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Canada

Running head: ReView

ReView: A Digital Video Player to Support Music Practice and Learning

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Abstract

Thanks to the emergence of digital video, producing and distributing video is now possible in ways that were previously limited to video production companies. Yet the functions of current digital media players differ little from the VCR's play, rewind, fast-forward, and pause functions, which may not support learning tasks appropriately. Therefore, we designed an enhanced digital media player, ReView, to better support video-based learning. To test ReView's usefulness, advanced music students in the Young Artists Programme of the National Arts Centre of Canada were given the opportunity to use the media player to review a video recorded lesson. In this paper, we present the students' ratings of the usefulness of ReView's features, and the frequency with which the features were used. We discuss these findings with respect to technological support for browsing video content. Additionally, we present findings related to the content of the video that the students chose to watch. Specifically, we found that students prefer to watch themselves play rather than review instructions received from a coach.

ReView: A Digital Video Player

to Support Music Practice and Learning

Introduction

The ability to record, store, and playback video has changed radically over the last ten years. The price of video equipment (cameras and playback devices) has declined dramatically, while the emergence of digital video has made it possible to stream, edit, and store video on computers. Moreover, the Internet is now being used to distribute and view videos. One fundamental impact of the recent evolution of video technology is that individuals have the tools to produce, edit, and distribute their own video much more easily than ever before. The success of Web sites such as google.video.com, YouTube.com, and MySpace.com indicates that self-produced digital video will play an increasing role in communication. As digital video becomes ubiquitous to communication, it will also become a key medium for instruction, particularly in areas requiring physical skills, such as music. Examples of this emergent phenomenon of video in music education could be capturing a coaching session on video for review at a later time; or using video as a visual aid to clarify a question about violin technique posted on the Internet.

Self-produced videos have been shown to be an important tool for supporting learning by self-observation in domains such as sports (Beilock, Wierenga, & Carr, 2002; Guadagnoli, Holcomb, & Davis, 2002; Horn, Williams, & Scott, 2002), nursing (Hill, Hooper, & Wahl, 2000), counseling (Urdang, 1999), music teacher training (Broyles, 1997) and conducting (Johnston, 1993). Moreover, data from sports indicate that students recognize their performance errors earlier when they, as opposed to their instructors, control the video (Menickelli, 2004). Fireman, Kose and Solomon (2003) showed that watching oneself perform a task, even inefficiently, is more effective for learning than observing expert performance. The ability to

self-monitor also appears to underlie skilled musical performance (McPherson & McCormick, 1999). Some studies indicate that reviewing video recordings of performances may even improve self-evaluation skills (Bergee & Cecconi-Roberts, 2002; Daniel, 2001). We believe that we can enhance this beneficial effect of video on learning by leveraging the power and flexibility of digital video via new video browsing features thereby increasing the effectiveness of video-based learning through self-observation.

One consequence of the greater ease with which video can be produced is an increase in the amount of video. This raises the problem of finding relevant video segments both between and within video files, and the related issue of supporting user navigation in video media. Chapters, as in DVDs, support jumping to locations that are pre-defined by the video's producer. Browsing tools that offer more control to the viewer are typically limited to a play head that has the dual function of indicating the current position on the video timeline, and of supporting navigation by dragging the play head left or right. VCR-like controls that enable quick and user-friendly browsing of multimedia content are still desirable in digital video applications (Lin, Zhou, Youn, & Sun, 2001), especially with progressive download and streamed video. However, digital video creates the potential for several new browsing features such as random access to video segments, looping, segment marking and preview by thumbnails (Geisler, et al. 2002a; Geisler, et al. 2002b), instant replay, and other mechanisms supporting video browsing independently of the video producer's markups and annotations.

In this paper, we investigate the video browsing behavior of music students reviewing one of their own coaching sessions, in order to establish some technological requirements related to accessing and browsing video content. The videotapes of the music students' coaching sessions were digitized so that the students could review their sessions with an enhanced media

player we developed: ReView[1]. ReView provides a set of video browsing features not present in standard media players like QuickTime Player, Windows Media Player, and Real Player. In some cases, the whole ensemble reviewed the video together, while in other cases, students reviewed the video of their ensemble individually. Through analyses of the students' browsing behavior and questionnaires we examined the role of ReView's digital media player features on learning through self-observation.

This study explores two main sets of research questions related to the students' use of our media player's features. The first set of questions focuses on the type of content that the students selected to watch. An identification of salient content is essential to determine some video content access requirements. Important questions in this respect are: Are students attending more to the coach's instructions or to the ensemble performance? Does the content reviewing pattern depend on whether the video is reviewed by a single person versus the whole ensemble? To answer these questions, we classified the video content as one of two types: coaching instruction and ensemble playing. We then determined the time the students spent reviewing each type of content.

The second set of questions address the browsing features' usefulness. Important questions in this respect are: Do students judge all features useful? Are some features used more often than others? To answer these questions, we asked students to rate the usefulness of each media player feature, and we collected usage data showing how often each feature was actually used.

The detail of the participants, apparatus, materials, design, and procedure is described in the following section.

Method

Participants

The participants were music students enrolled in the National Arts Centre's Young Artists Programme (YAP)[2] in Ottawa, Canada, during the summer of 2003. YAP is an intense three-week program providing private instruction and chamber music ensemble coaching to highly skilled advanced classical music students. For this experiment, we focused on the chamber music coaching, for which students were assigned to ensembles, each with a specific piece of music to master over the course of the program. Each ensemble received its coaching as a group. Ensembles ranged in size from three to five students depending on the piece and the instruments required.

Participation in the experiment conformed to the exacting standards of the National Research Council's Research Ethics Board. Twenty students between the ages of fourteen and twenty-five volunteered to participate. Parental consent was required for the participation of students under the age of eighteen. Eighteen of the students played string instruments, and two played the piano.

Design

The design consisted of a single between subjects factor, reviewing condition, with two levels: individual reviewing and ensemble reviewing. Each student in the individual reviewing condition used ReView to review his/her ensemble's coaching session video alone, without the other ensemble members present. In the ensemble reviewing condition, the entire ensemble reviewed its coaching session video together using ReView. In the ensemble reviewing condition, students were not instructed on managing the group control of ReView.

We assigned students to conditions based on their responses to recruitment. If all of the students in an ensemble consented to participate, they were assigned to the ensemble reviewing condition. Otherwise they were assigned to the individual reviewing condition. Three ensembles of respectively three, four and five students reviewed the video together, while eight individuals reviewed the video by themselves. It is important to note, though, that in both the individual and ensemble reviewing conditions, the reviewed video showed an ensemble coaching session.

As dependent measures, we collected the students' ratings of the usefulness of ReView's features, we recorded the actual frequency with which these features were used and, for the content analysis, which parts of the videos were reviewed.

The dependent measure for the content analysis was the proportion of time students spent reviewing different types of content (performance vs. instruction) in relation to the content's length in the video. To calculate this proportion, we first categorized the coaching session video content into three content types: instruction, performance, and miscellaneous. Instruction included video segments containing instructions from the coach, and student discussions of those instructions (which were very infrequent). Performance contained video segments in which the students played a section of their assigned piece. Miscellaneous included tuning and chitchat between the students and occurred almost exclusively prior to the actual coaching session and represented on average only three percent of the video recording. . Miscellaneous events were discarded from the analysis

We then calculated the proportion of time spent on instruction and performance in each video. For example, if 33 minutes of a 53-minute video showed performance, we would divide 33 by 53, giving us the performance proportion of 0.62.

We then computed the amount of time students spent reviewing each of these content types. Each second ReView was in "play" mode was categorized as either "performance" or "instruction", according to the content type being reviewed. The sums of these seconds are the total performance review time and the total instruction review time. For each content type we then calculated the reviewing proportion, which is the proportion of time the students spent reviewing that content type [3]. For example, if the students reviewed performance for 19 minutes with the video being played for 25 minutes, the performance reviewing proportion would be 19 over 25, or 0.76.

The content ratio, our dependent variable, was computed by dividing the reviewing proportion by the content proportion. The content ratio gives us a measure of the extent to which the students reviewed a particular content type in relation to that content type's proportion of the video running time. A content type greater than one indicates that the students spent more time reviewing that content type than would be expected given its running time. Conversely, if the number is less than one, the students spent less time reviewing that content type than would be expected given its running time. Using the examples above, we would divide .76 by .62 giving us 1.22. This would mean that the students spent a disproportionate amount of time reviewing their performance.

Apparatus

Students reviewed their coaching session videos using the ReView enhanced media player. ReView was developed for the Windows operating system using Visual Basic. We equipped the player (see Figure 1) with the usual VCR-type features: play, rewind, and fast-forward, and volume and mute features. With a VCR, the different parts of a tape must be accessed in sequence. In contrast, a digital video format provides the potential to access any part

of the video in an instant. Like many other standard media players (QuickTime Player, Windows Media, Real Player), ReView has a playback head that can be dragged to move quickly from one frame to any other (Figure 1, number 2). Like a computer window's scroll bar, the playback head provides a spatial indication of the current video frame's position in the video. A small pop-up tool tip dialog box also showed the video's time index when the head was selected.

ReView was developed in consideration of both the video browsing task, and as an aid to use video during instrument practice. Accordingly, to help musicians use auditory signals to recognize sections of the video more easily when browsing, or identifying musical mistakes (Drake & Palmer, 2000), we added a skip and play function that preserve pitch and tempo (unlike the classic rewind or fast forward). These added functions play back with undistorted sound for both the forward and backward buttons (after Li, Gupta, Sanocki, He, & Rui, 2000) and in the playback head. We also included features to create and save segments of the video. Looping these segments continuously was also made possible. Additional information about ReView's features is provided in the Figure 1 caption.

We were particularly careful about the learnability and usability of these features. Had the features been too difficult to use, or to learn, students would have avoided using them despite their usefulness. Therefore, to maximize the enhanced player's usability, we subjected it to cognitive walkthroughs by two usability experts. In a cognitive walkthrough, the expert plays the part of a user and uses the software to perform a specific task of the kind a user might perform. Any problems in using the interface, such as errors, confusion, excessive delays, and missing or overly complex functions are noted for correction in the next version of the software (see Hom, 1998). This process led to the final design that we implemented in ReView.

Insert Figure 1

Materials

We video recorded one coaching session for each ensemble that had a participant in the experiment. The camera was placed at a fixed distance from the ensemble, such that all members were visible in the recording. A single focal distance was maintained throughout the recording. The videotapes were then rendered into the video NTSC format (720X480, 29.97 fps) and uncompressed sound using iMovie on an Apple Macintosh G4 running OS X. The resulting NTSC files were then transferred to Windows-based computers for reviewing with ReView. The average file size was about 11 gigabytes. The videos were recorded no more than two days prior to the experimental session. The average duration of the eight videos was 53 minutes.

Procedure

Before participating, each student read and signed an informed consent sheet. The entire reviewing session took no longer than 70 minutes. The session began with an experimenter reading aloud the procedure script, which contained an overview and instructions for the students. Students were then given 10 minutes to complete a questionnaire, which probed their memory of their ensemble performance.

After completing this questionnaire, students were trained to use ReView's features with a video from the previous year's YAP session. Students were then given 25 minutes to review the video of their own coaching session using the ReView media player. All student actions were recorded for analysis. To encourage the students to use the player's features, the reviewing period (25 minutes) was about half the video's running time. Had we not limited the session in

this way, students could have reviewed the whole video by simply playing all of it without using any of the features.

Students were then given 10 minutes to complete a second questionnaire, similar to the first. The students were asked to base their responses to this second questionnaire on their reviewing of the recorded coaching session.

A final questionnaire about the usefulness of the features was then administered.

Results

Video Content Reviewing

We used the content ratio as the dependent variable to determine whether the students preferred to view one content type more than the other. A linear mixed effects model analysis (Lindstrom & Bates, 1990) was performed with content ratio as the dependent variable. Reviewing condition was a between subjects factor (individual vs. ensemble reviewing). Content type was a within subjects factor with two levels: performance and instruction.

Eleven observations were included in the analysis, the three ensemble reviewing sessions and the eight individual reviewing sessions. There was no significant effect of either reviewing condition (individual vs. ensemble) or interactions at the 0.05 level[4]. There was a main effect of content type ($F(1,9)=71.24$ $p<0.0001$). The mean content ratio for performance was 1.29, while the mean content ratio for instruction was .77. Students therefore spent roughly 30% *more* time reviewing performance than would be expected given the amount of performance content in the video, whereas they spent about 20% *less* time reviewing instruction than would be expected given the amount of instruction content in the video.

ReView Media Player Features

Usefulness Ratings. At the end of the experimental session, each of the twenty participants (twelve from the ensemble condition, and eight from the individual condition) rated the usefulness of each of the ten features on a scale of one to seven (see Figure 2).

A linear mixed effects model analysis (Lindstrom & Bates, 1990) was performed on these usefulness ratings. Reviewing condition was included as a between subjects factor (individual versus ensemble reviewing). The feature variable was included as a within subjects factor (the ten features).

Overall, the students rated the features as being very useful. The average rating over all features was 5.835 out of a maximum of seven. There was a main effect of reviewing condition ($F(1,18)=9{,}08$ $p<0.01$). The students in the ensemble reviewing condition judged the features significantly more useful than the students in the individual reviewing condition. The average rating was 6.308 in the ensemble reviewing condition versus 5.125 in the individual reviewing condition. There was also a main effect of features ($F(9,162)=3.71$ $p<0.0005$) on the usefulness ratings. Some features were rated as being significantly more useful than others. There was no significant interaction between reviewing condition and media player features.

Feature Usage Frequencies. We recorded the frequency of use of each ReView feature in each of the eight individual and three ensemble reviewing sessions. A linear mixed effects model analysis (Lindstrom & Bates, 1990) was performed on the frequency of feature use. Reviewing condition was a between subjects factor (individual versus ensemble reviewing), and the feature variable was a within subjects factor (ten digital video player features plus the play and pause buttons, whose usefulness was not rated). Data from the eleven reviewing sessions were included in the analysis. The results show a main effect of media player features ($F(11,99)=4.08$

$p<0.0001$) on feature use. The most used feature by far was the playback head, followed by play, pause, and fast-forward. The skip and play forward button was used extensively by only one of the students, who alone accounted for over 83% of its use. Reviewing condition was not significant, nor was there any significant interaction.

Figure 2 presents the two sets of results. One curve shows the average usefulness ratings by features, while the other curve shows the usage frequency by features. It is clear that some features were judged quite valuable even though they were hardly ever used. This suggests that the usefulness of a feature is not dependent only on how frequently it was used.

Insert Figure 2

Discussion

The use of digital video to support music education is emerging as an important research area. Digital video affords ways of creating and interacting with video material not previously possible, such as easy to use technologies for creating and publishing videos over the Internet. Self-produced videos can play an important role not only in supporting learning by self-observation, but also in enhancing distance communication, collaboration, and teaching.

The current study can be placed in the context of student self-produced videos, and more specifically, students' technological and user interface needs in reviewing their videos. The first set of questions focused on the content type, performance or instruction, students preferred to review. Identifying important content is essential in determining some video content access requirements. The second set of questions addressed the usefulness of ReView's video browsing

features. In the remainder of the discussion, we present some conclusions from our experiment as well as some potential enhancements to the use of digital video for music instruction.

The content browsing analysis showed that the students spent a disproportionate amount of their time reviewing their performance, as opposed to reviewing video of the coach's instructions (e.g. the coach saying "slow the tempo when you get here, like this la de de de dum"). These results indicate that music students reviewing a coaching session in which they participated pay more attention to their own performance than to the interactions they had with a coach. This suggests they used the video to evaluate themselves, their performance, rather than to remind themselves of the coach's instructions. It is important to note that we did not give any instructions to encourage this self-evaluation behavior, and that a maximum of 48 hours elapsed between the coaching session and the video review session. It is possible that a longer delay would have led the students' memory of the instructions to fade, thus reducing the performance reviewing preference. Nonetheless, this performance preference is consistent with our informal observation of other coaching sessions. Generally, students seem to be quite adept at remembering instructions, and so do not feel the need to review them, preferring instead to review video of their own performance. Therefore, reviewing self-produced videos of coaching sessions could be an interesting activity to support performance self-evaluation.

In terms of the tools provided by a media player to browse content, our experiment shows there is value to our approach in that the students rated the features as being very useful, even though the features we specifically designed were used less often than more familiar video functions. It is possible that students did not have enough time to learn our features or adapt them to their existing methods of learning. Additionally, since we enhanced the sound-browsing functionality of the playback head, the playback head may have adequately met the student's

browsing needs. Finally, the features we designed may have been useful in fulfilling particular, but infrequent, reviewing goals. If so, this would explain why the features were highly rated, but infrequently used.

A review of the literature on music practice and learning supports the explanation of the features having value for infrequent tasks. The literature documents that musicians usually divide their piece into segments of various lengths and practice them separately (Gabrielsson, 2003; Hallam, 1997; Williamon, Valentine, & Valentine, 2002), sometimes repeatedly playing one segment over and over (Miklaszewski, 1995). In addition, the practice segment boundaries change over the course of practice (Gabrielsson, 2003; Hallam, 1997; Williamon & Valentine, 2002). Similarly, practice goals seem to evolve from mastering technically difficult parts of the piece to more interpretative aspects (Chafin & Imreh, 2001). To support these types of behavior in a video-reviewing context, we equipped ReView with features to easily manipulate video clips, such as the capability to select, define, bookmark, and loop video segments. While these functions may not have been used often, the literature and the students' ratings suggest that the functions are nonetheless useful.

While not a ReView feature, indexing might be a useful function. For example, an index discriminating between performance and instruction would allow students to satisfy their preference for self-evaluation. An index could further distinguish between performance sections on the bases of parts of the score or different techniques displayed in the video.

Memorizing music implicates visualization of the notes, and both aural and kinesthetic memory (Hallam, 1997). Of these, the video provides aural support only. Thus, students may wish to review video with their instruments and score handy to provide support for the other means of memorization. An ability to annotate the score may also be useful (Nielsen, 1999). If

the students have their hands on their instruments, or are annotating the score as they review the video, they will need to control the browsing features through some means other than a mouse. One possibility is to control the player by voice.

While the majority of students were satisfied with the perceptibility of detail in the videos, some students reported that the detail was insufficient to adequately see fingering. A few students requested a zoom feature to help them examine fingering, and, to a lesser extent, posture. To meet the need to see greater detail one could conceive of a system that shows a split three part screen showing a close-up of an individual performer (full body shot), his/her fingering, and the entire ensemble playing.

The frequent manipulation of the playback head suggests that there is an advantage to have videos stored locally (on the student's computer) rather than being streamed from a remote server. The reason is that streamed video is much less responsive to playback head manipulation.

In summary, the recent evolution of digital video technology has provided most everyone with the capability to produce and distribute video. As digital video becomes ubiquitous to communication, it will also become a key medium for instruction in many areas including music education. The current study can be placed in the context of student self-produced videos, and more specifically, students' technological and user interface needs in reviewing their videos. The ReView media player used in the experiment incorporated functions to support the use of video in the context of musical instrument practice. The results indicate that students seem to focus their video review on self-performance at the expense of instruction from the coach. This finding has pedagogical as well as technological implications. The results also indicate that in the context of recorded music coaching sessions, the capabilities of a simple media player may be

sufficient. However, our field-testing of the player has already led to suggestions for further enhancements to increase its effectiveness.

We intentionally designed ReView as a technological tool to support complex learning in ways that are closely related to the cognitive needs of the learner. As technological tools become more sophisticated, refined, and targeted they can push the boundaries imposed by general applications to more specifically meet the cognitive needs of individual learners in particular domains. There remains great potential to develop such customized technology to more effectively support music learning.

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Footnotes

[1] ReView can be downloaded free of charge for non-commercial use at https://iit-iti.nrc-cnrc.gc.ca/license/

[2]See http://www.nac-cna.ca/en/educationandoutreach/professionaltraining/youngartistsprogramme/index.html. (Be sure to remove the line break.)

[3]Note that these proportions may not add to one because some of the review session was spent simply talking and not actively viewing the video.

[4]We adopted 0.05 as the threshold level of significance for this study.

Figure Captions

Figure 1. The enhanced media player "ReView". The viewer window displays the video image. 2. The playback head can be clicked and dragged to navigate through the video. 3, 4, and 5. The navigation control panel. 3a. The skip-to-beginning button instantly sets the playback head to the beginning of the video. 3b. The skip-to-end button instantly sets the playback head to the end of the video. 4a. Rewind plays backward through the video, at 4x the normal speed, playing distorted sound. 4b. Fast Forward plays forward through the video, at 4x the normal speed, playing distorted sound. 5. SpeedPlay control drop down menu (options: slowest, slow, normal, fast, and fastest). 6. Video segment control panel. The ClipMark features allow users to save video clips and replay them later. When a video clip is played, the navigation features work in relation to that clip only. 6a. Clicking on the record button starts or stops the recording of a video clip. As the clip plays, it is saved. 6b. The clooping button allows users to loop video clips. 6c. Video segment selection drop down menu, which allows users to choose a named video clip to play. 7. The SkipNPlay features allow the user to quickly skip through the video forward or backward by increments of one, five, and 30 seconds, or, one and five minutes. 8. Volume control and mute.

Figure 2. Feature Average Usefulness Ratings and Frequency of Use. The figure shows the usefulness ratings for each player feature, averaged over all questionnaire respondents. The frequency of feature use, counted over all reviewing sessions, is also shown. Though the students rated all features as very useful, they only used the play, pause, and play head dragging features extensively. *SkipNPlay forward (snp-fw) was used mainly by one student.

Figure 1

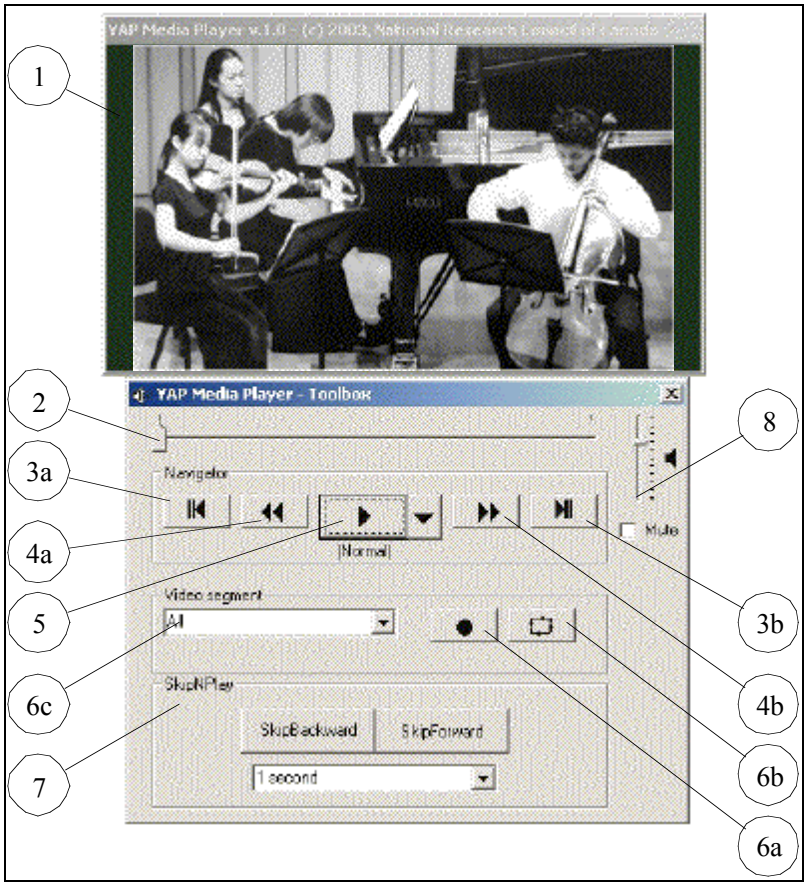
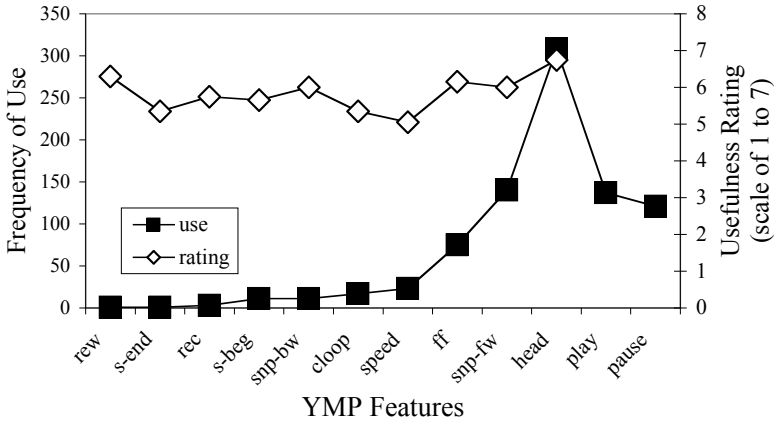

1
2
3a
4a
5
6c
7
8
3b
4b
6b
6a
YAP Media Player - Toolbox
Navigator
Normal
Mute
Video segment
All
SkipNPlay
SkipBackward
SkipForward
1 second

Figure 2



rew = rewind
rec = record (to record a clip)
snp-bw = SkipNPlay backward
speed = SpeedPlay
snp-fw = SkipNPlay forward
play = play

s-end = skip to end
s-beg = skip to beginning
cloop = clip looping
ff = fast forward
head = play head dragging
Pause = pause