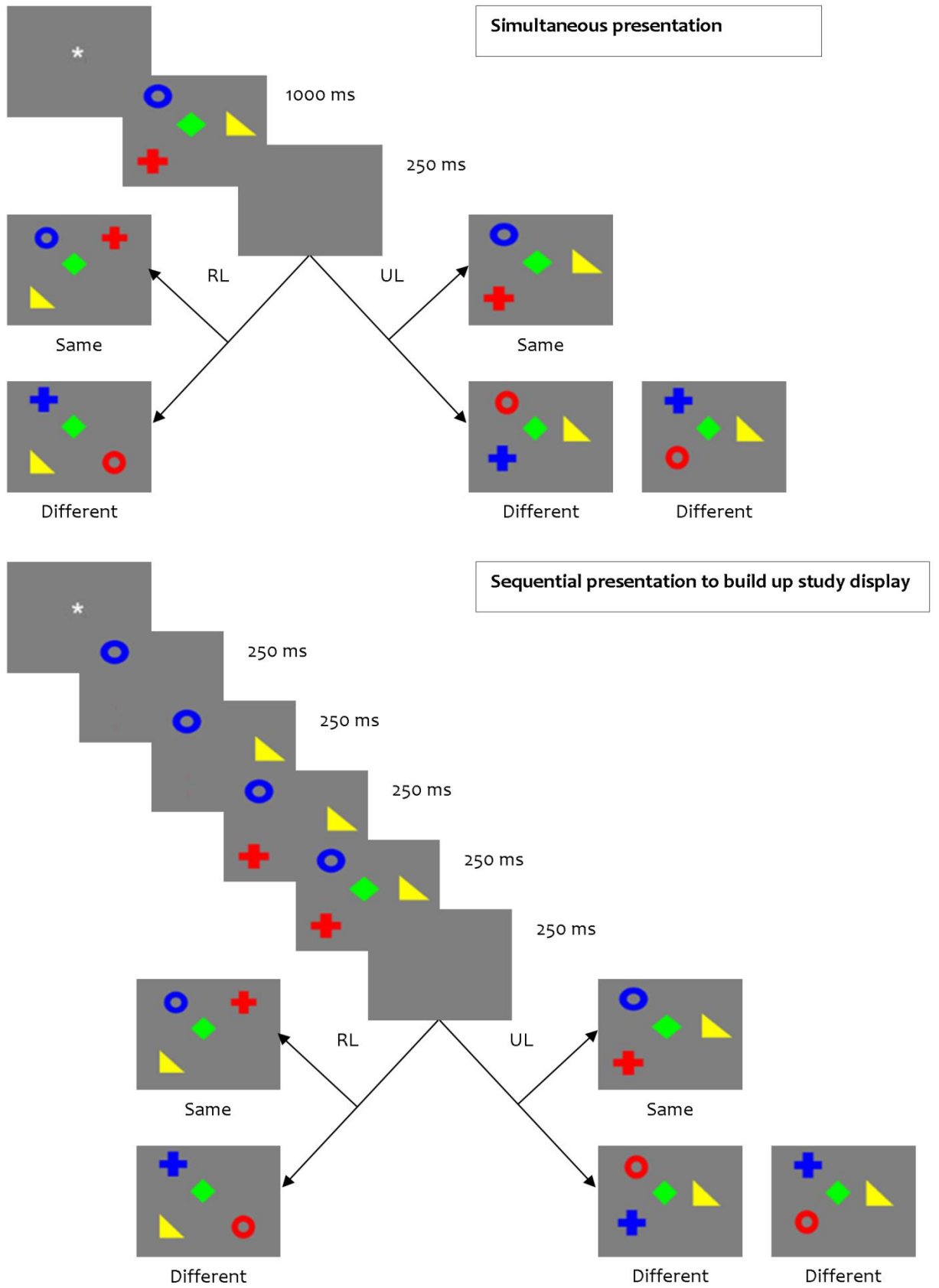
The sequential presentation in this experiment is such that the study display is gradually built up by the stimuli being presented one after the other. This mimics real life scenarios where the previous object remains in the same position in the visual scene when the next one appears. Thus, in this experiment, participants can take advantage of the spatial relations between the stimuli in the study display in both the simultaneous and the sequential conditions. The distribution of stimuli in space allows their encoding as an ensemble or pattern or configuration. Studies have shown that relational or configural encoding serves as a cue in feature binding of multiple stimuli [Jaswal and Logie, 2011; Xie and Zhang, 2017]. Nevertheless, in the present experiment, in the sequential condition, as the stimuli appear one by one, an additional cue is present – the temporal one. Thus, the participants can also encode the stimuli as a sequence. This might enhance performance in the sequential presentation condition relative to the simultaneous presentation condition.

On the other hand, performance may be reduced in the sequential presentation condition relative to simultaneous presentation, if the temporal cue conflicts with configural encoding, since configural encoding is almost immediate and automatic, resulting in an icon; whereas temporal separation may disturb this process of retaining an iconic representation. Still another possibility is that the temporal cue is simply redundant. Participants might rely so much on the spatial cue, that the information from the temporal signal is simply not required, more so because using the temporal cue is also likely to be more resource demanding.

The location-based configural encoding of stimuli will be easier in the unchanged locations condition, and in fact may actually hamper performance when the locations of stimuli change randomly from study to test. Thus, performance will be better in the unchanged rather than the random locations condition. It is also of interest to study how locations interact with mode of presentation to affect the performance of the participants. If locations are a factor in simultaneous presentation, but not sequential presentation, then the difference in performance between unchanged and random locations conditions is likely to be more with simultaneous presentation rather than sequential presentation. The serial position effects in the sequential presentation condition will also be analyzed to examine and understand the main results.

4.1.1 Design and procedure

The experiment was designed as a 2×2 factorial experiment with repeated measures on both factors. The two independent variables were mode of presentation [simultaneous vs. sequential] and locations [unchanged vs. random]. Figure 4.1 depicts the procedure.



Stimuli are not drawn to scale

Figure 4.2: Sequence of events in each trial in Experiment 1

The study display comprised four stimuli, which were random combinations of four colors and four shapes. The task of the participant was to remember the bindings between colors and shapes. The stimuli remained on the screen for 1000 ms for simultaneous presentation, and each of them was shown for 250 ms in the sequential presentation condition. Thus, the total exposure duration for both presentation modes was the same. The sequential presentation involved gradually building up the study display by presenting the stimuli one by one. The previous stimuli remain on the screen as the next appeared.

On half the trials, the test stimuli appeared in the same locations as the study display. This was the block comprising the unchanged locations condition. On the other half of the trials, comprising the random locations condition, the locations of stimuli in the test display were random with respect to the study display.

The task of the participant was to detect if any of the four stimuli changed in the binding of color and shape in each trial. When the change happened, it was actually a swap between any two stimuli. Note that the participants cannot do the task if they remember the colors alone or shapes alone; they have to remember the combinations of color and shape for each stimulus. The binding change happened only on 50% trials. Accuracy of response was the dependent variable of interest, and was calculated as d' prime.

4.1.2 Results

Primary Analyses

Mean change detection performance calculated from d' primes is shown in Figure 4.2. A repeated measures ANOVA revealed a significant main effect of unchanged and random locations, $F[1,17]=82.592$, $MSE=.559$, $p<.001$, $partial \eta^2 = .829$, $BF_{10}=2.549 \times 10^{11}$ such that overall performance was reduced when locations were randomly changed from study to test display than when locations were unchanged. Neither the main effect of mode of presentation $F[1,17]=1.089$, $MSE=.609$, $p<.311$ ns, $partial \eta^2 = .060$, $BF_{01}=3.44$, nor the interaction of mode of presentation with locations, $F[1,17]=.140$, $MSE=.394$, $p<.713$ ns, $partial \eta^2 = .008$, $BF_{01}=3.230$, were significant. In Bayesian ANOVA, the model comprising both the main effects and the interaction effect [$BF_{10}=3.464 \times 10^{10}$] was compared with a model comprising only the main effects [$BF_{10}=1.119 \times 10^{11}$]. The model comprising only the main effects better fit the data by a factor of 3.23:1.

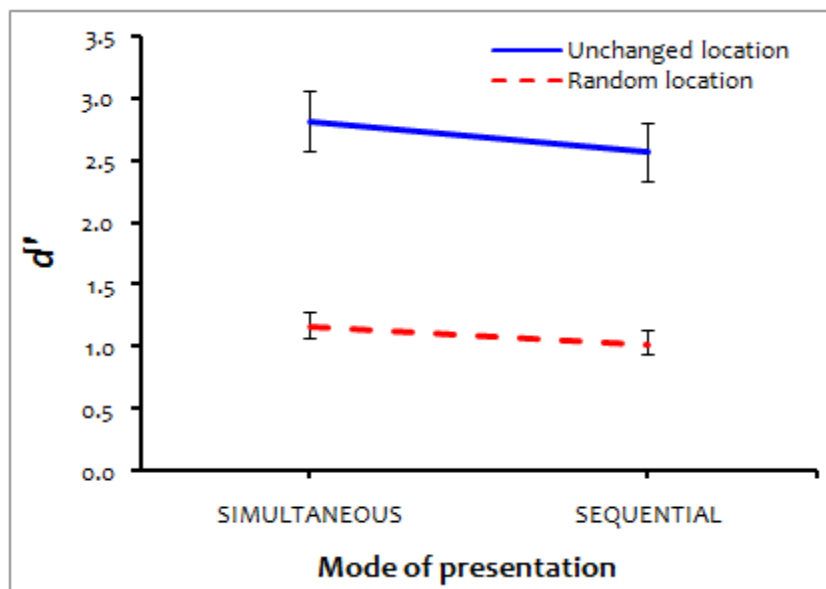


Figure 4.3: Mean d' prime scores in Experiment 1

Serial position effects in sequential presentation

To explore the serial position effects in the sequential presentation condition, a 2×4 repeated measures ANOVA [location × swaps] was carried out. The swaps selected for this analysis were between stimuli at serial positions 1 and 4 [showing the joint effect of primacy as well as recency], 1 and 2 [showing only the primacy effect], 2 and 3 [items in the middle positions], and 3 and 4 [showing only the recency effect].

There was a significant main effect of locations, $F[1,17]=60.407$, $MSE=3.074$, $p<.001$, $partial\eta^2=.780$, $BF_{10}=6.909\times 10^{18}$. Neither the main effect of swaps nor the interaction effect was significant. As can be seen in Figure 4.3, the graph lines for the two location conditions are very distinct, but the pattern across swaps is almost similar. Also, there is very little difference in performance due to the positions of the swap stimuli being different.

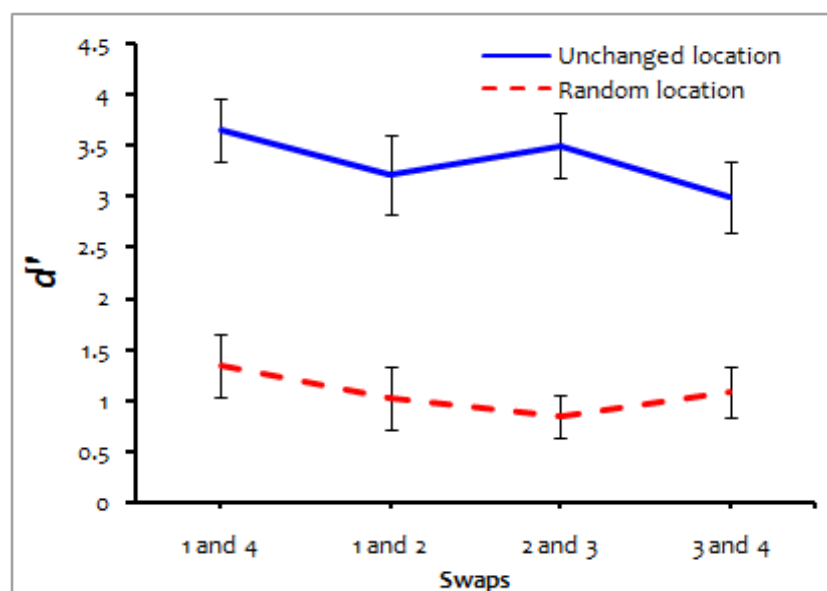


Figure 4.4: Serial position effects in Experiment 1

4.1.3 Discussion

The performance of the participants is better with unchanged locations than random locations as clearly depicted in Figure 4.2. Unchanged locations allow the participants to benefit from the spatiotopic representation of the study display as the test display matches the configuration of the study display in the unchanged locations condition. However, in the random locations condition, there is a mismatch between the pattern formed by the study and the test display and participants' performance is therefore, negatively affected in this condition.

However, there is no significant difference between simultaneous and sequential presentation. Thus, building up the study display by presenting stimuli one by one, and thus providing an additional temporal code, does not lead to any better performance than simultaneous presentation. This suggests that the difference between the two modes of presentation is not contingent on a temporal code. The similar performance in both modes of presentation suggests that the performance in these conditions relies on similar mechanisms. Certainly, seeing the stimuli appearing one by one, does not preclude the participants from coding them as a pattern or configuration. Alternatively, the similar performance in the two modes of presentation may occur because, simultaneous presentation is also like sequential presentation as participants most likely encode even simultaneously presented stimuli one by

one as suggested by eye-tracking studies [e.g., Becker and Rasmussen, 2008]. Nevertheless, the fact that there are no noteworthy serial position effects in the performance of the participants, suggests that the participants simply did not use the temporal code, and probably just encoded the stimuli in relation to each other as a pattern, in the sequential as well as the simultaneous mode of presentation.

4.2 EXPERIMENT 2

This experiment was designed to be the same as Experiment 1, except that for sequential presentation in this experiment, stimuli were presented one by one such that the previous stimulus vanished as the next was presented.

In a sequential presentation where the previous stimulus vanishes as the next is presented, retention of the earlier stimuli becomes difficult because any given stimulus may overwrite the representation of the earlier stimuli. In the absence of previous stimuli, relational or configural encoding is also much more difficult. Thus, in this kind of presentation, the participant presumably utilizes only a temporal cue in the absence of configural encoding. When the stimuli are presented simultaneously, their representation is retained as a pattern for a short duration and any change in that pattern is easy to detect. Thus, the performance of the participants is expected to be lesser with sequential presentation as compared to simultaneous presentation.

Further, if the representation of stimuli includes location as a feature and is thus a spatiotopic representation, binding swaps in the unchanged locations condition will be easier to detect than in the random locations condition. Also, since this spatiotopic representation is expected to exist more clearly with simultaneous presentation, the difference in performance between the unchanged and random locations conditions is likely to be more with simultaneous presentation rather than sequential presentation.

4.2.1 Design and procedure

The experimental design was the same as Experiment 1, except that for sequential presentation, stimuli were presented one by one such that the previous stimulus vanished as the next was presented. The trial procedure is depicted in Figure 4.4.

To briefly recapitulate the design, the experiment was a 2×2 factorial design with repeated measures on both factors - mode of presentation [simultaneous vs. sequential] and locations [unchanged vs. random]. In each trial, four stimuli were presented. They were random combinations of four colors and four shapes. The participant had to remember the bindings between colors and shapes. The stimuli remained on the screen for 1000 ms for simultaneous presentation, but in the sequential presentation condition, a stimulus appeared for 250 ms, with each stimulus being offset with the onset of the next stimulus. Thus, the total exposure duration for both presentation modes was the same.

On half the trials, comprising the unchanged locations condition, the test stimuli were presented in exactly the same locations as those in the study display. On the other half of the trials, comprising the random locations condition, the stimuli in the test display appeared in random locations [with replacement] in comparison to the study display.

The participant had to detect if any stimulus changed in the binding of color and shape. Binding change occurred on 50% trials. Whenever a change occurred, it was actually a swap between any two stimuli. The dependent variable was accuracy of response, calculated for each participant as the d' prime in each condition of the experiment. Results were analyzed using repeated measures ANOVA.

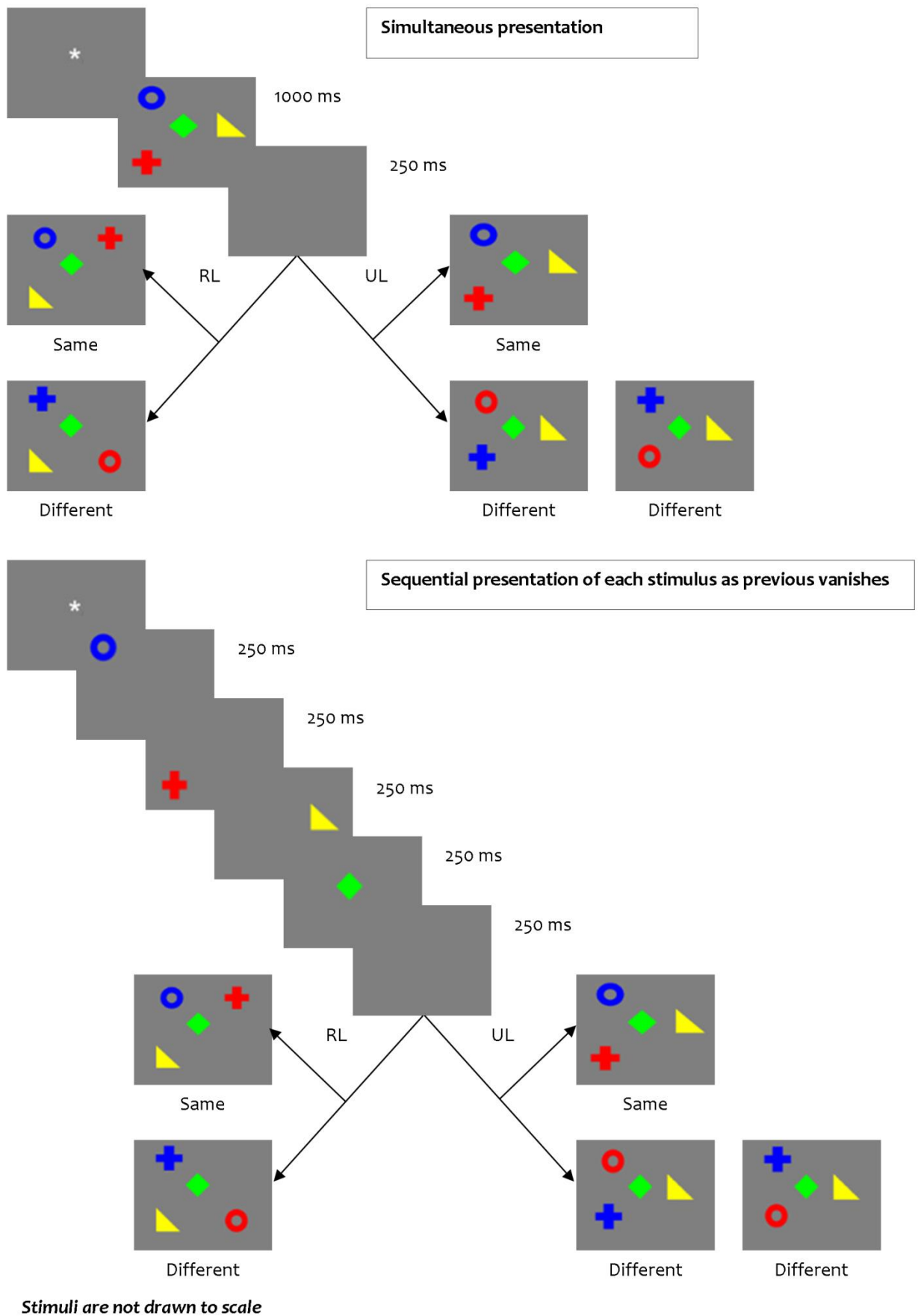


Figure 4.5: Sequence of events in each trial in Experiment 2

4.2.2 Results

Primary analyses

Mean change detection calculated from d primes is shown in Figure 4.5. A repeated measures ANOVA revealed a significant main effect comparing unchanged and random locations, $F[1,17]=34.587$, $MSE=.662$, $p<.001$, $partial \eta^2=.670$, $BF_{10}=6.939 \times 10^5$. Overall performance reduced when locations were randomly changed from study to test display than when locations were unchanged.

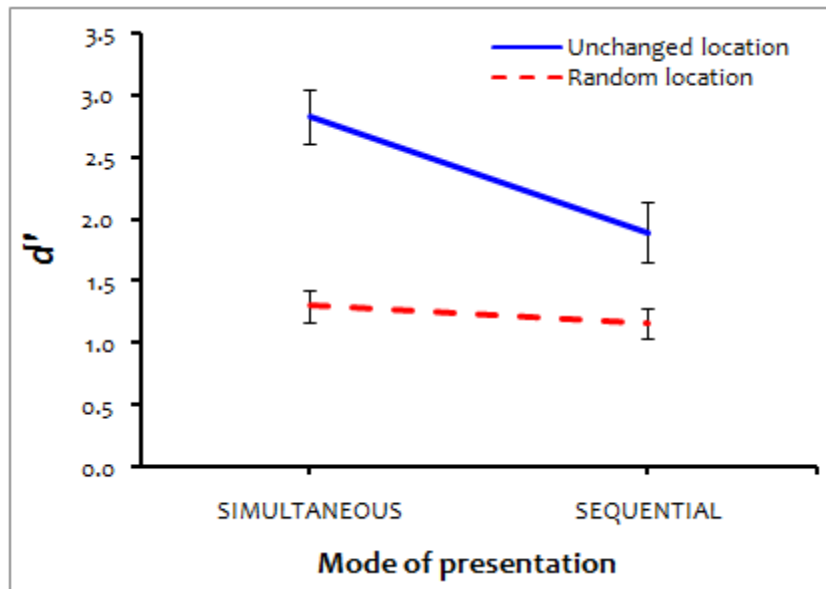


Figure 4.6: Mean d prime scores in Experiment 2

The main effect comparing simultaneous and sequential presentation was also significant, $F[1,17]=15.609$, $MSE=.327$, $p<.001$, $partial \eta^2=.479$, $BF_{10}=3.245$, with performance being better with simultaneous presentation than sequential presentation of stimuli. The interaction between mode of presentation and locations, $F[1,17]=10.370$, $MSE=.272$, $p<.005$, $partial \eta^2=.379$, $BF_{10}=4.378$, was also significant. Figure 4.5, showing the mean change detection performance calculated from d primes, substantiates that the difference in performance between unchanged locations and random locations is greater with simultaneous presentation, $t[17]=6.608$, $p<.001$, $d=1.577$, $BF_{10}=4.607 \times 10^3$ than sequential presentation, $t[17]=3.254$, $p<.005$, $d=0.767$, $BF_{10}=9.994$.

Serial position effects in sequential presentation

To explore the serial position effects in the sequential presentation condition, a 2×4 repeated measures ANOVA [location \times swaps] was carried out. The swaps selected for this analysis were between stimuli shown at serial positions 1 and 4 [showing the joint effect of primacy as well as recency], 1 and 2 [showing only primacy effect], 2 and 3 [items in the middle positions], and 3 and 4 [showing only the recency effect].

A significant main effect of location was found, $F[1,17]=8.323$, $MSE=2.568$, $p<.010$, $partial \eta^2=.329$, $BF_{10}=13,836$. The main effect of swaps was also significant $F[1.875, 31.877]=5.188$, $MSE=4.350$, $p<.013$, $partial \eta^2=.234$, $BF_{10}=94.137$. [Greenhouse-Geisser correction was applied because Mauchly's test of sphericity was significant]. Post-hoc analysis [with Bonferroni adjustment] shows a significant difference between swaps of stimuli in positions 1 and 4, and positions 3 and 4 [$t[17]=4.001$, $p<.001$, $d=.943$, $BF_{10}=40.13$], and stimuli in positions 1 and 2, and positions 2 and 3

[$t[17]=3.403$, $p<.003$, $d=.802$, $BF_{10}=13.14$]. The interaction effect was not significant. As Figure 4.6 clearly shows, both the primacy and recency effects are quite strong in this experiment.

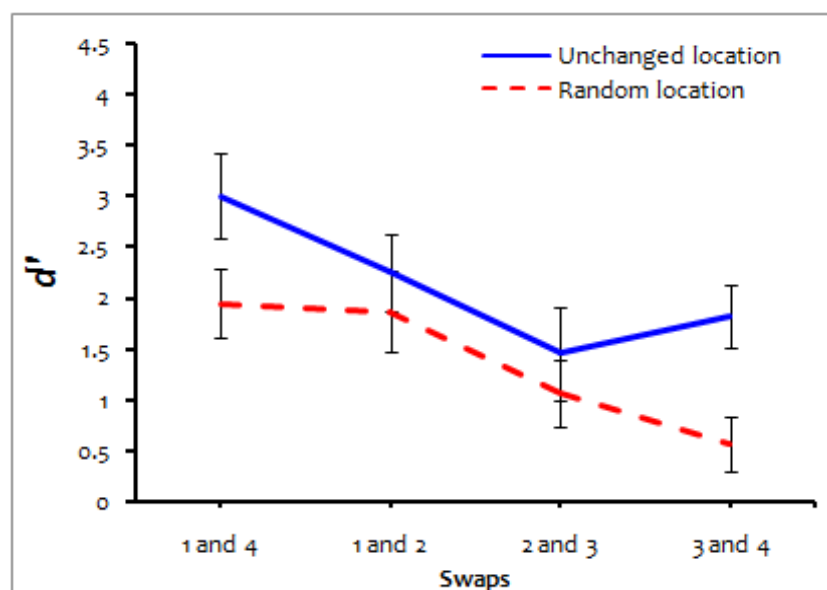


Figure 4.7: Serial position effects in Experiment 2

Comparison of Experiments 1 and 2

To compare the results of Experiments 1 and 2, three-way analysis of variance was carried out, taking experiments as between-participants factor, and mode of presentation and locations as repeated measures. The main effect of experiments was not significant. However, the interaction of experiments with locations, $F[1,34]=3.311$, $MSE=.611$, $p<.078$, *partial* $\eta^2=.089$, $BF_{10}=1.404$, and the three way interaction, $F[1,34]=3.136$, $MSE=.333$, $p<.086$, *partial* $\eta^2=.084$, $BF_{01}=1.127$ trend toward significance. Bayes factors were computed for all the combinations of main effects and interaction effect. The three way interaction was assessed by comparing the model comprising the three way interaction and all possible main and two way interaction effects [$BF_{10}=1.062 \times 10^{18}$] with a model comprising all three main effects and the three possible two way interaction effects [$BF_{10}=1.197 \times 10^{18}$]. The data fits better with a model without the three-way interaction only by a factor of 1.127:1. Although, this ratio is quite low, and the $p < .084$ of the three-way interaction is only trending toward significance, the experiments are quite likely underpowered for a between participants analysis; therefore these results are interpreted to infer that the performance of participants is different in the two experiments.

4.2.3 Discussion

Results show a clear effect of mode of presentation as simultaneous presentation yields significantly higher performance than sequential presentation. The experiment clearly revealed the advantage of configural encoding with the aid of location information for simultaneous presentation of stimuli. The sequential presentation in this experiment presents a stimulus as the previous one vanishes. This provides a temporal cue, but does not allow configural encoding. The results imply that location is a more advantageous cue than time for feature binding. The temporal cue alone is not reliable for feature binding in the visual domain.

Performance is not only better with simultaneous presentation, but there is also a significant advantage with unchanged locations within this condition, where maximum

advantage can be derived from configural encoding aided by the feature of locations. When locations are random from study to test, there is no advantage from the location cue, even with simultaneous presentation, and performance of the participants is virtually at the same level as with sequential presentation. Thus, configural encoding is not automatic and/or obligatory due to the mere presence of the location cue in a simultaneous display. The cue is used only if it is advantageous, and it is not used if it is likely to hamper the performance of the participants.

The question arises whether or not the participants are using the temporal cue at all. The serial position effects are evident in the results of this experiment. Both primacy and recency effects are clear in the performance of the participants. Thus, in the sequential presentation condition, participants were encoding stimuli according to their order and position in the series. But the temporal cue was not strong enough to generate a robust representation that would ensure performance in the sequential condition being similar to, or better than, performance with simultaneous presentation in this binding task. The evidence that performance in the unchanged locations condition is better than random locations condition, not only for simultaneous presentation, but also for sequential presentation, also supports the idea that participants prefer to rely on the location cue whenever it is relevant.

Although the three-way analysis carried out to test the differences between the Experiments 1 and 2 did not reveal a clear difference in the performance of the participants in the two experiments [as the main effect of experiments was not significant], the three way interaction showed a trend toward significance. This indicates that the pattern of interaction of the two repeated measures factors, viz., mode of presentation and locations, is somewhat different in the two experiments. This is clear from a comparison of Figures 4.2 and 4.5. Whilst the former shows almost parallel lines, the latter does show an interaction.

The only difference between the two experiments was in the nature of the sequential presentation of stimuli in the study display. In Experiment 1, stimuli were presented one by one so that the study display was gradually built up, but in Experiment 2, stimuli were presented such that the previous stimulus vanished as the next one was presented. In both experiments, the participants have a temporal cue to remember the stimuli, but they can also encode the stimuli in relation to each other in Experiment 1. Thus, they can use location as a cue in Experiment 1, but not in Experiment 2. Notice that serial position effects are shown only in Experiment 2, but not in Experiment 1. This also indicates that the temporal cue, provided by the sequential presentation, is used by the participants only when the more powerful location cue is absent, weak, or not conducive to better performance.

4.3 CONCLUSION

The primary aim of both experiments was to compare simultaneous and sequential modes of presentation. Mode of presentation did not have a significant effect in Experiment 1, with performance in simultaneous and sequential presentation conditions being quite similar. However, in Experiment 2, there was a clear difference in the performance of the participants due to mode of presentation. Also, an interaction between mode of presentation and locations was observed. Therefore, it was decided that the rest of the experiments comparing simultaneous and sequential presentation would be carried out with sequential presentation in which the offset of a stimulus coincides with the onset of the next stimulus, as happened in Experiment 2. A discussion of the results of these experiments in conjunction with other results in the current research, and in the context of previous literature is deferred to Chapter 7, entitled 'General Discussion'.