Title: Feature synchrony-asynchrony and rate of change in visual search

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Abstract

Attention is known to be sensitive to the temporal structure of scenes. We initially tested whether feature synchrony, an attribute with potential special status because of its association with objecthood, is something which draws attention. Search items were surrounded by colours which periodically changed either in synchrony or out-of synchrony with periodic changes in their shape. Search for a target was notably faster when the target location contained a unique synchronous feature change amongst asynchronous changes. However, the reverse situation produced no search advantage. A second experiment showed that this effect of unique synchrony was actually a consequence of the lower rate of perceived flicker in the synchronous compared to the asynchronous items, not the synchrony itself. In our displays it seems that attention is drawn towards a location which has a relatively low rate of change. Overall, the pattern of results suggested the attentional bias we find is for *relative temporal stability*. Results stand in contrast to other work which has found high and low flicker rates to both draw attention equally (Cass et al., 2009). Further work needs to determine the exact conditions under which this bias is and is not found when searching in complex dynamically-changing displays.

Abstract word count: 200

Introduction

The visual system is sensitive to the temporal character of visual input (Blake & Lee, 2005). Work has shown that visual attention can be drawn towards stimuli in a display which have unique temporal characteristics, mostly in the context of the visual search task (Cass, Van der Burg, & Alais, 2011; Pinto, Olivers & Theeuwes, 2006; Pinto, Olivers & Theeuwes, 2008a, Pinto, Olivers & Theeuwes 2008b; Pinto, Olivers & Theeuwes 2008c; Spalek, Kawahara & Di Lollo, 2009; Von Mühlenen, & Rempel Enns, 2005). For instance, in a display containing multiple flickering items, a target tends to be found more quickly when it has a uniquely fast or slow flicker rate compared to the distractors (Cass et al., 2011; Spalek et al., 2009).

It has also been shown that attention is sensitive to the temporal correspondence of visual features with other temporal events. Specifically, it has been found that visual features which change in synchrony with a stimulus from another modality tend to draw attention towards them, thereby facilitating search (Van der Burg, Olivers, Brokhorst & Theeuwes, 2008; Van der Burg, Olivers, Bronkhorst & Theeuwes, 2009; Fujisaki, Koene, Arnold, Johnston & Nishida, 2006). Temporal correspondence is also important with regards to the synchrony between features across different visual dimensions. Feature synchrony is a form of temporal synchrony involving the correspondence of feature changes at a location over time (Clifford Arnold, & Pearson, 2003; Oriet & Enns, 2010). Feature synchrony is interesting as a perceptual attribute because it is associated with objecthood (Oriet & Enns, 2010), and objecthood is something which attention is known to be sensitive towards (e.g. Yantis & Jonides, 1996).

Our initial interest in this paper was in understanding the extent to which certain types of unique temporal change influence attention in visual search. Specifically, in Experiment 1, we investigate whether unique feature synchrony is something which draws attention, a factor which has not yet been looked at in the literature. Our expectation was that synchrony might be salient for attention in an analogous way to the effects of cross-modal events synchrony (e.g. Van der Burg et al., 2008). To test this we present search displays which consist of items which periodically change their features across two dimensions (colour and shape). On some trials the target location item had feature changes which were either uniquely synchronous or uniquely asynchronous, in displays which contained both types of change. Search slopes were used as a measure of the extent to which the unique item draws attention in the display.

Experiment 1

An orientation search paradigm was used. Observers had to find a target vertical or horizontal bar among tilted bars. The critical manipulations concerned surround elements (red or blue, diamond or square hollow shapes) which enclosed each of the target and distractor items in the search display (see Figure 1). The colour and shape of these surround items periodically changed in a cyclical manner. The two feature changes in each item were either temporally aligned with one another (synchronous), or not (asynchronous) with the periodic shape changes. In the asynchronous case the shape feature change was exactly medial between the periodic colour changes within the cycle.

Four search conditions were given with respect to the synchrony manipulation. Figure 2 (A) gives a schematic depiction of some of these conditions. In two of the conditions the colour changes surrounding the target bar were synchronised with the changes in the target shape (T_S); in the other two the surrounding colour and shape change were asynchronous (T_A). For each of these targets, distractors either all had surrounds where the colour and shape changes were synchronous (T_SD_S, T_AD_S), or where the surrounding colour and shape changes were asynchronous (T_SD_A, T_AD_A). The critical condition was T_SD_A: If synchronous feature change is something favoured by the attentional system then search should be most efficient in this condition, one where synchronous changes occur uniquely at the target location. Search should be faster in this condition than any of the other three given conditions (T_AD_S; T_SD_S; T_AD_A). We further investigated whether any putative effects of synchrony might only be found at moderate or low rates of change where the temporal distinction between synchronous and asynchronous is most evident. Consequently, we ran the experiment across a range of display cycling values from 2.5-6.25 Hz.

Methods

*** Figure 1 here***

*** Figure 2 here***

Participants

There were twenty-two participants (female=10), recruited using opportunity sampling; all were staff or students at Oxford Brookes University. All had normal/corrected-to-normal vision.

Stimuli

Search displays were presented on a 20” CRT monitor (resolution=1024×768; refresh-rate=100Hz), viewed at an approximate distance of 1000 mm in a dimly lit room. Displays were generated using bespoke software written in *BlitzMax* (Sibley, 2011). This software also controlled all aspects of stimulus generation, randomisation, and response recording.

Search items consisted of 3 to 8 white rectangular bars (0.15°×0.38°subtended visual angle). The on-screen position of each bar was randomly determined with the constraint that the centre-point distance of any two adjacent bars was always a minimum of 3.82°, and that all bars were 2.33°-6.15° from the display centre. One bar (the target) was always either vertical or horizontal in orientation. The other (distractor) bars were all tilted. This tilt was randomly determined for each bar with the constraint that each bar was a minimum of 5 deg. from the horizontal/vertical.

Search items were presented on a grey background (RGB: 171, 171, 171). Surrounding each bar was a square or diamond (edge-length= 1.36°) with a circular hollow centre (radius=0.34°). Surrounds were initially randomly allocated as a square or a diamond in shape and as red (RGB: 255, 0, 0) or blue (RGB: 0, 0, 255) in colour and after which regularly alternated between the two possible values at the same defined rate. The key variable was whether this alternation occurred in or out-of-step across the feature dimensions. In the *synchronous* case the two feature changes were always temporally aligned. For instance, the surround might begin as a red diamond, then change colour and shape at the same time to become a blue square, and then return to being a red diamond. In the *asynchronous* case the two feature changes were out of alignment so that a feature change on one dimension was always exactly mid-way between the feature changes on the other dimension. For instance, the surround might start as a red diamond, as it alternated it might first change in colour (becoming a blue diamond), then shape (becoming a blue square), then colour again (becoming a red square), and then shape again (returning to a red diamond). The target and bars were independently varied to have a synchronous or asynchronous surround; the target and distractors did not themselves change in the display.

Feature synchrony-asynchrony

The rate at which the complete cycle of feature changes occurred in the display was varied across different trials of the experiment. This was either 2.5 Hz (1 cycle /400 ms), 3.57 Hz (1 cycle /280 ms), or 6.25 Hz (1 cycle /160 ms). All the surround items were randomised to start at different points within the phase cycle meaning that the changes in individual items were not temporally aligned with other display items in either the synchronous or asynchronous case.

Design and procedure

There were three repeated measures variables: *set size* (3, 5, 8 display items), *synchrony* (T_SD_S, T_SD_A, T_AD_S, T_AD_A), and *rate* (2.5 Hz, 3.57 Hz, 6.25 Hz). There were 18 search trials for each of the 36 factorially-combined conditions. This gave a total of 648 experimental trials. Trials were given in a randomised order in 12 equal-length blocks. The experiment took approximately 30 minutes to perform. Observers were instructed to locate the non-tilted bar in the display and indicate whether it was vertical or horizontal and report this by pressing the designated left or right trigger on a controller. Immediate auditory feedback was given. Observers were instructed to respond as quickly as possible when they identified the target but not to guess. Observers were first given a demonstration where they saw examples of the search displays. They then performed a practice block before the experimental block consisting of 30 randomly selected trials.

Results

One participant was removed from further analysis due to a high error rate on the task. After this removal, error rates averaged less than 4% across all conditions; consequently, no further analysis of errors was made. Analysis focused on median correct response times (RTs). These were calculated separately for each factorially-combined condition (see Figure 3). A repeated-measures three-way ANOVA was carried out on the RTs (Greenhouse-Geisser corrections made where appropriate. There was a main effect of *set size*, $F(1.292, 25.835)=200.87$, $p<.001$, $\eta p^2=.909$, and of *synchrony*, $F(3, 60)=26.06$, $p<.001$, $\eta p^2=.566$, but not *rate*, $F=1.645$, $p=.206$. Importantly, there was a two way *set size* × *synchrony* interaction, $F(3.497, 69.942)=5.034$, $p=.002$, $\eta p^2=.201$. The other interactions did not approach significance (ps >=.649).

*** Figure 3 here***

An analysis was performed on the median correct RT data using linear regression to calculate the individual slopes for the four synchrony conditions as a function of set size. In this analysis trials were aggregated across the three rate conditions, given that this factor had no main effect or influence on the synchrony × set size interaction. This was done to allow a better, less noisy, measure of the individual search functions. The mean slopes are shown in Table 1. A one-way repeated measures ANOVA showed that the slopes differed significantly between the conditions, $F(3, 60)=7.831$, $p<.001$, $\eta p^2=.281$. Post hoc tests (Tukey) showed that the T_sD_A condition had a significantly shallower slope than any of the other three conditions ($p=.005$, $p<.001$, $p=.043$, respectively for the T_SD_S, T_AD_S, T_AD_A groups). There were no other statistically significant differences in slope values between the synchrony conditions (all ps >=.22).

*** Table 1 here***

Discussion

As predicted, the target was found most efficiently when there were unique synchronous changes at the target location and asynchronous changes at all other search locations (T_SD_A). Importantly the advantage was asymmetric: The least efficient search was found when the target had unique asynchronous changes and all other search locations contained synchronous changes (T_AD_S). This same basic pattern was found across all display temporal frequencies.

The results, at first blush, seem to support the case for feature synchrony as an attribute which draws attention. However, caution is required in this interpretation. The synchronous and asynchronous item locations always cycled at the same rate in the display, they also had the same number of feature changes within a cycle on each dimension. However, because the feature changes are out-of-phase in the asynchronous case, there are twice the moments of change in a cycle than in the equivalent synchronous case.

This attribute may itself have driven the effect. As we noted earlier other work has shown that attention tends to be drawn towards locations with a unique temporal frequency (e.g. Cass et al., 2011; Spalek et al., 2009). There are two issues here. Firstly, where temporal frequency has been manipulated as a guiding feature in visual search, this manipulation as has always been to the rate of change on a single feature dimension. The rate of change in our stimuli was only different when considered in terms of the number of moments of change across both feature dimensions. Secondly, the effect of flicker has generally been found to be symmetric (uniquely fast-among- slow, or slow-among-fast, changing targets similarly produce faster search compared to targets with the same rate of change as their distractors, Cass et al., 2011; Spalek et al. 2009). The effect we observed in Exp. 1 was, by contrast, decidedly asymmetric.

In order to test whether this factor was driving the synchrony advantage a second experiment (Exp. 2) was conducted. This was the same as Exp. 1 except for certain key differences. Instead of comparing synchronous changing against asynchronous, all items were synchronous; the main manipulation was instead in terms of the relative temporal frequency of the items. In one case ($_S$) the synchronous items alternated at the same rate as in Exp. 1, in the control case ($_C$) the synchronous items alternated at twice the rate. This type manipulation was varied factorially across target and distractors to produce four conditions as for Exp. 1: T_SD_C, T_CD_S, T_SD_S, T_CD_C.

<u>**Experiment 2**</u>

Method

Participants

There were 22 participants (15=female) recruited in the same way as for Exp. 1.

Stimuli, design and procedure

The experiment was conducted using the same equipment described for Exp. 1. The displays were all the same, except those differences implemented regarding the presented conditions. In Exp. 2 the two feature changes were always temporally aligned (synchronous) for all display items. The main comparison, rather than between synchronous and asynchronous, was between the synchronous changing items ($_S$) identical to those given in Exp. 1, and *control synchronous* items ($_C$). These control items $_C$ were defined in relation to the standard synchronous items $_S$: changes occurred at double the rate as those in the corresponding standard synchronous items in the display. Thus, these $_C$ items were matched to have the same number of moments of change as the asynchronous ($_A$) items in Exp. 1. There were four conditions with respect to this variable of stimulus type: The target bar could either be the standard synchronous change item (T_S) or the control synchronous item (T_C). The distractors could either be the synchronous change items (D_S), or control synchronous items (D_C). This generated four type conditions, paralleling those in Exp. 1, two in which the target was unique in its rate of temporal change within the display (T_SD_C, T_CD_S) and two type conditions in which all items, target and distractor, had the same rate of temporal change within the display (T_SD_S, T_CD_C). The three display frequency conditions (2.5 Hz, 3.57 Hz, 6.25 Hz) were given as in Exp. 1. However, here the conditions only referred to the rate of change in the standard synchronous change item ($_S$); to reiterate, the rate of change in the $_C$ items, were always at twice the rate of the S items. An example schematic of some of these conditions is given in Figure 2 (B) for illustration.

There were therefore three repeated measures variables: *set size* (3, 5, 8), *type* (T_SD_S, T_SD_C, T_CD_S, T_CD_C), and *rate* (2.5 Hz, 3.57 Hz, 6.25 Hz). The same 648 trials were given in 12 self-paced blocks given after practice trials. Observers made their responses in the same way and were given auditory feedback on each trial.

Results

Error rates across all 36 conditions were comparable to Exp. 1. Data analysis was therefore carried out only on the response times. Firstly, median correct response times for each factorially-combined condition (see Figure 4) were entered into a repeated-measures three-way ANOVA (Greenhouse-Geisser corrections made where appropriate). There were main effects of *set size*, $F(1.348, 28.308)=190.059$, $p<.001$, $\eta p^2=.935$, *type*, $F(3, 63)=11.700$, $p<.001$, $\eta p^2=.999$, and *rate*, $F(2, 42)=7.759$, $p=0.001$, $\eta p^2=.935$. The only significant interaction was *type* x *set size*, $F(3.940, 82.750)=8.218$, $p<.001.$, $\eta p^2=.998$. All other interactions were non-significant ($p>=.095$).[1]

Figure 4

[1] Although there was no significant interaction with rate, observation of the graphs shows the asymmetry between T_SD_C, and T_CD_S was larger in the slowest (2.5 Hz) rate condition compared to the others. Our experiment may have lacked sufficient power to reveal a significant three-way interaction with rate. It should be noted that the difference between the slow ($_S$) and fast ($_C$) items was always a ratio; the 2.5 Hz condition therefore had the largest periodic difference in flicker between the slow and fast items. Given this, it is unsurprising that this rate condition produced the largest asymmetry.

A follow up analysis was performed on the median correct RT data using linear regression to calculate the individual slopes for the type conditions (T_SD_S, T_SD_C, T_CD_S, T_CD_C) as a function of set size. Trials were aggregated across the three rate conditions, given that this factor did not interact with the other two variables. This allowed for a better, less noisy, measure of the individual search functions. The mean slopes are shown in Table 2. A one-way repeated-measures ANOVA indicated that the slopes differed significantly between the type conditions, $F(3, 63)=12.2$, $p<.001$, $\eta p^2=.37$. Post-hoc tests (Tukey) indicated that the condition driving this effect was $T_SD_{C,}$ which had a significantly shallower slope than any of the other 3 conditions ($p<.001$, $p=.002$, $p<.001$ for $T_CD_{S,}$ $T_CD_{C,}$ and $T_SD_{S,}$ respectively). There were no other significant differences (all ps>=.21).

Finally, a two-way mixed ANOVA was performed to compare across the slope data from Experiment 1 and 2. In this ANOVA the four *search-type conditions* were given as a repeated measures factor and *experiment* as an independent factor. The factor for the search conditions was significant, $F(3, 123)= 19.82$, $p<.001$, $\eta p^2=.326$. However, there was no main effect of experiment, nor any significant *experiment* × *search condition* interaction (all ps>=.66).

Table 2 here

Discussion

The same pattern of data as Exp. 1 was found when the asynchronous stimuli were replaced with synchronous stimuli matched to the rate of change of the asynchronous stimuli in Exp. 1. Exp. 2 shows that it is locations of unique slow feature change that tend to draw attention when present in higher-rate feature changes ($T_SD_{C,}$), resulting in faster searches. Importantly uniquely higher-rate changing items amongst slower-rate items ($T_cD_{S,}$) showed no hint of facilitating target search.

General discussion

We tested whether unique synchronous feature changes attracted attention. Exp. 1 found that a target, presented at a location of unique synchronous feature change tended to be found more easily than either a non-unique location in terms of synchrony status, or one unique in displaying asynchronous change. Exp. 2 however showed that this effect was accounted for by the differential number of moments of change in the synchronous and asynchronous cycle, not by synchrony status per-se.

How do we understand these results? Firstly, we must comment on the fact that the perceived rate of change in our stimuli was seemingly determined by the overall number of moments of change across the two dimensions. The similarity in results between Exp. 1 and 2 indicate an interpretation in which our synchronous and asynchronous stimuli in Exp. 1 were perceived as having different flicker rates due to the feature transitions being in or out-of alignment. Indeed, some evidence suggests that feature transients are elementary perceptual sensations in themselves and perceived independently of the underlying feature changes generating them (Kanai & Verstraten, 2004). It seems then that it is these transient sensations that are driving the pattern of search in our experiments.

Why then should a unique synchronous stimulus (or in the case of Exp. 2, a unique slower changing stimulus) draw attention, but not the unique asynchronous stimulus (or in the case of Exp. 2 a unique faster changing stimulus)? We think that the key attribute explaining search performance in our two experiments is *relative temporal stability*: the visual system –presented with a scene containing dynamic and uncorrelated feature changes across multiple locations, is biased towards a location which is the most temporally stable, or least unstable.[2]

As mentioned earlier, other researchers which have manipulated flicker rate as an attribute in search tasks have not reported such an asymmetry (Cass et al., 2011; Spalek et al., 2009). For instance, Cass et al., varied the relative rate of flicker of surrounds of target and distractor stimuli across a wide range of values, a search advantage for the target location was found irrespective of whether a target location was uniquely fast or uniquely slow within the display; the only relevant factor guiding search was the extent of the difference in rate between target and distractor.[3]

Our effect of relative temporal stability is arguably like the earlier mentioned studies which have shown that static objects tend to draw attention when presented among dynamically changing

[2] We note that we did not monitor eye movements in this study. The long search times in our results (often over 2 seconds in the largest set size conditions) mean that observers were almost certainly making voluntary eye movements searching for the target. We suspect that the effect biasing attention is one which arises from direction of covert attention, and that any effects on eye movements would be a consequence of this. We suspect that similar findings would be obtained regarding the effect of temporal stability if, for instance, observers had to maintain fixation and the search displays were presented in the periphery.

[3] An exception to this is a study by Ivry and Cohen (1992). These observers found that a high-rate moving target tended to pop out in search while a slow moving target did not. Thus the manipulated attribute was motion speed rather than flicker frequency and the search asymmetry, though present, was in the opposite direction to ours.

items (e.g. Pinto et al. 2006; Pinto et al., 2008c). However, our findings differ in two ways. Firstly, in our experiments all search locations changed dynamically, even the slower changing item in our display sometimes had a high change rate (up to 6.25 Hz), yet still facilitated search when this was the unique target. This is a rather different situation to one in which an entirely unchanging target location draws attention among other items which all flicker. Secondly, in these studies of search for static objects, such as Pinto et al. (2006), the search was not an asymmetric one. This was not directly tested in these studies, but it is well established across many experiments that a dynamically changing item pops out in the context of static items (e.g. Rensink, O'Regan, & Clark, 1997).

Thus, our finding of an attentional bias for relative temporal stability seems to be novel. Why did we not find the same symmetrical effects of temporal rate in the manner found by Cass et al. (2011) and Spalek et al. (2009), studies that also varied the rate of change of target and distractor stimuli? We suspect that it is due to the different nature of our displays. Our stimuli exhibited discrete categorical feature changes across two dimensions. In the work of Cass et al. (2011) and Spalek et al. (2009) the changes consisted of sine- or square wave oscillations on a single dimension (luminance). A consequence of these two things meant that our displays were more heterogeneous, with multiple feature conjunctions and feature changes, compared to earlier studies.

Our results are perhaps most similar to findings reported by Kunar and Watson from their 'MAD' visual search paradigm (Kunar & Watson, 2011). In this paradigm, search displays consisting of variable numbers of letters were presented with the task being to search for the presence of a vowel letter. A portion of the search items would either be static, flicker, or move in an uncorrelated way. Under these conditions of search, a target was found most effectively when it was both static and without flicker within the display. The conditions of multiple uncorrelated dynamic changes arguably present a similar situation to our synchronous or asynchronous feature change displays. When faced with a display consisting of multiple temporally unstable elements the attentional system tends to be drawn towards those locations which show the least change, be that because they are entirely static (Kunar & Watson, 2011), or just have a lower relative rate of change, as in our results.

Conclusion

We initially framed this research in terms of exploring whether feature synchrony has any special status for the visual system. We had assumed this possibility because of the close relationship between feature synchrony and objecthood. Indeed, our results showed that the presence of unique feature synchrony-among-asynchrony did draw attention. Importantly, the converse situation of unique asynchrony-among-synchrony did not produce any guidance. However, feature synchrony was not itself the relevant attribute, nor responsible for this search asymmetry: a second experiment showed that the driving factor was the relatively lower rate of perceived flicker in synchronous compared to asynchronous stimuli. We conclude that feature synchrony itself does not attract attention.

The asymmetry of our effect with respect to rate of flicker is still curious and worthy of further investigation. It stands in contrast to other studies which have investigated flicker where effects of unique high and low rate flicker have been found to be equally effective in drawing attention (Cass et al., 2011). One possibility is that the presence of feature changes across multiple dimensions affects how attention is prioritised. It may be that under these conditions areas of temporal stability tend to be prioritised over unstable ones.

We are currently doing a number of further experiments using our visual search paradigm to try to identify the specific required conditions for the asymmetry we found to occur. One possibility, as suggested above, is that it is a consequence of the multiple types of feature change present in our displays. We will look at whether the search asymmetry persists to the same extent when the same feature changes only occur on a single feature dimension within a display on a particular trial, e.g. just colour or just shape changes, compared to when feature changes occur across two dimensions. Another possibility is that the effect may be driven by the character of the feature changes themselves. For instance, in Cass et al. (2011) the flickering stimuli consisted of smooth variations of luminance at different rates of change. In our stimuli the flicker consisted of discrete changes of feature value between two distinct colours or shapes. It may be that the presence of discrete feature changes is critical for our asymmetry to occur. To test this, we are looking at the effect of continuous verses abrupt feature changes in search (e.g. a surround object smoothly changing in colour between two colour values vs abruptly changing in colour, but at the same temporal rate). We expect that these additional experiments should help us understand why our results are so different from those reported by Cass and colleagues.

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Tables

Table 1. Slopes (ms per item) for each of the four synchrony status conditions and pair-wise comparisons for Experiment 1.

Synchrony	Slope		Significance		
			T_SD_A	T_AD_S	T_AD_A
T_SD_S	139		*	ns	ns
T_SD_A	103		-	*	*
T_AD_S	152			-	ns
T_AD_A	131				-

*-significant at least p<.05

Table 2. Slopes (ms per item) for each of the four type conditions and pair-wise comparisons for Experiment 2.

Type	Slope		Significance		
			T_SD_C	T_CD_S	T_CD_C
T_SD_S	145		*	ns	ns
T_SD_C	96		-	*	*
T_CD_S	163			-	ns
T_CD_C	140				-

*-significant at least p<.05

Figure headings

Figure 1. An example static snapshot of the search display.

Figure 2 Schematic depictions of the temporal structure of the surround stimuli. Plate A depicts two conditions of Experiment 1 T_SD_A (left) and T_AD_S (right). Plate B depicts two conditions of Experiment 2 T_SD_C (left) and T_CD_S (right). In both plates: D= Diamond; S=Square; R=Red; B=Blue. In all depicted examples the set size is 3 and the temporal frequency condition is 6.25 Hz.

Figure 3. Experiment 1: Across-participant means of the median correct search times for each display condition for the three temporal rates (A, 6.25Hz, B, 3.75Hz, C, 2.5Hz) and D. overall (combined across all frequency rates).

Figure 4. Experiment 2: Across-participant means of the median correct search times for each display condition for the three temporal rates (A, 6.25Hz, B, 3.75Hz, C, 2.5Hz) and D. overall (combined across all frequency rates).

Feature synchrony-asynchrony

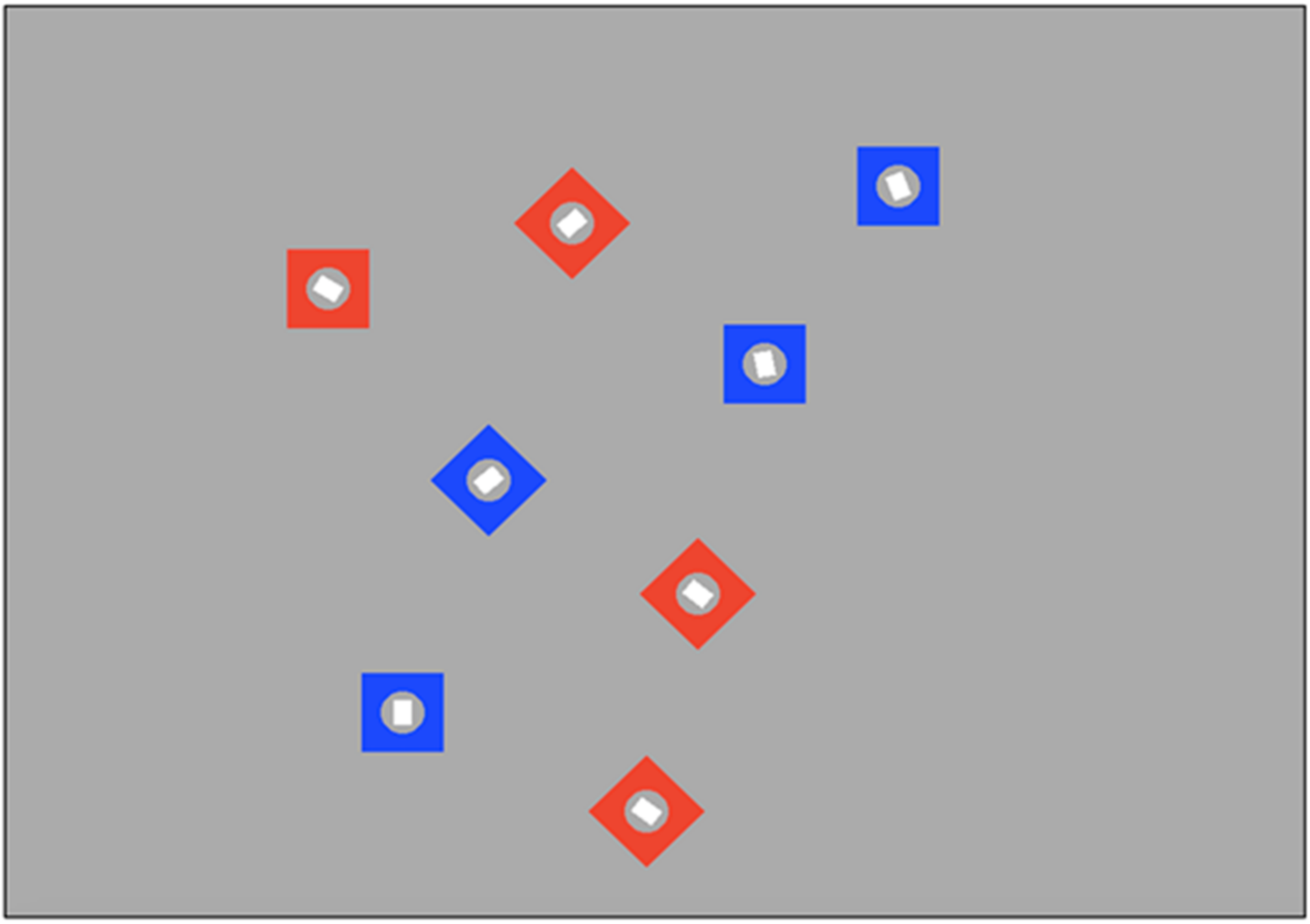

Figure 1.

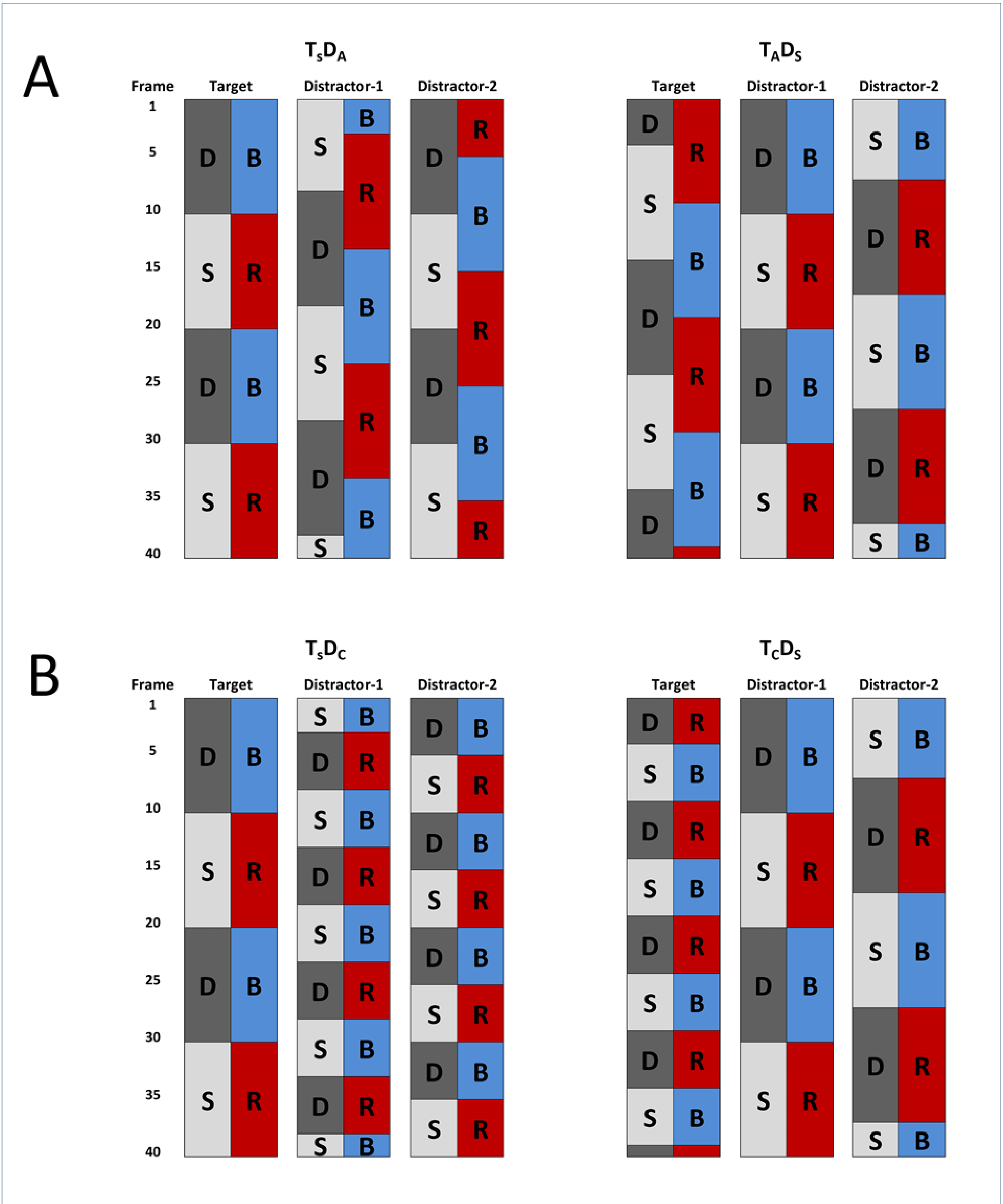
A
T_sD_A
T_AD_S
Frame
Target
Distractor-1
Distractor-2
1
5
10
15
20
25
30
35
40
B
T_sD_C
T_CD_S

Figure 2.

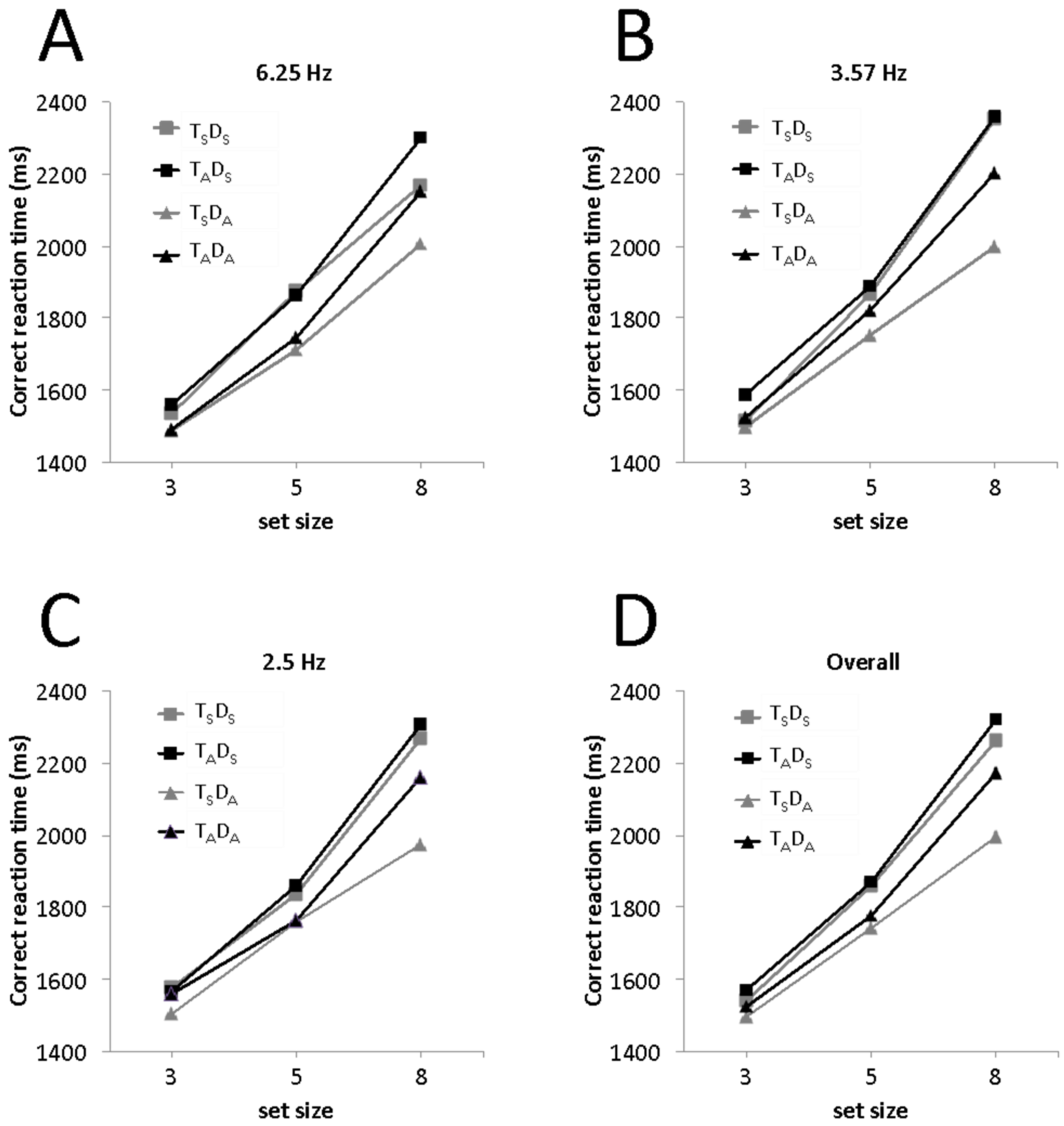
A
6.25 Hz
B
3.57 Hz
C
2.5 Hz
D
Overall
Correct reaction time (ms)
2400
2200
2000
1800
1600
1400
3
5
8
set size
T_SD_S
T_AD_S
T_SD_A
T_AD_A

Figure 3.

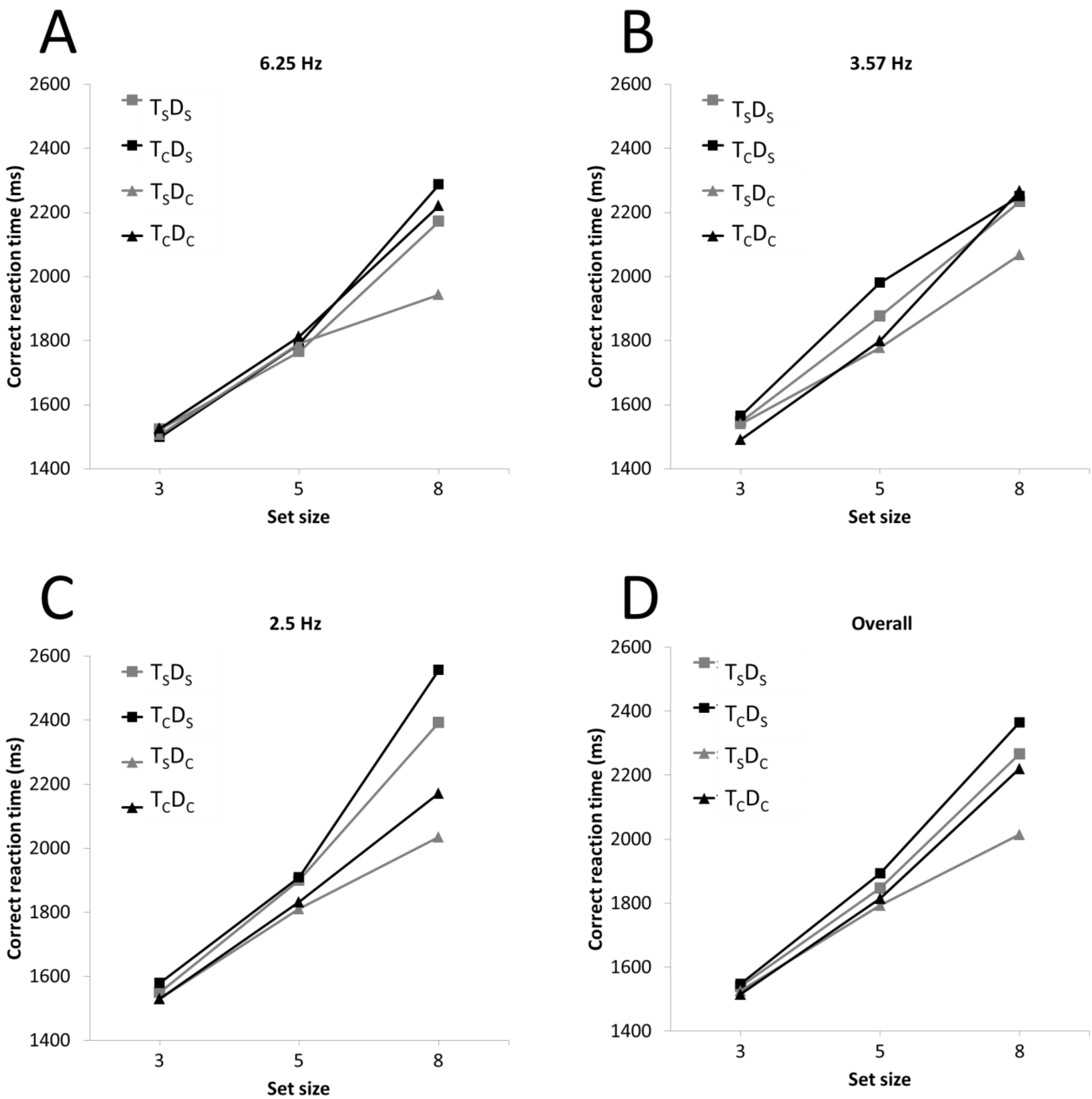
A
6.25 Hz
B
3.57 Hz
C
2.5 Hz
D
Overall
$T_S D_S$
$T_C D_S$
$T_S D_C$
$T_C D_C$
Correct reaction time (ms)
1400
1600
1800
2000
2200
2400
2600
Set size
3
5
8

Figure 4.