Concept mapping second screens to augment understanding of science on television

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ABSTRACT

Science programmes on television are the main source for public understanding of science; they also make some of the greatest demands of TV viewers. Companion second screens running on connected, handheld devices have the potential to augment viewers' understanding of science programmes, for example by providing additional explanations or additional information about the programme. We examine two prior exemplars of second screen designs that were explicitly created to support viewer understanding of programme content. They suggest primary representational functions that a second screen should provide if it is to augment understanding of science TV programmes. We describe an interactive concept map as a second screen that shows promise for achieving those representational functions.

Author Keywords

Companion second screen; public understanding of science; augment understanding; user interface adaptation; interactive concept maps.

ACM Classification Keywords

H.5.2. User interfaces: theory and methods.

INTRODUCTION

Television programmes are the primary means of increasing public understanding of science [6,1]. If they are to be effective in this role, they need to be engaging and interesting and they need to be understandable for a very broad audience.

Science programmes on TV also make some of the greatest demands of viewers. At one level and in purely cognitive terms, viewing a science programme involves interpreting a presented fact base through understanding a nexus of more or less explicit scientific concepts informed by the viewer's background knowledge. Much of the art of the producer lies in designing TV science programmes that accommodate the diverse limits of the audience in relation to these processes.

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Science TV programmes are a rich potential application for companion second screens. Second screens, running on connected, handheld, personal devices provide their viewer users with synchronized content as well as enabling them to participate in online activities and share comments with other viewers. They are likely to become an accepted part of watching TV on a large screen, having already demonstrated their potential for making TV viewing more active and participative [4,8].

Of course producers have no control over who will watch their programme and different viewers will have very widely varying background knowledge. A family watching a popular science programme might include a child not understanding much of the programme because of his or her lack of basic background concepts, whilst a parent finds the programme to be largely uninformative because it doesn't engage with knowledge of the subject they already have. Simply put, children may want more explanation while adults may want more information. In addition, viewers have different approaches to the use of TV programmes as an authoritative source of knowledge about science [6].

Development of second screen techniques is being pursued particularly actively by commercial interests, for example, to push synchronized adverts and offers to viewers. To date, programme makers have used second screens mainly for sports programmes, game shows and quizzes, and reality TV shows [8,10]. Second screens have been demonstrated with fact-based programmes including natural history programmes, but so far as we are aware not for science programmes and not for augmenting the viewer's comprehension. This prospect raises the question of in what form and by what method could a second screen augment the viewer's understanding of a science programme?

We address this question by identifying primary representational functions of second screens for science programmes. These functions are assayed from a review of two second screens previously developed to support viewer understanding. The representational functions we extrapolate from these prior systems take account of the kind of cognitive processes involved in understanding a science programme on television.

TWO EXEMPLAR SECOND SCREENS

Two notable designs of second screens for augmenting understanding of programme content give insight into the representational functions required of second screens for science programmes. The first exemplar is the second screen developed for an episode of Frozen Planet [1]. This app pushed content to the viewer in synchrony with the programme; with each animal introduced in the programme, a thumbnail image/ icon appeared in the app, giving access to a summary of facts about the animal which could be bookmarked.

Figure 1. Frozen Planet companion second screen [1].

Findings from the evaluation trial of the Frozen Planet second screen included the following [1]:

- it broadened and deepened viewers' engagement with the programme content;
- it allowed users a personalised viewing according to their interests;
- it encouraged curiosity and shared discovery;
- it provided additional but not excessive authoritative information;
- it worked as a log of items of interest to a particular viewer and marked things to access later;
- it particularly engaged 'pre-family' viewers (who sought more information) and children (who used it to continue learning journeys);
- it could compete negatively for the viewer's attention and was ignored during highly visual parts of the programme;
- smartphones rather than tablets were used to view the second screen during the programme, the converse for viewing the second screen later;
- simply repeating the broadcast content was not valued and additional content was expected;
- the second screen interaction should be user paced, not system paced.

The second exemplar is the Story-Map second screen for long form drama [11]. The app was designed to give viewers of serialized dramas an overview of the setting and narrative, to remind them of plot threads and to allow them to review important story sequences across episodes. Its main representation was an updating map of characters synchronized with the TV content to identify the people in the story and their relationships. As new characters appeared, they were added as a new node to a graph in which all the characters and their relationships were shown.

Characters who were mentioned but who had yet to appear were greyed. Characters who had appeared but were not currently present were indicated by a reduced size icon. Rather than showing who is literally visible in the frame, the map showed who was present in the semantic dramatic unit. Characters were also grouped according to geographical location and were iconified, providing access to a brief biography which was updated with the narrative. No evaluation trials with Story-Map have been reported.

Figure 2. Story-Map's character map with the broadcast programme in the background [11]

Both the Frozen Planet and Story-Map systems were developed to support the viewer's understanding of the programme content. The Frozen Planet screen extended users' knowledge beyond the programme and assisted them in recalling what they had seen and learnt in the programme. By contrast, the Story-Map screen more intentionally provided an explicit representation of the content of the watched programme and provided explanation of that content supporting understanding of the story, in particular in explaining the relationships between characters. Both programmes involved understanding a set of facts (even if in one case those facts were about fictional characters and events). In this respect both programmes have similarities with science TV programmes. However they do not share the concepts and language that characterise science programmes and which are typically specialist, abstract and complex. We now identify a set of representational functions for second screens supporting science programmes that take account of these features,

REPRESENTATIONAL FUNCTIONS

Creating a second screen application to augment comprehension of a science programme is a challenging problem as the design space is large. By extrapolating from our review of exemplar systems above, we identify the primary representational functions a second screen for science programmes should provide.

Synchronized & coordinated

Synchronization is the most distinctive feature of second screens. Since second screens are used while watching a broadcast programme, their displayed content should be synchronized with the programme's current content. Input capabilities and user interactions should also benefit from this context of synchronization. For science programmes, it is of particular value to synchronize the second screen with the broadcast programme in order to (a) augment the concepts that are currently presented and (b) offer the viewer possibilities to interact with the second screen.

Both the Frozen Planet and StoryMap second screens were synchronized with the broadcast programme and were viewed in a passive and discretionary mode by the viewer user. The Frozen Planet study reported that user's access of the second screen should be self-paced rather than system-paced, implying that the screen updating should avoid being attention-seeking.

Coordination refers to the designed combination of contents of the screens to take account of the viewer's focus of attention. When not coordinated, users will develop their own ways of dividing and managing their attention between the screens, for example, by focusing on the second screen when the broadcast programme is showing only a presenter's 'talking head'. A coordinated second screen implies a requirement on the broadcast programme itself to provide opportunities for the viewer to look away. The Frozen Planet evaluation reported that viewers would ignore the second screen during highly visual sequences of the broadcast.

Persistent & accumulating

Viewers of science programmes need a view of the content they have already viewed. Television is, of course intrinsically transient and viewers' recall of what they have viewed needs to be augmented since science programmes often involve relating together their parts within a linear narrative. Therefore, the second screen needs to provide a persistent representation of the content already viewed that can be re-consulted. Moreover, the representation should be accumulating dynamically so that the content currently viewed extends the second screen representation. This dynamic leading edge would allow the viewer to easily find their place when shifting visual attention. This aide memoire function of second screens was provided by Story-Map; by contrast, viewers of Frozen Planet were found not to want only a repetition of the content they had seen broadcast, although that particular programme usually does not involve back reference to earlier content for understanding.

Synoptic

If, as we claim, viewers need a representation of the broadcast content already watched, a verbatim transcript and frame-by-frame record is unlikely to be helpful. Rather, viewers need an abstraction of the content that summarises the important ideas and their connections, and the significant facts in the broadcast that relate to these. The process of understanding the broadcast may be recognized as fundamentally constructing this conceptual abstraction over the content. We therefore identify the need for a synoptic representation of the programme. This representation would also provide a means of categorizing, indexing and therefore re-finding content already viewed.

The StoryMap second screen provided a synoptic representation of the drama in terms of the characters and their relationships and visually identified meta level features of the characters. The Frozen Planet second screen used the separation of the broadcast into sections dealing with different animals and events. Simple navigation through the second screen was provided by the thumbnails as a highest level synopsis.

Interactive (navigable, interrogable, indexable)

A second screen interface has the potential for making the usually passive viewing of a science programme into a active learning experience, engaging the user and improving overall satisfaction. In the context of science programmes, interactivity could offer the possibility to navigate and interrogate the flow of concepts and notions that have been introduced in the TV programme so far. Interactivity clearly has to be designed carefully as extended interactivity will lead to distraction that will undermine comprehension of the programme. Both the Frozen Planet and StoryMap systems enabled users to navigate through a representation of the programme content and to access additional information. Frozen Planet allowed users to add bookmark indexes to personalize the content for later referral.

Adaptable and adaptive

As already discussed, different viewers will have different needs and expectations for how the science programmes should be augmented. Viewers with a little knowledge would need more explanation to properly understand the programme, while viewers with better knowledge would need more information. For this reason the second screen should be adaptable so that the viewer can adapt its content to his or her expectations and needs. Ideally, the second screen should be able to infer these needs and automatically adapt. This adaptivity could be achieved by modeling the user using a combination of information about his or her background and monitoring the interaction.

CONCEPT MAPPING SECOND SCREENS

The design space of second screens for science programmes is clearly very large. Interactive concept maps are one possible kind of design, one we believe is capable of offering the desired representational functions.

A concept map is a form of directed graph used to capture and present knowledge in specific domains. Ideas and information are represented in abstract as labeled boxes or circles connected with labeled arrows, often in a downward-branching hierarchical structure. Relationships between concepts can be typed and annotated using constructs such as *is-a*, *has*, *causes*, etc. Using these constructs a concept map is able to model semantic associations between concepts and propositional knowledge (for example, the proposition 'an iMac is an apple' could be expressed with two nodes and one relationship).

Concept maps are related to, but distinct from, mind maps and argument maps [5]. Mind maps express ideas and the associations between ideas only loosely, sometimes using images as nodes rather than labels and not labeling the relationships; at the other end of the spectrum, argument maps often have well defined syntactic constraints which allow definite argument structures (e.g., claims, rebuttals, etc) to be expressed over sets of nodes and links.

Concept maps are a practical application of semantic networks [1] and have been advocated as a tool for learning in the sciences in particular [12]. They are probably most often used in the classroom in a constructional mode with students drawing maps of some learning contents they have been exposed to. In this mode they have also been used as a way of assessing knowledge and learning; stereotypical morphologies ('spoke', 'chain' and 'network' structures have even been identified [7]). But concept maps are not limited to a constructional mode of use; they can also be used in presentational mode, as a way of summarizing a set of taught material to aid learning.

Concept maps can equally be created for television science programmes and an example of one is shown in Figure 3. It represents the first three minutes of a programme on supernovae, an episode from a series on the lifecycle of stars [2]. The map was created using the concept mapping tool Cmap [3] and its nodes represent the main ideas explicitly stated in the narration overlaying a set of related video images in this opening part of the programme. The narration has been parsed and re-expressed into these separate nodes then relationships fixed between them. The figure uses colour coding to differentiate the nodes for each successive minute of the programme. The orange shaded nodes would therefore all appear in the first minute of watching the programme.

This map could be presented dynamically on a second screen so that nodes appear serially, synchronized with the play of the recorded programme. There are many possibilities for the visual transitions in displaying the map. For example, it might be presented as a fixed global view that is progressively filled in with blossoming nodes and arcs. Alternatively, the view might be a roving porthole that skims across the map revealing the network of nodes 'already there'. Both a roving porthole and dynamically appearing nodes could be used. Multiple detailed presentation design decisions arise, for example, the limiting speed of transition of the moving map without disrupting reading.

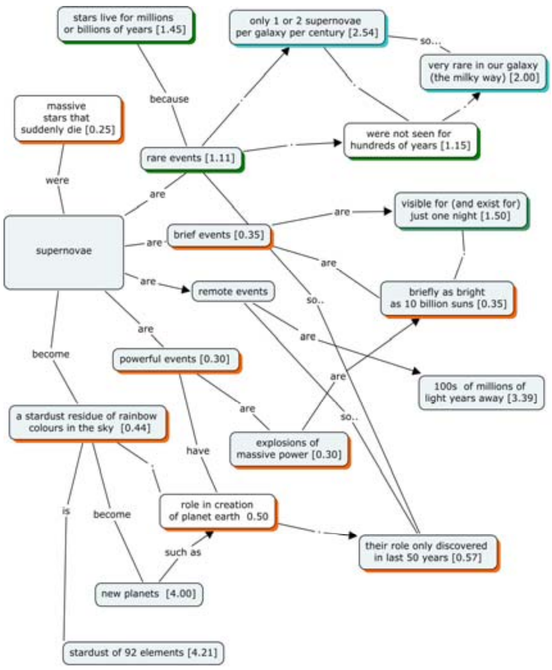

Figure 3. Concept map of the first three minutes of *Supernovae,* Episode 5 of *The Seven Ages of Starlight* [2].

This concept map can also be interactive. At a minimum, viewers will be able to pause the dynamic display of the map. The map would then need to catch up with the programme. Beyond this simple touch-and-hold interaction, viewers could navigate the map and expand and mark nodes. Interactive concept maps have been previously demonstrated as a knowledge elicitation tool [9] but the second screen application greatly expands the possibilities for interaction.

We can also anticipate how the concept mapping second screen can achieve the desired representational functions identified earlier. Its synchronization with the science programme has been described, with nodes and branches coming into view at the right moment. Coordination would require the TV programme to be created with use of the concept map taken into account, and cued for example by a visual flag or by reducing the attentional demands of the programme. A viewer pausing the concept map could also be a signal to the programme to pause.

The concept map second screen provides a persistent representation of the programme content already seen and an accumulating representation through its controlled exposure. The map necessarily abstracts the rich audio-visual programme into a synoptic representation. The possibility for drilling down on a node to reveal more detail means that it is a synopsis of varying abstraction.

Navigation, interrogation and indexing of the concept map are possible during viewing of the programme and of course separately after viewing the programme. Familiar methods for navigating geographical maps and hypertext can be provided, as can common methods for browsing and searching visual databases. The value of simple indexing of items, marking favourite items etc, has already been proven for second screens. The possibility to *star* a topic of interest could be used to improve the relevance of additional content offered after the programme has been watched.

Adaptation in the second screen to respond to the viewer's understanding of the programme is also feasible. By providing choices for viewers in navigating and browsing the map, the second screen is offering a basic form of adaptability. If the choices available to the viewer are constrained by their individual profile, or by the trajectory of choices already made through the map, then the map is achieving at least a rudimentary degree of adaptivity.

Many open questions remain about the form of concept mapping second screens. If done badly it is entirely possible that a concept mapping second screen would be ignored, or worse, make comprehension of the TV programme harder. But if the primary representational functions are provided, we believe the concept map will be effective. A multitude of detailed interface design issues are apparent. For example, it is currently uncertain whether the relationships between nodes should be of only a few stock kinds, or not typed at all. It is even unclear if links should have an annotation at all for presentation on a second screen.

CONCLUSION AND FUTURE WORK

Television is the most important channel we have for supporting the public's understanding of science. Although TV science programmes are abundant, their production is a matter of compromise in order to reach the largest audience. As a result, science programmes can be both too easy for some viewers and too challenging for others.

A companion second screen offers the ideal interface for augmenting the science programme, supporting a more active engagement, augmenting viewers' grasp of the programme and extending their knowledge beyond the broadcast content. To date however, use of second screens for science programmes has not been explored.

In this paper, we examined two prior second screen designs intended to augment viewer understanding. Although the programmes they accompanied, one a natural history and the other a crime drama, may not offer the same intellectual challenge as science programmes, they gave insight into five representational functions we believe a second screen for science programmes should. We then proposed the concept map as a particular form of second screen display for science programmes, one we argue that is capable of providing e the desired representational functions. It has the potential for adaptation to individual users, broadening the reach of science programmes.

Our joint UCL/BBC project is developing a concept mapping second screen as a prototype for the Supernovae programme. The prototype will be used to demonstrate that a concept mapping second screen is able to foster learning from watching science on the television; is at an appropriate level of abstraction at which users will wish to interact, and; offers possibilities for augmenting different users differently so that the broadest audience can be both engaged and informed by science programmes.

REFERENCES

1. BBC, *The Frozen Planet Dual Screen.* 2012.
2. BBC, *The Seven Ages of Starlight.* 2012.
3. Cañas, A. J., Hill, G., Carff, R., Suri, N., Lott, J., Eskridge, T., Gómez, G., Arroyo, M. and Carvajal, R. CmapTools: A knowledge modeling and sharing environment. *Proc. first international conference on concept mapping*. 2004.
4. Cesar, P., Bulterman, D.C., and Jansen, A. Usages of the secondary screen in an interactive television environment: Control, enrich, share, and transfer television content, in *Changing television environments*. 2008, Springer. p. 168-177.
5. Davies, M., Concept mapping, mind mapping and argument mapping: what are the differences and do they matter? *Higher education*, 2011. **62**(3): p. 279-301.
6. De Cheveigné, S. and Véron, E. Science on TV: forms and reception of science programmes on French television. *Public Understanding of Science*, 5(3), 1996.
7. Hay, D.B., H. Wells, and I.M. Kinchin, Quantitative and qualitative measures of student learning at university level. *Higher Education*, 2008. **56**(2): p. 221-239.
8. Klein, J., Freeman, J., Harding, D., & Teffahi A. *Assessing the impact of second screen,* 2014. Ofcom.
9. Kornilakis, H., Grigoriadou, M., Papanikolaou, K. and Gouli E. Using WordNet to support interactive concept map construction. *Proceedings* of ICALT '04. IEEE.
10. Moulding, J., *BBC Reveals Companion Screen App Strategy.* Videonet, 2012.
11. Murray, J., et al. Story-map: iPad companion for long form TV narratives. *Proceedings of EuroiTV '12*. ACM.
12. Novak, J.D., Concept mapping: A useful tool for science education. *Journal of Research in Science Teaching*, 1990. **27**(10): p. 937-949.
13. Schäfer, M.S., Taking stock: A meta-analysis of studies on the media's coverage of science. *Public Understanding of Science*, 2012. **21**(6): p. 650-663.
14. Steyvers, M. and Tenenbaum, J.B. The Large-Scale Structure of Semantic Networks: Statistical Analyses and a Model of Semantic Growth. *Cognitive science*, 2005. 29(1): p.41-78.