Time series analysis of BBC News bulletins using running Mann-Whitney Z statistics

Nick Redfern

Abstract

Shot length data from 15 news bulletins broadcast at 1300, 1800, and 2200 on BBC 1 between 11 April 2011 and 15 April 2011, inclusive, is used to compare the editing style between different bulletins broadcast at different times on different days and to examine the time series structure by identifying clusters of shots short and long duration. The results show there is no evidence that shot length distributions of BBC news bulletins vary with the time or day of broadcast, and the style of editing is consistent across the sample. There is also no evidence the highly structured format of television news is related to the time series of shot lengths beyond the opening title sequence, which is associated with a cluster of short shots in every bulletin. The number, order, and location of clusters of longer and shorter shots is different for each bulletin; and there are several examples of abrupt transitions between different editing regimes, but no evidence of any cycles present in the time series. Although there is no overall common pattern to the editing, there are some consistent features in the time series for these bulletins: clusters of shorter shots are associated with footage derived from non-BBC sources (library footage, other broadcasters, public information films) and montage sequences; while clusters of shots of longer duration are associated with shots in which the viewer is addressed directly by the presenter or reporter (including graphics), live-two-way interviews, and speeches or interviews with key actors in a news item.

> What is different about cinema editing is that it brings together time, imprinted in the segments of film. Editing entails assembling smaller and larger pieces, each of which carries a different time. And their assembly creates a new awareness of the existence of time ...
>
> Andrey Tarkovsky (1986: 119)

1 Introduction

Along with object motion, camera motion, and sound energy, editing organises the viewer's experience of time in a motion picture by varying the pace. The evolution of the temporal structure of a motion picture gives shape to its semantic content. Adams *et al*. (2000) and Dorai and Venkatesh (2001) observed that in Hollywood narrative cinema, large changes of pace occur at the boundaries of story segments (e.g. transitions between scenes), while smaller changes in pace are identified with local narrative events of high dramatic import. The excitement level of a scene increases as shot lengths decrease (Wang & Cheong 2006), so that, for example, action scenes (combat, explosions, car chases, etc) are typically edited

more quickly than dialogue scenes. The difference in pace between these types of sequences can be used to index events in motion pictures (Lehane & O'Connor 2006). Variation in the pace of a film is not only evident at the level of individual sequences and specific narrative events, and can be observed at larger scales: Cutting *et al.* (2011) noted that within each quarter and possibly each act of a Hollywood film there is a pattern of general shortening and then lengthening of shots reflecting a fluctuating intensification of continuity. Differences in pacing are used attract the attention of viewers and to improve recall in advertising. Lang *et al.* (2000) studied the impact of increased editing rate in television commercials, and found that as the number of edits increased physiological and self-reported arousal, attention to the message, and memory of the content of the message all increased. Bolls *et al.* (2003) also reported that fast-paced advertisements resulted in greater viewer arousal and recall of non-claim-related information than slow-paced advertisements, although claim-related information recall was poorer. Television commercials are edited more quickly than the programmes that envelop them in order to take advantage of this effect. The pace of editing is also associated with particular emotional states. Kang (2003) identified rapid editing as being characteristic of scenes in which the dominant emotion was fear, while sadness was associated with a slow cutting rate. Hanjalic and Xu (2005) used variations in the length of shots as a means of describing the affective content of video, with shorter shots creating stressed, accented moments and longer takes used to de-accentuate an action, and identified these patterns to be common in both feature films and sports broadcasts.

It would seem natural that time series analysis can help us to describe how the pace of a motion picture changes over its running time and to understand the underlying stochastic processes of visual style. However, such an approach is challenging when analysing shot lengths. Unlike most data sets to which time series methods are applied, we are not measuring the value of some variable as a function of time. Rather, we are measuring time itself as each data point represents the duration of a shot between two edits, and the results of applying time series methods require careful interpretation in this context. For example, applying spectral analysis to shot length data will be event- rather than time-based, and will lead to statements about any cycles that may be present in terms of the number of shots per cycle rather than the temporal duration of a cycle (Warner 1998: 21). A further set of problems arise in applying a wide range of common time series methods to the shot lengths of motion pictures due to the assumptions they make regarding the Gaussian distribution and linearity of the data. The distribution of shot lengths in a motion picture is typically positively skewed with a number of outlying data points. Consequently, methods that assume normality or which are not resistant to the effect of outliers (e.g. simple moving averages, autocorrelation functions, spectral analysis) will produce inaccurate descriptions of the data and lead to flawed estimation of the parameters of time series models. If the type of variation between different narrative segments and the clustering of shots of similar length that is said to be characteristic some films (e.g. the rapid editing of car chases or combat sequences in action movies relative to dialogue scenes) is present, then we may encounter conditional heteroscedasticity as the variance of the time series will be different for different types of sequence. Any cycles present may be asymmetric, and/or there may be abrupt change points in style as one sequence ends and another begins. Given that any of these features may be present in a motion picture, we can expect the time series of its shot length data to be nonlinear (Fan & Yao 2005).

These problems may be overcome by applying ordinal and rank-based time series methods that do not use all of the information in the data but which focus on the order relations between the values in a series of observations (Bandt 2005, Bandt & Shiha 2007, Hallin &

Puri 2003, Keller & Sinn 2005). Such methods include relative frequency measures (e.g. $p(d)$), rank autocorrelation, local ranks, permutation entropy, and the order structure matrix. These methods are fast and robust when faced with non-Gaussian and/or non-linear features, and are appropriate for conducting exploratory data analysis of time series present in shot length data without making assumptions about the distribution of the data. This paper applies rank-based time series analysis to the evolution of style over the course of television news broadcasts. The next section describes the method of identifying clusters of low-and high-ranking regimes of data values in a time series using running Mann-Whitney Z statistics. Section three presents a statistical analysis using this method of a sample of 15 BBC news bulletins in order to answer three main questions: (1) does the distribution of shot lengths in a BBC news bulletin vary with the time or day of broadcast; (2) is there are a relationship between the structure of a news bulletin and the evolution of its editing style over time; and, (3) are there any common factors that account for the presence of clusters of long and/or short shots in a bulletin?

2 The running Mann-Whitney Z statistic

The Mann-Whitney U test is a nonparametric test of the null hypothesis of stochastic equality between two independent random variables (Mann & Whitney 1947). The test compares each data value from the first sample with each data value in the second sample; and proceeds by ranking the pooled data in ascending order and calculating the sum of ranks of the data values in each sample. If the two variables have the same distribution, then a value in sample one has an equal probability of being greater or less than each value in sample two. If one variable is stochastically superior, then data values in this sample will tend to have higher ranks than data values of the other variable and we reject the hypothesis that they similarly distributed.

Time series analysis using running Mann-Whitney Z statistics is described by Mauget (2003, 2011) as a method for identifying the most significant clusters of data points by using moving windows to sample the rankings of a time series. The first step is to rank the N shots in a motion picture, with the smallest x_i assigned rank 1 and the largest x_i assigned rank N. Shots of equal length are assigned the average of the ranks they would have been assigned if there were no ties: if x_2 and x_3 are observations with equal values, the average rank assigned to each is $\frac{2+3}{2} = 2.5$. The rankings are then sampled with a moving window of size n_1, and converted to U statistics by

$$U = R_1 - \frac{n_1}{2}(n_1 + 1),$$

where R_1 is the sum of ranks in the window of size n_1. When the sample size is large ($n_1 \geq 10$), the distribution of U is approximately normal with mean, $\mu = (n_1 \times n_2)/2$, and standard deviation,

$$\sigma = \sqrt{\frac{n_1 n_2(n_1 + n_2 + 1)}{12}},$$

[3]

where $n_2 = N - n_1$. Statistical significance can therefore be determined by calculating a Z statistic,

$$Z = \frac{U - \mu}{\sigma},$$

which is compared to a standard normal distribution. For $\alpha = 0.05$, the critical Z-value is ± 1.96 and when the Z statistic calculated from the data exceeds these limits it indicates a significant cluster of data values relative to the null hypothesis. Therefore, when $Z \leq -1.96$, we will identify a window that represents a cluster of low-ranking (i.e. shorter) shots; and, when $Z \geq 1.96$, we will identify a cluster of high-ranking (i.e. longer) shots. The set of Z statistics produced by this process is screened for the most significant clusters in order to remove redundant significant values resulting from the overlapping windows.

The method described by Mauget is simple to implement, robust, and does not depend on assumptions about the distribution of the data. Crucially for the analysis of the evolution of style across a film it is required only that the order in which the data values occur is maintained, and we need not be concerned that time is not an independent variable. Applying this method to film style allows us to identify trends over the course of a motion picture, to identify clusters of takes of long or short duration, to identify the points at which the style of a film changes, and to determine if any intermittent cyclical patterns are present. As it makes so few demands on the data, it is a method than can be used as a part of exploratory data analysis to evaluate the assumptions required for further time series analysis of film style.

3 Time series analysis of BBC News bulletins

Television news bulletins are a highly structured form of discourse that unfold in a predictable manner due to the strong constraints that govern the presence of a limited set of structural elements and the order in which they occur, so that

> there is a clear expectation that headlines will precede studio presentation of items and that reports will be introduced from the studio (not vice versa). It is not just that the separate structural elements of a news programme will be intrinsically different from each other (headlines, for instance, are recognisably different from reports) but that the elements are defined in part by their place in the sequence (Montgomery 2007: 38).

The overall structure of a bulletin follows a basic pattern consisting of opening titles and headlines (though the order may be reversed), a sequence of news items interrupted by a recap of the main story and/or a preview of upcoming news items (which often precede advertisements in the case of commercial television), a weather report, and a final summary of the main story (possibly with a trail for a later bulletin) (Montgomery 2007: 39). This general pattern is common across different broadcasters in different countries. Transitions between these different elements are deliberately and explicitly signposted, typically by the presenter who introduces the next element verbally and which may be accompanied by a physical movement (e.g. looking away from the camera to a video monitor, or turning to face an interviewee or reporter) (Montgomery 2007: 52). These structural elements also

display a regular structure. Each *news item* comprises an obligatory *news kernel*, and an optional *news subsidiary*. The subsidiary material may include a news report, and/or a live two-way interview, in which. Neither of these subsidiary elements is compulsory, and the order in which they occur within a news item may also vary. However, a news kernel always precedes the news subsidiary.

Research on the structure of television news broadcasts has focussed on the relationship between this organisation and the content of news items as discourse analysis (e.g. Bentele 1985; van Dijk 1988; Choi & Lee 2006; Montgomery 2007), but has rarely been concerned with the close analysis of the stylistic elements of motion picture production. Consequently, the discourse structure of the news is not analysed in relation to its formal structure. What little attention has been paid to editing in television news bulletins has focussed on how interview fragments are cut together to create new verbal sequences (Ensink 2006), the relationship between competing audio and visual information sources (Davies *et al.* 1985) or the viewer's attention to discontinuities in editing (Drew & Cadwell 1985). However, television news *documentaries* have been analysed in terms of their visual style in a similar manner to theatrically-released documentaries (e.g. Schaefer 1997). This section looks at the editing of news bulletins as an element of visual style, and compares the shot length distributions and time series of the different bulletins.

3.1 Data description

Shot length data was collected for the 1300, 1800, and 2200 bulletins broadcast on BBC 1 for the five day period beginning 11 April 2011, giving a total of 15 datasets used in the study. All broadcasts were recorded at 50 Hz, and shot length data was analysed at 25 frames-per-second by loading each bulletin in Magix Movie Edit Pro 14 (Magix 2008).[1] The 1300 and 1800 bulletins include the weather forecast, whereas 2200 does not; and to make the comparison between different bulletins direct these shots were discarded (including shots in which the newsreader announced the weather and interacted with the weather announcer before and after the forecast). The recap of a bulletin's main news story and the signoff by the newsreader that occur after the weather forecast in the 1300 and 1800 bulletins were retained as part of the data sets as these have corresponding shots in the bulletin at 2200. Each of the bulletins includes the headlines for the regional news programme to follow the nation broadcast (in this case *Look North* (Yorkshire)), and as a common feature of all the bulletins this data was also retained.

The structure of the 2200 bulletin from 15 April 2011 as an example of a typical BBC news bulletin is described in Table 1. A typical BBC news bulletin in the sample opens with the headlines, which will feature an opening shot of the presenter in the studio followed by excerpts from reports of three to five news items. This section will also include the headlines for (typically) two news items from the local news that follows the national broadcast and features a different presenter. The headlines are followed by the opening titles, a series of six to nine shots of between 0.9 and 2.5 seconds in duration that feature a stylised image of a globe and the names of major cities around the world. A bulletin comprises between eight and fourteen news items, of which one to four will be a brief item featuring a news kernel and three or fewer shots by way of illustration but lacking an extended report or two-way interview. Often these brief items will follow a longer report on a similar subject, such as a brief item on the political crisis in Syria following a longer item

---

[1] A *shot* is defined as a continuous sequence of frames, and an *edit* is defined as any transition between two shots, such as a hard cut or a gradual transition (wipe, fade, dissolve, etc). When the edit is gradual, the ending of the first shot and the beginning of the second shot is measured at the approximate mid-way point of the transition.

on the political crisis in Libya from the 1800 bulletin on 12 April 2011. On rare occasions a visual will not be preceded by a news kernel, as the presenter will continue speaking as the footage changes from the previous item, and continuity is maintained by similarity in subject matter in consecutive items. An example of this type of programme structure can be seen in Table 1, in which the item on dangerous driving (comprised of footage from a police video) follows from the traffic story that immediately precedes it but does not have a separate kernel. Approximately half-way through a bulletin, the main news item will be recapped and/or later news stories will be previewed. This section often includes a repeat of the headlines for the local news. A bulletin ends with the sign off by the presenter, and may include a trail for follow up items on the BBC News channel, but does not include closing credits. Although the number of news items varies from one bulletin to another, the overall structure of headlines ⇒ opening titles ⇒ news items ⇒ recap/preview ⇒ news items ⇒ (weather) signoff remains constant irrespective of the time or day of broadcast.

3.2 Shot length distributions

Table 2 presents the descriptive statistics for each bulletin in the sample, including the five-number summary and the dispersion of shot lengths measured using Q_n (Croux and Rousseeuw 1992, Rousseeuw and Croux 1993). From Table 2 we see that, like other types of motion pictures, the shot length data for each news programme is positively skewed with the maximum shot length much greater than the mass of the data, indicating the presence of outliers. It is evident that the 1300 bulletins are the longest or each day, while there is no pattern for the 1800 or 2200 programmes. The number of shots in a bulletin ranges from a minimum of 182 to a maximum of 238, with a median of 216; and 11 of the 15 bulletins have more than 200 cuts. The minimum shot length of a bulletin is typically 0.8 seconds, with very few shorter shots. The shortest shot in the sample is just 0.1s, and results from the difference between to editing modes as part of the trail for the BBC News channel from the 1300 bulletin on 14 April as a live-cut to the presenter in the studio does not coincide with the pre-recorded cut in the visual package. There is little difference in the shot length distributions of these broadcasts. The lower and upper quartiles and median shot length exhibit little variation, The median value for the lower quartile is 2.9s, with all 15 bulletins within ±1 second of the average; and the median of the upper quartile is 8.2s, with 11 of the 15 bulletins within ±1 second. The median of the median shot lengths is 4.6s, with 14 of the 15 bulletins within ±1 second of this value. The values of Q_n are also covered by a narrow range; with a median value is 3.3s and all 15 bulletins within ±0.7s. A 5 × 3 (day × time) factorial analysis of variance without replication was conducted for both the median shot lengths and Q_n to determine if day of the week or time of broadcast were important factors in shaping the editing style of news bulletins (Figure 1). The results show that for the medians there is no significant effect for either the day ($F(4, 8) = 1.30, p = 0.35$) or time ($F(2, 8) = 0.29, p = 0.76$) of broadcast. Equally, neither day ($F(4, 8) = 1.03, p = 0.45$) nor time ($F(2, 8) = 0.00, p = > 0.99$) has any significant effect on the dispersion of shot lengths.

The consistency in shot lengths over the course of the week and during a single day indicates an invariant mode of production. The same studio, with the same layout, and camera positions are used for each bulletin. Figure 2 shows shots from different bulletins covering different stories, but which are nonetheless similar, if not identical. News bulletins are composed of a narrow range of structural elements and feature a narrow range of shots, and so the absence of any significant variation is unsurprising (Bertini *et al.* 2001). Bulletins broadcast at different times on the same day show no difference in style since they will often feature the same stories using the same footage, although this does not mean that they are identical. For example, the three bulletins broadcast on 13 April 2011 all feature a

[6]

report on unemployment figures released by the UK government. The report in the 1300 bulletin is the fourth item, is 161.4 seconds in length, and includes 23 shots (min = 2.9s, median = 5.0s, max = 18.6s); whereas it is the third item in the 1800 bulletin, with 20 shots lasting 181.7s (min = 1.6s, median = 6.4s, max = 31.6s), and the fifth item at 2200 comprised of 21 shots with a total running time of 195.5s (min = 1.7s, median = 6.4s, max = 36.5s). In this way these bulletins include the same report and make use of the same footage, but they place the report at different points in the bulletin, and re-edit the footage to alter the emphasis of a report or to adjust for the different running times of the bulletins. This can be seen in Figure 3, where the shot lengths of the unemployment news item in the 1300 bulletin is similar to the two later bulletins at some points and different at others, while the shot lengths from the 1800 and 2200 items are practically identical at nearly every point.

3.3 Time series analysis

A time series of running Mann-Whitney Z statistics was generated for each bulletin according to the above described method using a moving window of 15 shots. To enable side-by-side comparison of the series, the duration of each bulletin was normalized to a unit length by dividing the length of each shot by the total running time after any weather-associated shots had been removed. Following Mauget's (2011) suggestion, the most significant non-overlapping windows of shots with high and low rankings were colour-coded and plotted on a single horizontal axis. This makes it possible to transform event-based time series analysis into a time-based format via a simple method that is easy to interpret, and to compare the bulletins side-by-side. Figure 4 presents this information for the 15 BBC news bulletins, with windows of low-ranking shots coded as blue and windows of high-ranking shots coded as red. The running Mann-Whitney Z statistic for the 2200 bulletin from 15 April 2011 described in Table 1 is shown in Figure 5.

We note a cluster of short shots at the beginning of each programme, indicated by the blue segments to the far left of each series in Figure 4. This is due to the use of the same opening titles in each bulletin, and is the only regime of short or long shots that is common across the sample. Included in these regimes are the tail of the national headlines and the local headlines, which also tend to have low ranking shots relative to the rest of the programme.

Footage used in a report derived from a source other than BBC news is associated with a cluster of shots of short duration. These sources include stock and library footage, public information films, and news footage from other broadcasters. For example, the bulletins broadcast at 1300 and 1800 on 12 April included a report marking the 50th anniversary of Yuri Gagarin's first manned space flight. This report was largely comprised of library footage of the flight and Gagarin's return to the Soviet Union, and accounts for the cluster of short shorts occurring at 0.66 for the 1300 bulletin and at 0.90 for the 1800 bulletin in Figure 4. The bulletin broadcast at 1300 on 13 April includes a report on domestic violence amongst teenagers, and features a segment of a public information film. This footage is cut much more quickly than the rest of the broadcast, with shot lengths ranging from 0.6 to 5.8 seconds and median of 1.4s, and accounts for the cluster beginning at 0.69 for this bulletin in Figure 4. Footage from US broadcasters features in the three bulletins broadcast on 15 April. The lunchtime bulletin features a report on US air traffic controllers falling asleep at work, and this report includes the cluster of low ranking shots beginning at 0.71 for this bulletin in Figure 4. This footage used in this report is from ABC News, with whom the BBC has a content sharing and distribution agreement. The two evening bulletins feature the same item on the build up to the impending royal wedding on American television (at 0.94 at 1800 and 0.95 at 2200). In the 2200 bulletin, this item also accounts for the trough at 0.54 – the point at which this item was previewed. The clusters of short shots associated

with this news item include trailers for the coverage of the wedding on both ABC and NBC. The reports on the royal wedding also included excerpts from *William & Kate* (2011), the dramatisation of the relationship between Prince William and Kate Middleton. As noted above, promotional footage (e.g. adverts, trailers) is known to be typically edited more quickly than programme footage in order to attract the attention of viewers and to improve their recall, and this accounts in part for the quicker editing in these reports.

Although non-BBC news footage is frequently associated with clusters of short shots, they do not account for all such clusters. One feature that is repeated across several such clusters is the use of montage sequences combined with the voice over of the reporter who is off-screen. For example, the cluster of short shots in the 15 April 2200 bulletin at 0.81 in Figure 4 is from the report on the likely prospects of the UK Independence Party at the English local elections (see Table 1). This cluster follows the news kernel (which is a single shot of 16.8s), and is comprised of a montage of shots of public spaces and shoppers in Barnsley town centre over which the voice of the reporter provides the context and background to the news item. The shortest shot in this cluster is 2.1s and the longest shot is 5.6s, with a median of 2.8s, and the 15 shots last a total of 49.4s. The longer shots in this cluster are associated with brief interviews from two members of the public. This cluster is then followed by a further seven shots lasting 56.6, which include more in-depth interviews with members of the public, an interview with the leader of UKIP, and a piece to camera by the reporter in summary of the story (min = 2.8s, median = 5.2s, max = 18.0s). A second example occurs at 0.26 in Figure 4 for the bulletin 1800 bulletin from 14 April as part of an item on immigration. This cluster comes at the end of lengthy report on non-EU immigration to the UK, and is immediately prior to a live summary of the story by a reporter and a live two-way interview. Like the above example of the local elections item, it is comprised of shots of the public places with a voice over by the reporter interspersed with brief interviews with members of the public. The total length of the cluster is 62.6s (min = 2.0s, median = 3.9s, max = 9.1s), and as before the longest shots are associated with the on-street interviews with members of the public.

Clusters of short shots may bridge across two different stories, although as noted below this is relatively rare. This is the case in the cluster occurring at 0.84 in the 1300 bulletin from 13 April, which includes the end of the report on pollution in the English rivers and the kernel and beginning of a report of the next item on the role of exercise in combating dementia. This cluster is 62.2 seconds long, with a minimum shot length of 1.6s, a maximum of 17.8s, and a median of 3.1s. With the exception of the kernel for the second news item (which accounts for the longest shot in this cluster), the same montage-with-voice-over and talking head pattern that we see in the two examples above accounts for the remainder of the cluster. This is also the case for the cluster that immediately follows in the same bulletin at 0.88, which is comprised of a series of shots of shorter duration (min = 1.4s, median = 3.2s, max = 7.0s) of the elderly exercising accompanied by the voice of the off-screen reporter. That the first cluster in this example bridges across these two news items may also be in part due to the lack of an on-screen summary or live-two-way interview which typically feature at the conclusion of an item on the BBC news, whereas the second cluster is followed by a long take in which the reporter appears on camera to summarise the main points of the story.

The fifteen bulletins in the sample include a total of 41 clusters of longer shots, of which 25 (61%) bridge across two or more news items and/or the mid-bulletin recap and preview. There are 46 clusters of short shots in Figure 4, of which 24 (52%) bridge across two or more elements. However, this figure includes the 15 clusters that include the opening titles

and if these are removed we see that the proportion of falls to 9 of 31 clusters, or 29%. Clusters of short shots are much more likely to be contained within a story than a cluster of long shots, which are more likely to cross over different elements in a bulletin. The shots of longest duration in a news item are typically the first shot, which is the news kernel, and the shots towards the end that include the summary of the report and the live two-way interviews. It is unsurprising, therefore, that a majority of these clusters stretch across more than element.

In general, clusters of long takes are associated with the news kernel, speeches, interviews with named key figures in news items (whereas *vox pop* interviews with unnamed members of the public tend to be shorter), the reporter talking directly to camera at the beginning and/or end of a report, and graphics used to illustrate a news item (e.g. maps, key points, statistics). For many of these features the camera is static, as is the object in the frame; though graphics often feature a mobile camera (zooms to close in on a specific area of a map, pans across an image from point to point) and object motion within the frame (animated visuals). Examples of such clusters can be seen in the 1800 bulletin broadcast on 13 April. The cluster of long shots at 0.12 in Figure 4 is primarily made of the latter part of a report on NHS news reforms, and includes an onscreen interview with a nurse, an interview with the health minister, and the live two-way interview, along with the news kernel for the next report. This cluster is 207.8 seconds long (min = 2.3s, median = 7.6s, max = 60.4s), with seven shots of 12 seconds or more. The longest shot in this cluster is the correspondent's part in the live two-way interview, and this is typical for a news item. From the same bulletin, we identify a cluster at 0.79 that accounts for the whole of a single item on reforms to the NHS in Wales and lasts for a total of 161.2s (min = 3.8s, median = 6.4s, max = 38.2s), and includes the news kernel, two different graphics, a lengthy tracking shot of a hospital ward, and the reporter's lengthy piece to camera. This item also includes an unusual shot that combines interviews with several different politicians within a single continuous take by framing them within the visual field of a hospital monitor, and which accounts for the longest shot in the item.

The cluster at 0.07 from the 1800 bulletin of 14 April begins immediately after the opening titles and is the first part of an item on the debate on immigration policy in the coalition government. The whole item has 50 shots in total and is 449.7s in length with an overall median of 6s, with the first 15 standing out as a significant cluster of long shots. This cluster lasts for 178.6s (min = 1.7s, median = 11.4s, max = 35.4s), and includes the kernel, two different graphics, footage of the prime minister's speech, and interviews with the business secretary and leader of the opposition. Of these shots, nine are 11 seconds or longer. The remainder of the item is edited more quickly, with a median of 4.6s and only 6 of the remaining 35 shots longer than 11 seconds. This second part of the item focuses the public reaction to the immigration debate and includes the cluster of shorter shots at 0.26 from the montage sequence described above; although it does include the live two-way, which is again the longest shot in the item at 54.8s. This item is therefore divided into two parts with two distinctive editing styles.

Not all non-BBC footage is associated with a short cluster. The 1300 bulletin from 15 April includes a cluster of longer shots at 0.77 in Figure 4, a major part of which is accounted for by police footage of a car chase recorded by a camera mounted on the front of a police car. This cluster is 210.0s long (min = 5.6s, median = 13.2s, max = 28.7s), and bridges across news items about the police chase and the preparations of the household cavalry for the royal wedding. Another cluster of long shots associated with similar footage occurs at 0.36 for the 2200 bulletin from 12 April in Figure 4, which shows footage from a closed circuit

television camera as part of an item on the killing of a young woman caught up in a gang conflict that comprises the majority of the cluster. This suggests that footage from surveillance sources is handled differently to library footage and that of other broadcasters, which has been pre-processed before it reaches the BBC newsroom, and that the continuous running of a CCTV camera is maintained to some degree in the presentation of a news report.

Although we can identify a handful of common features associated with different types of clusters, there is no overall pattern to the time series of the broadcasts. While television news bulletins follow a predictable and highly structured format, there is no evidence of a relationship between this organisation and the editing structure revealed by the time series analysis. The number of significant clusters in a bulletin ranges from a low of two to a high of nine, but shows no pattern by time or day of broadcast. There is no order in which the significant clusters of long or short takes occur: clusters of long shots may be followed by clusters of short shots and clusters of short shots may be followed by clusters of long shots, with numerous occasions when there appear to be runs of similar clusters. There is no pattern to distance between clusters, with clusters in some bulletins sparsely distributed while others appear to run into one another. For example, the 1300 bulletin from 11 April has only one significant cluster other than the opening title sequence, while the seemingly very long cluster at 0.10 in the 1300 bulletin from 13 April is in fact two separate clusters. There is no evidence of any cyclical patterns in any of the bulletins, though there are some abrupt transitions between different clusters. The only common editing feature is the sequence of opening titles noted above.

In summary, specific editing regimes in BBC news bulletins are associated with different types of programme segments but there is no overarching formal structure that governs the pace of the programme.

4 Conclusion

Time series analysis can reveal the evolution of style in motion pictures, creating an awareness and understanding of 'the existence of time' in dynamic visual media. This paper has analysed the distribution and time series of shot lengths in BBC news bulletins, and the results show that (1) there is no variation in the distributions with the time or day of broadcast; (2) there is no relationship between the structure of a news bulletin and the time series of its shot lengths beyond the cluster of short shots associated with the opening titles; and, (3) there are some common features associated with clusters of short and long shots, although these may not always be present. Future research in this area will need look at different broadcasters in the UK (e.g. ITV, Channel 5, regional news bulletins), and compare news bulletins from different countries. Television news bulletins typically contain the same structural features (e.g. news kernels, live two-way interviews, vox pops, etc.) irrespective of the channel on which they are broadcast, and so we may expect them to exhibit similar stylistic attributes. However, the above results suggest that American news bulletins may be cut more quickly than those of the BBC, and this deserves to be examined in greater detail. Future research will also benefit from refinements of the time series method employed here (e.g. employing multiple windows of different sizes to the same data set), and other ordinal and/or rank-based methods; and from the exploratory data analysis that enables the construction of better time series models.

References

Adams B, Dorai C, and Venkatesh S 2000 Role of shot length in characterizing tempo and dramatic story sections in motion pictures, in IEEE Pacific Rim Conference on Multimedia, December 2000, Sydney, Australia: 54-57.

Bandt C 2005 Ordinal time series analysis, *Ecological Modelling* 182 (3-4): 229-238.

Bandt C and Shiha F 2007 Order patterns in time series, *Journal of Time Series Analysis* 28 (5): 646-665.

Bertini M, Del Bimbo A, and Pala P 2001 Content-based indexing and retrieval of TV news, *Pattern Recognition Letters* 22 (5): 503-516.

Bolls PD, Muehling DD, and Yoon K (2003) The effects of television commercial pacing on viewers' attention and memory, *Journal of Marketing Communications* 9 (1): 17–28.

Choi YJ and Lee JH 2006 The role of a scene in framing a story: an analysis of a scene's position, length, and proportion, *Journal of Broadcasting and Electronic Media* 50 (4): 703-722.

Croux C and Rousseeuw PJ 1992 Time-efficient algorithms for two highly robust estimators of scale, *Computational Statistics* 1: 411-428.

Cutting JE, Brunik KL, and DeLong JE 2011 How act structure sculpts shot lengths and shot transitions in Hollywood film, *Projections* 5 (1): 1-16.

Davies MM, Berry C, and Clifford B 1985 Unkindest cuts? Some effects of picture editing on recall of television news information, *Journal of Education Television* 11 (2): 85-98.

Dorai C and Venkatesh S 2001 Bridging the semantic gap in content management systems: computational media aesthetics, in *Proceedings 2001 International Conference on Computational Semiotics in Games and New Media*, 10-12 September 2001, Amsterdam: 94-99.

Drew DG and Cadwell R 1985 Some effects of video editing on perceptions of television news, *Journalism Quarterly* 62 (4): 828-831, 849.

Ensink T 2006 Pragmatic aspects of televised texts: a single case study of the intervention of a televised documentary program in party politics, *Journal of Pragmatics* 38 (2): 230-249.

Fan J and Yao Q 2005 *Nonlinear Time Series: Nonparametric and Parametric Methods*. New York: Springer.

Hallin M and Puri ML 2003 Rank tests for time series: a survey, in PG Hall, M Hallin, and GG Roussas (eds.) *Madan L Puri: Selected Collected Works, volume 3 – Time Series, Fuzzy Analysis, and Miscellaneous Topics*. Utrecht: VSP International Science: 212-254.

Hanjalic A and Xu L 2005 Affective video content and representation modelling, *IEEE Transactions on Multimedia* 7 (1): 143-154.

Kang H-B 2003 Affective contents retrieval from video with relevance feedback, in TMT Sembok, HB Zaman, H Chen, S Urs, and SH Myaeng (eds.) *Digital Libraries: Technology and Management of Indigenous Knowledge for Global Access*. Proceedings of the 6th

International Conference on Asian Digital Libraries, 8-12 December 2003, Kuala Lumpur, Malaysia. Berlin: Springer: 243-252.

Keller K and Sinn M 2005 Ordinal analysis of time series, *Physica A: Statistical Mechanics and its Applications* 356 (1): 114-120.

Lang A, Zhou S, Schwartz N, Bolls, PD, and Potter, RF 2000 The effects of edits on arousal, attention, and memory for television messages: when an edit is an edit can an edit be too much?, *Journal of Broadcasting and Electronic Media* 44 (1): 94-109.

Lehane B and O'Connor NE 2006 Movie indexing via event detection, WIAMIS 2006 – 7th International Workshop on Image Analysis for Multimedia Interactive Services, 19-21 April 2006, Incheon, Korea. Available online: http://www.cdvp.dcu.ie/Papers/MovieIndexingEvent_Bart_Lehane.pdf, accessed 24 June 2011.

Mann HB and Whitney DR 1947 On a test of whether one of two random variables is stochastically larger than the other, *The Annals of Mathematical Statistics* 18 (1): 50-60.

Mauget S 2003 Multidecadal regime shifts in US streamflow, precipitation, and temperature at the end of the twentieth century, *Journal of Climate* 16 (23): 3905–3916.

Mauget S 2011 Time series analysis based on running Mann-Whitney Z statistics, *Journal of Time Series Analysis* 32 (1): 47-53.

Montgomery M 2007 *The Discourse of Broadcast News: A Linguistic Approach*. London: Routledge.

Rousseeuw PJ and Croux C 1993 Alternatives to median absolute deviation, *Journal of the American Statistical Association* 88: 1273–1283.

Schaefer R 1997 Editing strategies in television news documentaries, *Journal of Communication* 47 (4): 69-88.

Tarkovsky A 1986 *Sculpting in Time: Reflections on the Cinema*, trans. K Hunter-Blair. Austin, TX: University of Texas Press.

Wang H-L and Cheong L-F 2006 Affective understanding in film, *IEEE Transactions on Circuit Systems for Video Technology* 16 (6): 689-704.

Warner RM 1998 *Spectral Analysis of Time-Series Data*. New York: The Guildford Press.

**Table 1** The structure of the 2200 BBC news bulletin broadcast on 15 April 2011

Segment	Structural elements	Shots	Running time (s)	Cumulative running time (s)	Cumulative normalized running time	Description
Headlines		1 - 18	81.0	81.0	0.05	Including headlines from local news (shots 16-18)
Opening titles		19 – 26	14.8	94.8	0.06	
Main item	Kernel + Report & Live 2way	27 – 90	577.9	672.7	0.43	NATO bombing raids on Libya and the rebels fighting in Misrata
News item	Kernel + Visual	91 – 92	18.5	691.2	0.44	Political crisis in Syria
News item	Kernel + Report	93 – 112	171.8	863.0	0.55	News of the World phone-hacking scandal
Preview		113 – 123	20.1	883.1	0.56	A preview of the last item of the bulletin, featuring examples of promotional footage from US television
News item	Kernel + Report	124 – 152	239.5	1122.6	0.72	The aftermath of the Japanese earthquake
News item	Kernel + Report & Live 2way	153 – 159	96.0	1218.6	0.78	The murder of an activist in Gaza
News item	Kernel + Visual	160 – 161	18.4	1237.0	0.79	M1 closed due to scrap yard fire
News item	Visual	162	15.2	1252.2	0.80	Police footage of dangerous driving
News item	Kernel + Report	163 – 185	122.8	1375.0	0.88	UK Independence Party and the local elections in England
News item	Kernel + Report	186 – 232	184.8	1559.8	1.00	The royal wedding on US television, featuring promotional footage from ABC and NBC
Sign off		233	1.1	1560.9	1.00	

[13]

Table 2 Descriptive statistics of BBC News bulletins, 11 April 2011 to 15 April 2011

Bulletin	Length (s)	Shots	Minimum Shot Length (s)	Lower Quartile (s)	Median Shot Length (s)	Upper Quartile (s)	Maximum Shot Length (s)	Q_n (s)
11/04 - 1300	1714.6	216	0.8	3.1	4.6	8.0	94.9	3.1
11/04 - 1800	1558.3	182	1.0	3.4	6.3	10.9	57.9	3.9
11/04 - 2200	1602.5	197	0.9	3.4	5.3	9.4	67.9	4.0
12/04 - 1300	1732.8	233	0.8	2.7	4.4	8.2	73.1	2.9
12/04 - 1800	1621.7	238	1.0	2.6	4.0	7.6	68.2	2.6
12/04 - 2200	1577.2	195	0.4	3.1	4.8	9.6	70.6	3.5
13/04 - 1300	1697.6	233	0.6	2.8	4.2	8.0	65.1	3.1
13/04 - 1800	1600.7	220	0.8	3.0	4.9	8.0	60.4	3.3
13/04 - 2200	1562.3	214	1.0	2.8	4.5	7.2	67.6	2.8
14/04 - 1300	1722.8	212	0.1	2.9	4.7	8.7	89.3	3.5
14/04 - 1800	1557.7	203	0.6	3.2	5.0	9.8	54.8	3.5
14/04 - 2200	1560.3	231	0.6	2.8	4.2	7.4	63.3	2.7
15/04 - 1300	1709.2	190	0.8	3.2	5.6	8.9	111.8	3.7
15/04 - 1800	1589.2	237	0.8	2.6	4.5	8.6	66.4	3.1
15/04 - 2200	1560.9	233	0.4	2.6	4.6	8.2	80.2	3.3

Figure 1 Two-way analysis of variance (without replication) of BBC news bulletins, 11 April 2011 to 15 April 2011

(a) Median shot lengths

(b) Q_n
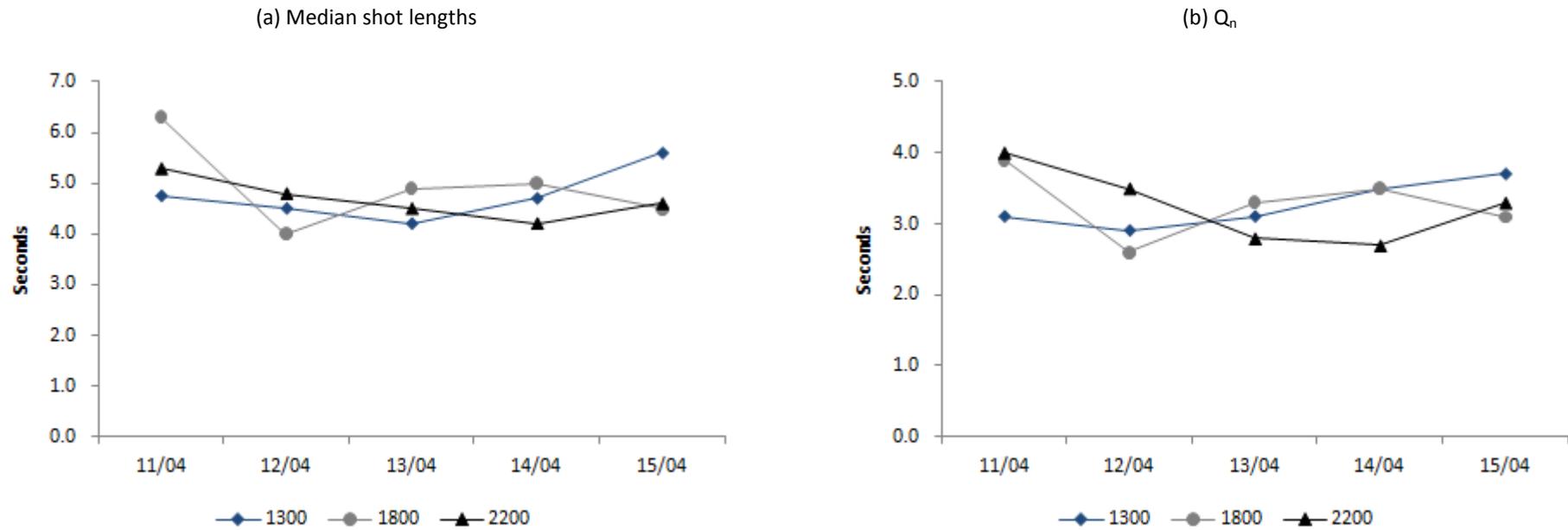
Figure 2 A limited range of shots are used in BBC news bulletins broadcast at different times on different days

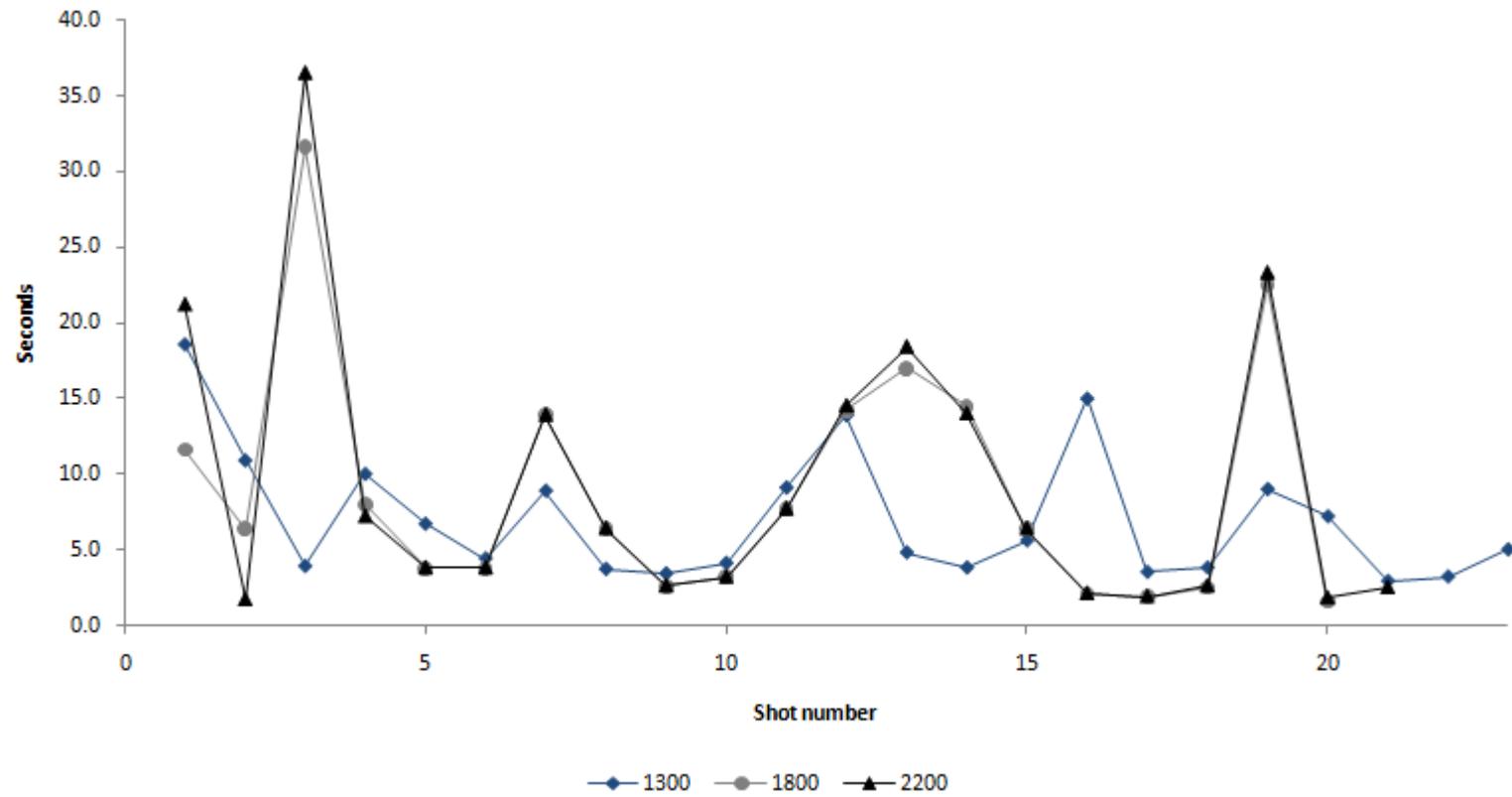(a) Live two-way interview from the 1800 bulletin on 13 April 2011

(b) Live two-way interview from the 1800 bulletin on 14 April 2011

(c) Live two-way interview from the 1300 bulletin on 15 April 2011

[16]

Figure 3 Time series of shot lengths for the news item on UK unemployment figures broadcast at different times on BBC 1 on 13 April 2011

Figure 4 Side-by-side comparisons of the most significant non-overlapping regimes of short and long shots based on running Mann-Whitney Z statistics using a 15 shot window in BBC News bulletins, 11 April 2011 to 15 April 2011
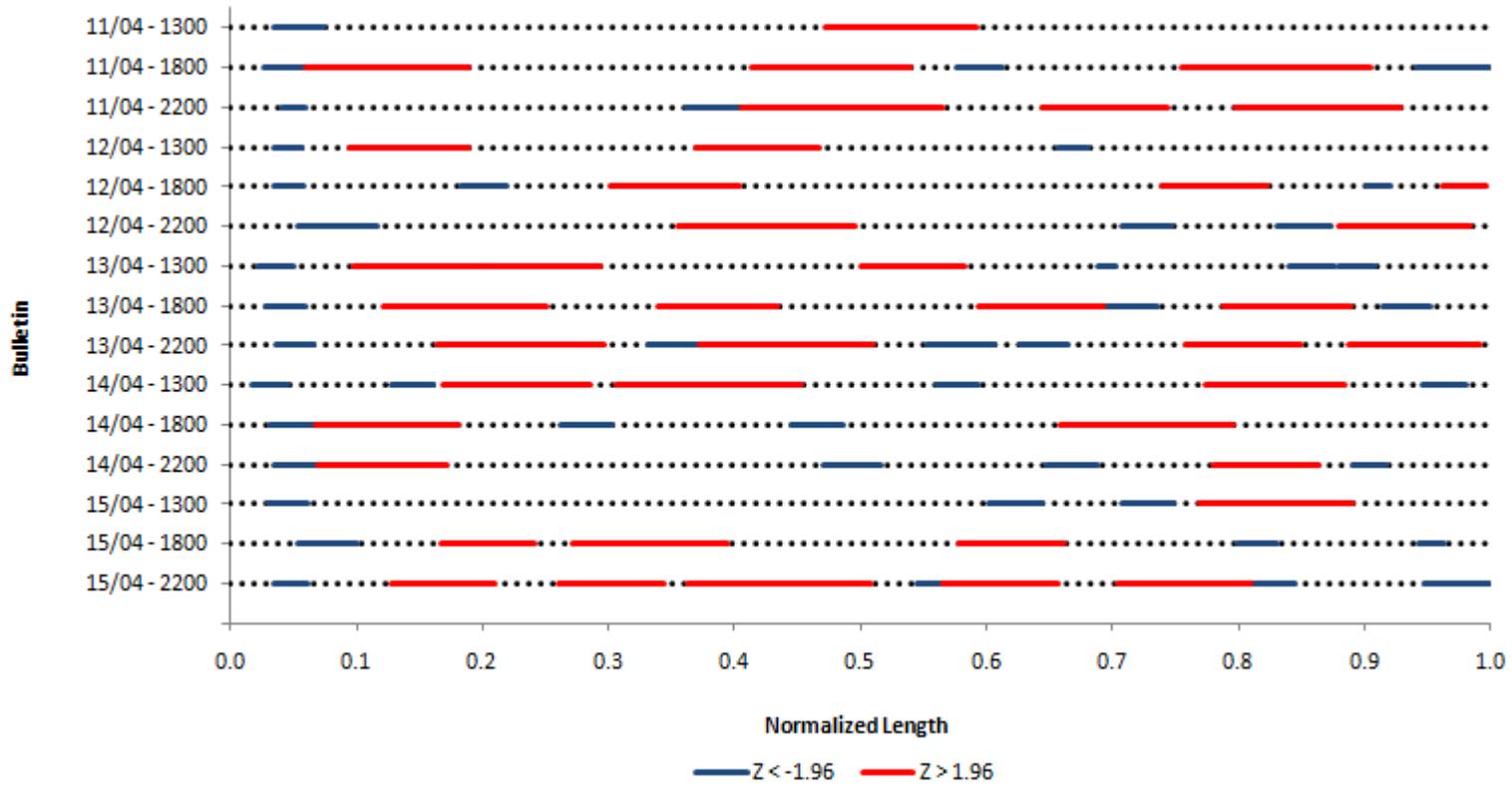
Figure 5 Times series based on the running Mann-Whitney Z statistic using a 15 shot window for the 2200 BBC 1 News bulletin, 15 April 2010