Attentional Synchrony and the Effects of Repetitive Movie Viewing

David Breathnach

School of Computer Science and Informatics
University College Dublin, Ireland.
david.breathnach@ucdconnect.ie

Abstract. Attentional synchrony is a new theory in the studies of scene perception, proposing that multiple viewers of dynamic scenes attend to the same location of the scene at the same time. The following paper investigated the effects of repetitive viewing of a professionally edited movie scene on the attentional synchrony of viewers. Participants were required to view a scene from the James Bond movie, Casino Royale, while their eye movements were recorded. The results of the study showed that there was a decline in the degree of attentional synchrony both within- and between- subjects, though there was a higher degree of attentional synchrony along the horizontal axis in comparison to the vertical axis.

1 Introduction

Initial research into eye movement and gaze allocation during the viewing of dynamic scenes has demonstrated that people attend to dynamic scenes in a different manner than they do to static scenes. During static scene viewing, the fixations of multiple viewers have revealed that the prioritisation of certain features of the scene occurs e.g., foreground objects, faces, etc., [1] though these fixations occur at separate times for each individual when viewing the scene. In comparison, when viewing dynamic scenes, particularly those created with the intention of holding a viewer's attention, there is strong evidence that gaze allocation is similar amongst viewers in both where and when their fixations are allocated. This high degree of spatiotemporal clustering of viewers' gaze has led to the proposal of the *Attentional Synchrony* theory [2].

Although the study of attentional synchrony is a fledgling topic of research in scene perception studies, it has been a phenomenon that filmmakers have exploited for more than 70 years through the use of continuity editing techniques to compose an illusion that events on screen are unfolding with spatiotemporal consistency whilst guiding viewers' gaze. Loschky et al. [3] argued that due to the use of these continuity editing techniques when creating and editing movies, movie viewers are incapable of exerting their own endogenous control over where and when they look at the scenes depicted on the screen. The authors referred to this as the *Tyranny of Film Hypothesis*, claiming that due to the use of the editing techniques a film will exert an

exogenous control over the viewers' eye movements and gaze behaviour. The majority of studies of attentional synchrony have focused on viewers' eye movements, and gaze allocation when watching films and television programs [4, 5, 6], though there has been a recent growth in research on attentional synchrony and natural dynamic scenes[1] in an attempt to study whether this phenomenon occurs during everyday activity. Simultaneously a new approach to studying attentional synchrony, pioneered by Hasson [7], has begun to look at the occurrence of attentional synchrony amongst viewers in conjunction with synchronized neural activity when viewing films, the foundation of Hasson's [7] "inter-subject correlation theory".

While the study of attentional synchrony has developed and expanded beyond the original area of movie viewing alone, where research has begun looking at attentional synchrony within the context of natural dynamic scenes and whether this phenomena occurs during day-to-day activities, as well as being studied from a neuroscientific perspective, there are many aspects of attentional synchrony that are still unknown, as such the following paper intends to investigate whether repetitive viewing of a movie scene will result in a decline in the attentional synchrony of viewers, both within subject and between subject, or whether the use of continuity editing techniques used to edit the movie will exert an exogenous control over the viewer's gaze behaviour resulting in the attentional synchrony of viewers to be unaffected. In the following section, the key information concerning attentional synchrony is presented.

2 Related Work

2.1 Attentional Synchrony in cinematics

To further understand the relationship between attentional synchrony and movie viewing, Loshky et al., [3] tested whether differences in viewer comprehension of a movie scene would affect the viewers' eye movements, postulating that the viewers' endogenous control of eye movements would be superseded by the exogenous control of the film they are viewing.

To test their hypothesis, participants were shown either a 3 minute and 8-second-long video clip, or a 12-second-long video clip from the James Bond movie, Moonraker, depending on whether they were in the context or no context group, whilst their eye movements were recorded. At the end of the clip participants were asked to make a predictive inference of what was going to happen based on what they had watched. The results indicated that a high degree of attentional synchrony had occurred between viewers regardless of their viewing condition and their comprehension of the scene, though there was an indication of subtle influences on the viewer's

[1] The term "natural dynamic scenes" is used here in the context of using unedited and unstructured video recordings as stimuli to replicate everyday environments, e.g., people in a park, cars driving down a street etc.

eye movements within the context condition, leading to speculation that endogenous factors still play a role in movie viewing but can be overridden by exogenous ones.

Though the results show that attentional synchrony strongly occurred regardless of viewer comprehension, Loshky et al., expanded on their research [8] looking again at the effects of comprehension on gaze behaviour but using a single cut video clip from Orson Welle's movie "Touch of Evil", in an attempt to lessen the possibility of the viewers' eye movements and attentional synchrony becoming guided by multiple cut editing techniques. Following a similar procedure as in the original research, the authors found that the viewers in both the context and no context conditions displayed similar eye movements and gaze behaviour when viewing the scene, results reflective of the original ones and supportive of the conclusions that the exogenous control of attentional synchrony overrides the endogenous control of the viewer, though there are minute and subtle differences in eye movements due to comprehension. These results demonstrate that the attentional synchrony of viewers is not entirely controlled in cinematics by the use of continuity editing techniques, but is subsequently also unaffected by the viewers' comprehension of the scene they are viewing.

Although the topic of attentional synchrony has recently become encompassed by the neuroscientific theory of inter-subject correlation [7], the research none the less provides insights into the effects of movie viewing on eye movements of viewers. In their research, Hasson et al., [9] presented viewers with video clips played both forwards and backward from silent films (City Lights, and The Adventurer). The results showed that regardless of whether viewers saw the clips played forwards or backwards there was similar attentional synchrony in both conditions. Furthermore, repetitive viewings of the video clips showed similar eye movements across all participants. These results further demonstrate that the participant's eye movements are guided by the movie, but also provide an insight that the attentional synchrony can also occur when viewing movies in reverse as well as when repetitively viewing a movie, further supporting the theory that movies exert an exogenous control over viewers. As insightful as the results are, a primary concern becomes apparent from these results, which is the use of silent movies as stimuli. One would speculate that when watching a movie with audio in reverse viewers would be distracted by the abnormality of the audio being played in reverse resulting in low attentional synchrony amongst viewers.

2.2 Attentional Synchrony in natural dynamic scenes

In an attempt to better understand how people view natural dynamic scenes, Dorr et al., [10] recorded the eye movements of participants whilst free viewing uncut, natural dynamic scenes, which were then compared with the recordings of participants' eye

movements when free viewing static images, stop-motion videos[2], and Hollywood movie trailers, as well as repetitive viewings. The results of the study showed that the highest degree of attentional synchrony occurred when participants were viewing the professionally edited Hollywood trailers in comparison to when viewing the natural dynamic scenes, stop motion, or static images. Although there was an occurrence of attentional synchrony when viewing the natural dynamic scenes, these occurences were due to sudden onset of motion when a new object entered the screen, which rapidly dropped after participants had viewed the new object. Furthermore, the authors found that when presented with the same naturalistic dynamic stimuli repetitively, there was a higher rate of attentional synchrony within-subjects in comparison to between-subjects however the attentional synchrony gradually decreased with each repetition.

In their research of whether goal specificity would influence the similarity of gaze behaviour amongst participants while viewing natural dynamic scenes, Taya et al.,[11] showed participants videos of tennis matches under two conditions, the first condition was a free viewing one with no goals, whilst the second condition required participants to watch the video clips with the goal of answering a specific question at the end of viewing. The authors hypothesised that by providing the participants with a goal they would exert a top-down exogenous control over their gaze behaviour. Additionally, the authors tested the effects of repetitive viewing of natural dynamic scenes on gaze behaviour. The results of the research showed that goal specificity had no significant effect on the attentional synchrony of the participants when viewing the video clips, demonstrating that the endogenous influence of movements had a greater influence on the gaze behaviour of the participants. Moreover, the results showed that repetitive viewing did not result in a decrease in attentional synchrony amongst participants. The authors speculated that this contradictive result to earlier results [10] was due to the context of the stimuli, where the focus was predominantly on the tennis ball and both players.

Smith et al., [12] tested whether viewing tasks influenced attentional synchrony of participants, whilst attempting to overcome the limitations of previous research [11], through utilising stimuli that is less constrained and a task that dissociates endogenous and exogenous control of gaze behaviour. Participants were required to either free view the natural dynamic scene stimuli, or perform a spot the location task, where they had to accurately identify the location shown in the dynamic scene. The results of the study showed that there was a lower degree of attentional synchrony amongst participants performing the spot the location task in comparison to the participants free viewing the scenes. These results strongly contradict the results of the previous research [11], claiming that the participants showed an endogenous control over there gaze behaviour based on the task, though this endogenous control was slow to take effect with participants looking at the screen centre, areas of high motion, and people before attending to the task.

---

[2] The stop motion stimuli were composed by editing half of the natural dynamic scene stimuli so that every 90th frame was displayed for 3 seconds, allowing for a similar depiction of events.

3 Experiment

Experiment Materials: For the stimuli of the current experiment, a chase scene from the James Bond film 2006, Casino Royale was chosen which lasted 5 minute and 34 seconds. This scene was chosen based on the multitude of cuts that were used to compose it as well as the fact that it is a fast moving scene with a variety of events occurring both in the foreground and background.

Participants: Eight adults with normal and corrected to normal vision participated in the study. All participants had previously seen the film when it was originally released in cinemas but had not watched the film since its release.

Procedure: To gather the eye movement data, a Tobii Studio^{TM} 2.2 eye tracking device was used. The eye tracking device recorded both the eye movements of the left eye and right eye individually. All participants were required to sit 1.5metres away from the screen, no head restraints were used during the experiment. A calibration test was performed before recording participant's eye movements, and repeated when necessary. Once the calibration procedure was completed the experiment began, participants were shown a six-second-long notice reminding them to refrain from any excessive head movements. Participants were then shown the James Bond scene four times in a row, with a 3 second gap between each viewing where they were presented with a notice informing them of which clip they were about to view.

4 Data Preparation and Results

For the data analysis, the average gaze direction of both eyes together was used along both the horizontal and the vertical axes, given the nature with which people primarily move their eyes along the horizontal axis when perceiving their environments, this separation of both axes will allow for a better understanding of how the stimuli would affect the eye movements of the participants. All the subsequent data was checked for validity, allowing for blinks and closed eyes to be removed from the data, as well as verifying that there were no abnormalities amongst the data for each participant, leaving only the average gaze points of both eyes along both the horizontal and vertical axes and the accompanying timestamp of each of the gaze point.

For the analysis, both a between-subject and a within-subject analysis was performed on the horizontal and vertical gaze points of each participant. For the within-subject analysis the gaze points of each participant's 1st viewing was compared to the gaze points of each subsequent viewing and the proportion of synchrony between these viewings was reported, this procedure was repeated by comparing the participants' 2nd viewing with their 3rd and 4th. A similar procedure was used when performing the between-subject analysis, though the gaze points of each participant's 1st viewing were compared and the portion of synchrony for each one was reported, this procedure was repeated for each of the viewings along both the horizontal and vertical axes.

4.1 Within-Subject

Horizontal: The results of the analysis of participants' horizontal eye movements (figure 1) showed a decline in synchrony amongst all participants between the first and second viewing and the first and third viewing. This steady decline continued between the first viewing and the fourth viewing, though the degree of synchrony of participant 7 dropped by a significant amount when the first and fourth viewing were compared, which will be discussed in the following section.

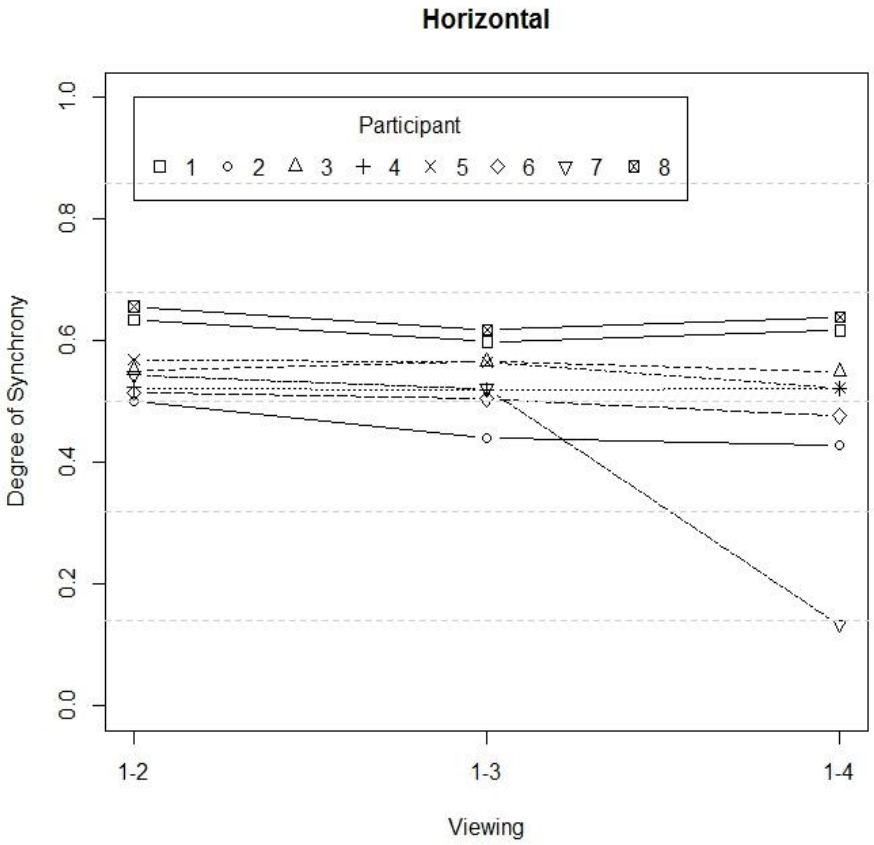

Fig. 1. The degree of synchrony amongst participants when 1st viewing is compared to 2nd, 3rd, and 4th.

The decline in synchrony can also be seen to occur when the 2nd viewing is compared to the 3rd and 4th viewing of participants (figure 2), whilst a substantial drop in synchrony is present which is reflective of the results of the first within-subjects analysis.

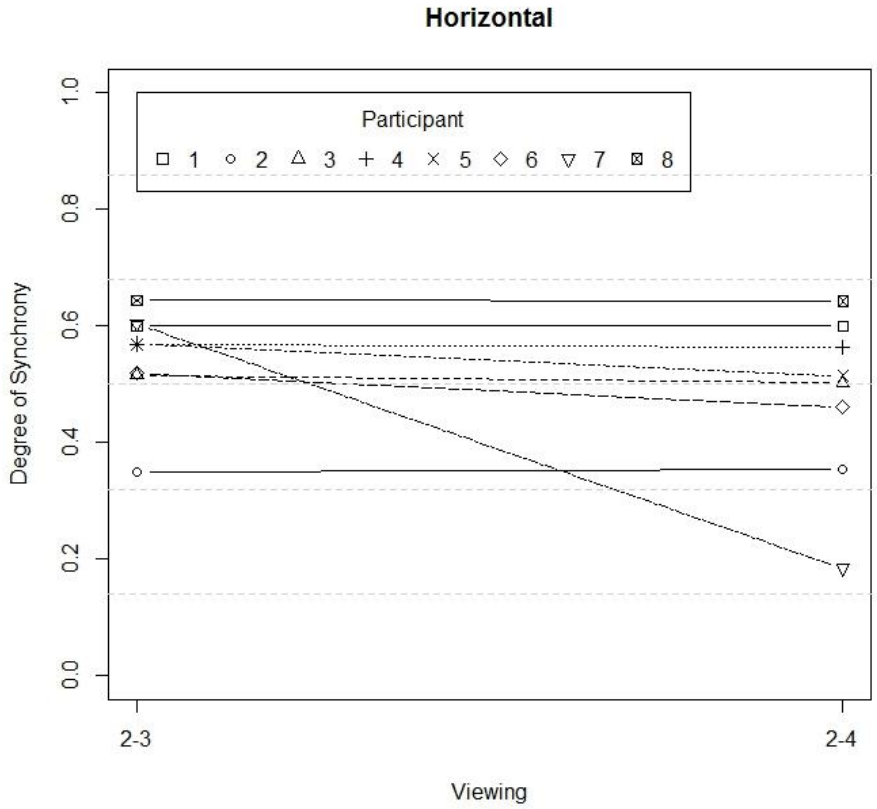

Fig. 2. The degree of synchrony amongst participants when the 2nd viewing is compared to the 3rd and 4th viewing.

Vertical: The results of the vertical eye movements (figure 3) of participants showed a similar decline in synchrony between the 1st viewing and subsequent viewings which is reflective of the results of the horizontal eye movements. Furthermore, the sudden decrease in synchrony of participant 7 when the 1st and 4th viewing were compared is also present, though this decrease is not as substantial in the vertical eye movements in comparison to the horizontal eye movements.

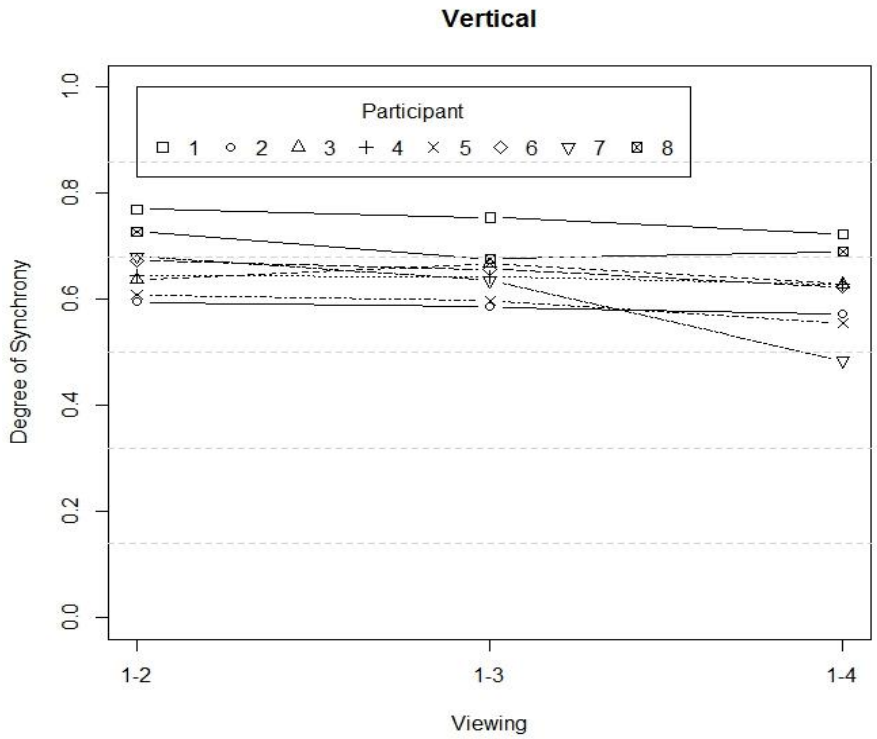

Fig. 3. The degree of synchrony amongst participants when 1st viewing is compared to 2nd, 3rd, and 4th viewing.

This decline in synchrony can be seen to reflectively continue when the 2nd viewing is compared to subsequent viewings (figure 4), though the decrease in synchrony of participant 7 when the 2nd viewing is compared to the 4th viewing is more substantial in comparison to the decline noted between the 1st viewing and the 4th viewing.

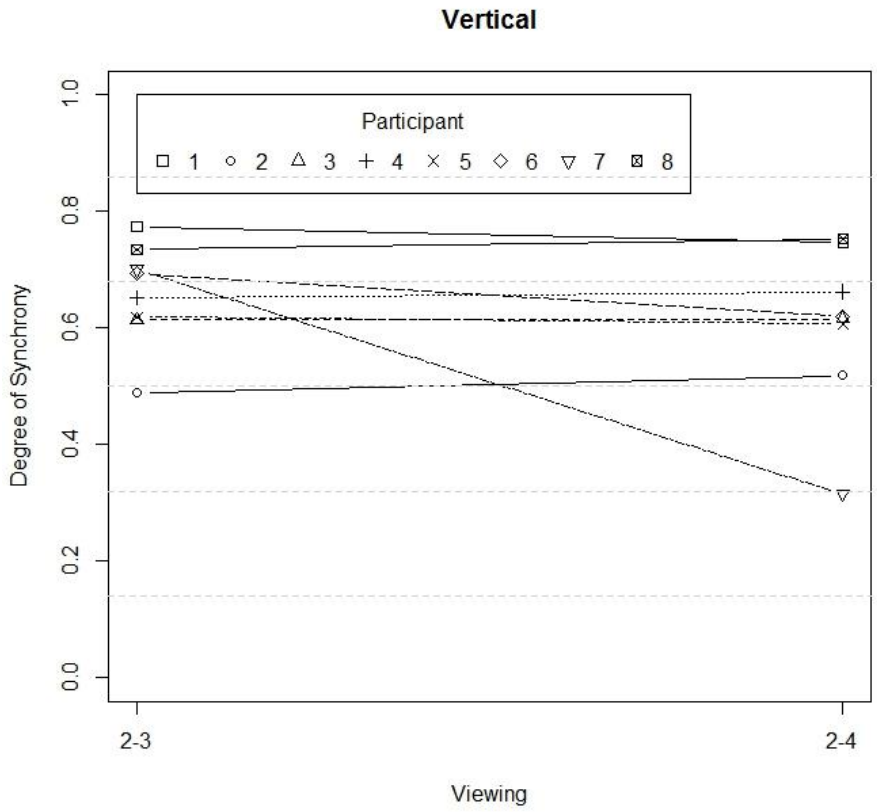

Fig. 4. The degree of synchrony amongst participants when the 2nd viewing is compared to 3rd and 4th viewing.

4.2 Between-Subject

The results of the between subject analysis of horizontal eye movements showed a progressive decrease in synchrony with each repetition of viewing amongst participants (figure 5). A similar decline in synchrony can be seen in the results of the vertical eye movements analysis (figure 6), though there was a larger variation in the degrees of synchrony as it declines.

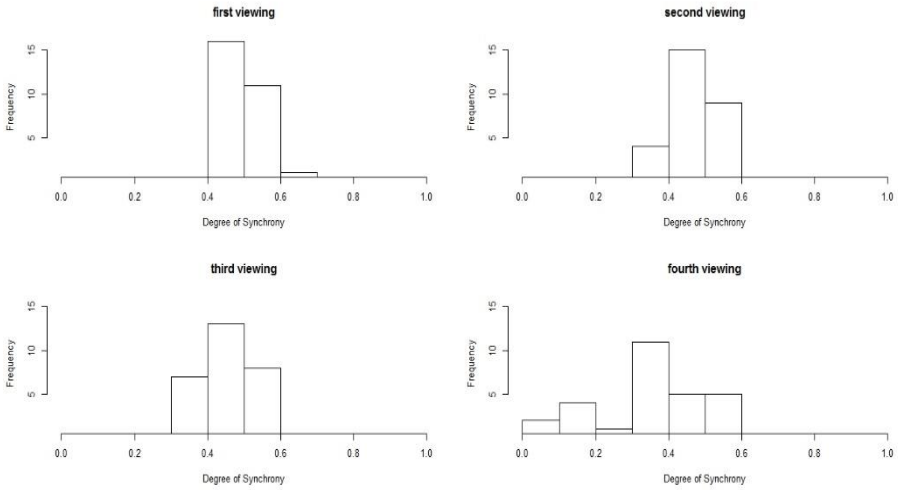

Fig. 5. The degree of synchrony of horizontal eye movement amongst participants.

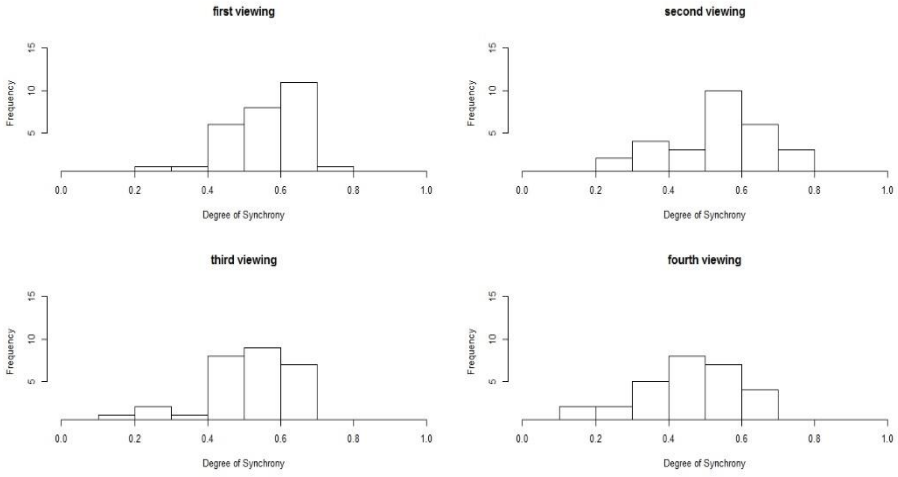

Fig. 6. The degree of synchrony of vertical eye movements amongst participants.

5 Discussion and conclusion

The intention of this study was to test the hypothesis that participants' attentional synchrony would not decrease after repetitive viewings of a professionally edited movie due to the exogenous control that the movie would exert over the gaze be-

haviour of viewers due to the use of continuity editing techniques. This is the first experiment to perform an in-depth investigating of the relationship between attentional synchrony and repetitive viewing of a professionally edited movies, although previous researchers have studied the effects of repetitive viewing of dynamic scenes [10, 11], only one study has looked at the effects of repetitive viewing of movie scenes on attentional synchrony [9], though not in as much detail as the current study.

The results of the research showed that there was a decrease in attentional synchrony amongst participants, both when compared within- and between- subject. Results of which contradict those found in previous studies of repetitive scene viewing and attentional synchrony [9], [11]. Although, the results of previous studies that have found no decrease in attentional synchrony when viewing cinematic scenes [9], these results come from a study using movie scenes with no audio, though silent movies are still a genre of films viewed by people the absence of audio cues may have influenced the viewers' eye movements.

Though the current study shows that there is a decrease in attentional synchrony with each repetition of viewing, this could possibly be due to the experiment design itself, where participants were required to sit still for 22 minutes and watch a repeated movie scene, with each repetition the participants would find less and less new information in the stimuli, as such there attention would begin to become unfocused on the central focus in the stimuli (i.e., Bond chasing the antagonist) leading to them losing interest, this is a possible cause for the substantial decline in attentional synchrony of participant 7. A preferable approach in future studies would be to perform the viewings at different times, for example one week between each viewing of the stimuli, this approach would allow for a more generalisable result reflective of how people would view movies repetitively, rather than watching a movie repeatedly back to back. Unfortunately, due to time constraints this approach was not possible in the current study.

Furthermore, from the results, there is evidence that though the attentional synchrony of participants declined with each repetition there was a higher degree of attentional synchrony among the horizontal eye movements of participants in comparison to the vertical eye movements. This could be a possible result of people being more accustomed to horizontal eye movements when navigating everyday life opposed to vertical eye movements. Alternatively, this could be due to the panoramic shot style that the scene was shot in, where both characters entered a new scene from the side of the screen shot rather than from above or below.

The theory of attentional synchrony is a relatively new and unexplored theory of scene perception studies, one which requires more of an understanding before it can be fully extended, and applied, to other fields of study. Many questions still remain in regards to attentional synchrony, particularly the effects of repetitive scene viewing performed in a more ecologically valid experiment, the effects of different cut techniques (to this date only one study has looked at the effect of using stimuli with no editing performed [8]), as well as whether there is a substantial difference between horizontal and vertical attentional synchrony. One key question that remains is whether attentional synchrony indicates that a viewer is attending what they are viewing, or whether it is a phenomenon of synchronised eye movements

References

1. Mannan, S., Wooding, D., Ruddock, K.: Fixation sequences made during visual examination of briefly presented 2D images. Spatial Vision. 11, 157-178 (1997).
2. Smith, T.Henderson, J.: Attentional synchrony in static and dynamic scenes. Journal of Vision. 8, 773-773 (2010).
3. Loschky, L., Larson, A., Magliano, J., Smith, T.: What Would Jaws Do? The tyranny of film and the relationship between gaze and higher-level comprehension processes for narrative film. Journal of Vision. 14, 761-761 (2014).
4.Carmi, R.Itti, L.: Visual causes versus correlates of attentional selection in dynamic scenes. Vision Research. 46, 4333-4345 (2006).
5. Goldstein, R., Woods, R., Peli, E.: Where people look when watching movies: Do all viewers look at the same place?. Computers in Biology and Medicine. 37, 957-964 (2007).
6. Mital, P., Smith, T., Hill, R., Henderson, J.: Clustering of Gaze During Dynamic Scene Viewing is Predicted by Motion. Cogn Comput. 3, 5-24 (2010).
7. Hasson, U., Landesman, O., Knappmeyer, B., Vallines, I., Rubin, N., Heeger, D.: Neurocinematics: The Neuroscience of Film. Projections. 2, 1-26 (2008).
8. Hutson, J., Loschky, L., Smith, T., Magliano, J.: The Look of Evil: How are Eye Movements Influenced by Film Comprehension?. Journal of Vision. 14, 760-760 (2014).
9. Hasson, U., Yang, E., Vallines, I., Heeger, D., Rubin, N.: A Hierarchy of Temporal Receptive Windows in Human Cortex. Journal of Neuroscience. 28, 2539-2550 (2008).
10. Dorr, M., Martinetz, T., Gegenfurtner, K., Barth, E.: Variability of eye movements when viewing dynamic natural scenes. Journal of Vision. 10, 28-28 (2010).
11. Taya, S., Windridge, D., Osman, M.: Looking to Score: The Dissociation of Goal Influence on Eye Movement and Meta-Attentional Allocation in a Complex Dynamic Natural Scene. PLoS ONE. 7, e39060 (2012).
12. Smith, T. Mital, P.: Attentional synchrony and the influence of viewing task on gaze behavior in static and dynamic scenes. Journal of Vision. 13, 16-16 (2013).