The effects of musical tempo on time perception and memory

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ABSTRACT

The present study investigated the effects of musical tempo and music presence on duration estimations and content recall of a video advertisement. Thirty male and thirty female participants took part in this study. They were divided into 2 groups and a control group. The first group saw the advertisement with fast-tempo music, the second saw the same advertisement with slow-tempo music. The control group saw the advertisement in silence. According to previous research and theories it was hypothesised that music tempo would have an effect on duration estimations and content recall. It was also hypothesised that the presence of music (in contrast to its absence) would impede content recall. The findings revealed that participants in the high tempo condition gave shorter duration estimates than in other conditions. Participants in the slow tempo condition were found to have worse content recall than in other conditions. However, no significant effect of music presence was found on content recall in all conditions. The findings are discussed in terms of theories and past research and several methodological limitations are considered. Various implications of this study's findings are also discussed, and suggestions for future research are proposed.

KEY WORDS	MUSIC	TEMPO	TIME	PERCEPTION	MEMORY

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Introduction

It comes as no surprise that music plays an important role in our lives. Since ancient times people have created and enjoyed music. Nowadays music is widely used in and plays an important role in such areas as marketing, customer services, media, and advertising (Oakes & North, 2006). Research has shown that different characteristics of music, such as volume, timbre, genre and tempo, can have an effect on people's behaviour and perceptions. For example, Edworthy (2006) found that louder and faster music increased arousal during fitness exercises and increased performance. A study by Oakes & North (2006) found that when participants were presented with an advertisement accompanied by music with a more congruent timbre it increased the advertisement content recall. Oakes (2000) has suggested that in service environments certain genres of music may attract different types of customers, for example, classical music may attract more mature and sophisticated people, whilst contemporary music is more likely to attract younger people. In various settings, for example, in restaurants, musical tempo has been shown to affect how long the customers take to dine or even the speed of their conversations (Caldwell & Hibbert, 2002).

It has been found that music tempo can have an effect on several other factors, such as the person's arousal, endurance, attention, speed of decision-making, time-perception and memory. For instance, Waterhouse (2010) found that increasing musical tempo resulted in participants running longer distances on a treadmill, possibly due to increased arousal.Another study found that when slow-tempo music was in the background, participants spent more time shopping in a supermarket (Milliman, 1982).

Much of the previous research has focused on the musical tempo as a separate factor because it is a variable that is relatively easy to objectify and measure. Music tempo can be defined as the speed at which the musical passage progresses (Oakes & North, 2006). It is normally measured in beats per minute (BPM) using a metronome. It has been proposed that when tempo is less than 72bpm it is considered slow, whereastempo that is higher than 94bpm is considered fast (Milliman, 1982). In order to explain how music tempo can affect time perception and memory, researchers have adopted various theories, the most prevalent of which are discussed below.

Time perception theories and research

Human time perception and memory are known to be affected by various external factors, and there are several theories that attempt to explain how this might happen. The theory that has seen the most support from research is the storage-size memory model (Ornstein, 1969).It suggeststhat the amount of information that has been stored in memory during a particular time-slot or event can be used by people to estimate time duration. If the amount of information-processing is high during a particular event, the person should perceive that the event lasted longer, because

they have more bits of information to recall. On the contrary, if less information has been stored in memory during an event, duration estimates should be shorter. So, for example, if one person sees a 10 minute video clip, and another person waits in a quiet room for 10 minutes, the person who watches the video shouldoverestimate its duration, whereas the second person should underestimate the duration of their wait (because they have less information stored from it) (Wearden, 2008). Oakes (2003) has proposed that when people are exposed to higher musical tempo, it results in a higher information load on memory because people are exposed to more bars of music in a specific period of time. This in turn causes the duration of a particular event to seem longer, because more memory space is allocated to the increased data-processing. This suggests that higher tempo should produce longer duration estimates.

On the other hand, the cognitive-time model proposed by Frankenhauser (1959), suggests that increased information processing results in the distraction of the internal cognitive timer.When participants are engaged in an activity, cognitive resources are allocated to activity-related information. As the information load increases, the internal cognitive timer becomes correspondingly more distracted and less able to keep up with the time (Sucala, 2010). This results in shorter perceived durations. From this perspective, faster temposhould result in shorter duration estimates, as it would distract the internal timer-keeper. Some researchers propose that perhaps this model is better able to explain findings in studies which adopted a prospective paradigm as opposed to a retrospective one (Hicks et al, 1977; Sucala, 2010).However this has not been widely researched (Block, Hancock & Zakay, 2010).

More recently, another theory that has been applied to an understanding of how time perception may be affected by other extraneous factors is the levels-processing theory proposed by Craik & Lockhart (1972). According to this theory, when people process information on a deeper level, they tend to remember it better than when they process it on a shallower level. It has been suggested that deeper processing results in more information-processing which in turn causes shorter duration estimates. Indeed, one study found that participants gave shorter duration estimates of events which involved deeper information-processing (Wearden, 2011). However, how musical tempo may affect time perception or memory has not yet been considered in terms of this theory, and not much research has been carried to test the theory's relation to time perception in general.

It is important to point out that there are several methodological differences between various studies that have investigated time perception: different methods produced varying results. The first difference is in the procedure of the experiments. Studies that adopt prospective timing methodsare those that involve informing the participants that they will be asked to estimate the time before they begin participating in an experimental activity. In contrast, in retrospective timing experiments, participants are not informed about the requirement for time estimation, and are only asked to estimate time after an event (Block, 1990; Sucala, 2010). The other difference is in the task asked of the participants. Participants can either be asked to estimate the duration of a given event (duration judgements), or they can be asked to describe how fast the time went by for them during the event (passage-of-time judgements) (Block, 1990; Sucala, 2010). In order to assess duration judgements, researchers use such methods as verbal estimation or ask the participants to note how long the duration was, for example, in seconds or minutes.

To assess passage-of-time judgements, researchers ask participants to state the speed of time during an event, for example, ‘fast’ or ‘slow’ (Wearden, 2005).

A meta-analytic study by Block, Hancock & Zakay (2010) showed that in experiments using prospective timings, increased information-processing resulted in shorter duration estimates. However, in experiments with retrospective timings, increased processing load resulted in longer duration estimates. There could be various reasons for these differences. It has been suggested that in prospective timing conditions, when participants are told that they have to pay attention to the time, their internal timekeeper gets more distracted which makes participants underestimate time (Sucala, 2010). On the other hand in retrospective timing conditions, participants need to rely on their memory in order to infer the duration of an event. Thus, when participants remember more information from an event they tend to think it lasted longer than those events which contained less information. However, there were no studies in that meta-analysis that used music tempo as a variable which affected participants’ time perception (Block, Hancock & Zakay, 2010).

A somewhat limited amount of research has been conducted on the effects of music presenceor musictempo on time perception, and studies show varying results. For example, Gueguen & Jacob (2002) found that when people heard music in an on-hold telephone situation, they tended to underestimate the duration of their wait, while those who waited without hearing music tended to overestimate it. Bailey et al. (2006) found that participants who heard familiar music underestimated the elapsed time compared to those who heard unfamiliar music.

Another study investigating music in a casino setting showed that when music was present, participants gave longer time estimates (Noseworthy & Finlay, 2009). This study also found that participants underestimated the duration when the music tempo was fast, and overestimated the duration when it was slow, which gives support to Ornstein’s (1969) model.They concluded that the presence of music resulted in more accurate time estimations, however varying its speed can impact on duration estimates.

North, Hargreaves & Heath (1998) played either slow or fast tempo music during a gym session and then asked participants what the time was. They found that tempo did not influence time perception in any particular direction. However, participants who heard fast music were more accurate at estimating the time than those who listened to slow music. These results could have occurred because slow tempo music was perceived as incongruent in the gym setting, and so distorted participants’ time perception (North, Hargreaves & Heath, 1998).

Other studies have found that fast tempo leads to overestimates of time. For example, in a study by Oakes (2003), it was found that when participants waited in a queue for approximately 10 minutes and slow music was played in the background, they underestimated the duration of the wait, while in the fast or no music conditions they overestimated the time. The findings in that study support the storage-size memory model.

Music tempo and memory

Some research has focused on how musical tempo affects memory for a particular stimulus when it is paired with the music. Interestingly, some researchers have used the storage-size memory model to explain how content recall might be affected by

musical tempo (Oakes & North, 2006). According to the model, the increase in information load results in more processing load requirements for participants. Thus, increasing musical tempo should impede content recall, because participants will have less processing resources to allocate to other cognitive tasks such as memorising the information.

Research has, however, produced conflicting findings in this area as well. Some researchhas found that altering musical tempo during word learning tasks reduces the accuracy of subsequent recall of the words (Balch & Lewis, 1996). One study involving the recall of information from various radio advertisements, found no significant effects of different musical tempi on participants' memory (Brooker & Wheatley, 1994).Hang & Hwang (1999) investigated the effect of music tempo and familiarity on the accuracy of message acquisition. They showed participants identical video advertisements but with different sound tracks (some had slow-tempo music; some had fast-tempo music). They found that when participants heard familiar music, they were more likely to be able to recall the message that they heardin the advertisement when the music was slow-paced rather than when it was fast-paced. However, when the effect of tempo on memory was analysed overall, no significant differences between familiar and unfamiliar conditions were found. This suggests that when people are more familiar with the music, its tempo may have an effect on the ability to retain information (Hang & Hwang, 1999). Other studies measured the effect of tempo as a sole variable and found that participants less accurately recalled information in conditions where fast tempo music was accompanying the stimulus, than in the slow tempo conditions, supporting the storage-size memory model theory (Wakshlag et al., 1982; Oakes & North, 2006).

Whether the presence of music in general has an impact on memory has also been investigated in the past. Although Hoyer, Srivastava & Jacoby (1984) did find that when the music was present it seemed to facilitate comprehension and recall of different advertisements, the researchers did not keep other musical characteristics constant, or took into account that advertisements with particular types of music may deliberately be made simple to comprehend. A number of previous studies, on the other hand, have suggested that the presence of music impedes content recall (Kellaris et al., 1993, Gorn et al., 1991; Furnham & Bradley, 1997)

North & Oakes (2006) investigated the effect of musical tempo on both time perception and memory. They created 3 identical 40-second long radio advertisements (audio only) and paired them with either fast tempo music (170 BPM), slow tempo music (90 BPM), or no music at all. The advertisements contained a message about the product and an offer associated with it. The participants were first asked to listen to the radio ads and then to estimate how long the ads lasted, and also to recall some information from them. When the results from the three conditions were compared, it was found that tempo did not produce a significant effect on the estimations of the ad duration. However, the researchers did find that in the fast tempo condition, participants were able to recall less information than in the other conditions. They also found that participants who heard the ads accompanied by music tended to on average have worse recall than those who heard the ads without music. These findings were not consistent with the storage-size memory model's (Ornstein, 1969) explanation of time perception, however, they did support the model's explanation for the effects of music tempo on memory. Furthermore, Oakes & North (2006) argued that advertisements which contain music require more auditory data processing than advertisements without music. Therefore, because listening to music required more cognitive resources to be allocated to process it, it

potentially distracted the people from paying full attention to radio advertisements, which impeded their recall.

Oakes & North's (2006) experiment had some important limitations. For example, one of the reasons why they did not find any significant differences in duration estimations was possibly due to the fact that they used marketing students as participants. It is likely that marketing students were aware that the average duration of a TV or a radio advertisement is approximately 40 seconds long. This might have encouraged them to simply choose that duration, instead of having to rely on their memory to estimate the length of the advertisement. Another limitation comes from the unusually high tempo (170BPM) that they have used in the fast tempo condition. According to Kellaris& Rice (1993) most music used for marketing purposes (e.g. advertisements) is between 60BPM and 120BPM. It can be arguable that the tempo as high as 170BPM might have been highly incongruent with the advertisement used by Oakes & North (2006), which might have caused poorer content recall.

The present study is based on the Oakes & North (2006) experiment however, instead of the auditory stimulus (i.e. a radio advertisement), a visual stimulus (i.e. a TV advertisement) was used. Given that since the new millennium video advertising has been made increased use of in marketing and media, it was of interest to see whether different music tempi would have an effect on the duration estimation and content recall of the visual stimulus.

From this review of the literature it is clear that studies investigating the effects of musical tempo on both time perception (or duration estimation of the events) and content recall, have produced conflicting results. Some studies have found a positive relationship between tempo and duration estimation, whilst others have found a negative or non-existent relationship. Furthermore, very little research has employed video clips as stimuli that were paired with music (fast or slow), but rather has used audio clips, word lists or simply required participants to wait. The majority of the studies that have investigated the effects of music tempo on time perception, involved events or stimuli which lasted, on average, around 8-10 minutes. It was of interest to see what effects musical tempo would have on duration estimation of a much shorter stimulus. With respect to the effect of music presence on information recall, a number of studies have shown that music presence does lower recall accuracy. Drawing on these findings, the following hypotheses were devised to be tested in the present study:

Hypothesis 1: There will be a difference in length duration estimates given by participants exposed to fast tempo music, compared to those exposed to slow tempo music.

Hypothesis 2: There will be a difference in the amount of content recalled by participants exposed to fast tempo music, compared to those exposed to slow tempo music.

Hypothesis 3: Participants who see a video clip accompanied by music will be able to recall less information compared to participants who see the video clip in silence.

Method

Design

This study employed a between subjects design. There were 3 conditions in this study. The participants in the first condition were shown the video with fast tempo music, the participants in the second condition were shown the same video with slow-tempo music, and in the control condition ('no music' condition) the same video was presented but with no sound.There were two independent variables in this study – one was the musical tempo, and the other was the presence of music (or its absence). The dependent variables were the participants' time estimation of the video, the number of video scenes correctly recalled, whether the brand advertised was correctly recalled and whether the slogan associated with the brand was correctly recalled. Participants were also asked to state whether they had heard the music in the video before and how much they liked it (only in the conditions where music was present), and whether they have seen and how much they liked the video (in all conditions).

Participants

There were 60 participants (30 males; 30 females) who took part in this study. They were mostly students (studying various degrees) and staff members at the University of Buckingham. The mean age of the participants was 26.1 (*SD*= 9.21). They were recruited via opportunity sampling.There were 20 participants (10 males and 10 females) in each of the 3 conditions.

Materials

The present study used a 60-second long video clip. The video was an advertisement for Chivas Regal whiskey, which was published in 2008. It was made up of separate 11 scenes plus a picture of the brand, its name and the brand slogan (both in writing) at the end. The scenes were all different in context, and featured different people engaging in various activities (e.g. playing sports, skydiving or horse-riding) (see Appendix 1 for the description of all scenes).

The original audio track which accompanied the video was removed and replaced with different audio tracks by the researcher. A 60-second long section from the song 'Sky and Sand' by Paul Kalkbrenner, which was measured to be 127 beats per minute (BPM), was used to accompany the video clip in the fast-tempo condition. In the slow tempo condition the same video clip was accompanied by a 60-second long section from the song called 'They Move on Tracks of Never-Ending Light' by the artist This Will Destroy You. This song was 60 BPM (almost half as much as the fast tempo song). The clip played in the control condition contained only the original video with no sound. Both of the songs used were purely instrumental and had no vocals, in order to avoid the possibility of the participants getting distracted by the lyrics. Although the song in the fast-tempo condition primarily featured electronic keyboard and the song in the slow-tempo condition featured electric guitar, they were both chosen for their repetitive rhythmic patterns.

The video was shown to the participants on a Sony Vaio VPCF1 personal portable computer and was played using the VLC media player program. In the conditions where music was present, the participants were asked to wear high-quality Sennheiser HD501 headphones. The volume of the music was always kept constant at 75% volume level.

A self-report questionnaire was used to collect data in this study. It consisted of 2 parts and 8 questions in total (6 in the 'no music' condition). The first part consisted of 5 questions. The first question asked participants to estimate how long they thought the video clip was by circling an appropriate number from a table consisting of 20 to 159 seconds. The second question asked participants to state whether they have seen the video before, while the third asked them how much they liked the video. The fourth question asked whether the participants ever heard the music and fifth asked whether they liked it. To indicate exactly how much they liked the video or the music, they had to rate it on a scale of 1 to 10 (1 being 'not at all' and 10 - 'very much'). The questions about music were of course not present in the conditions were the participants watched the video in silence. The sixth question asked the participants to recall as many scenes as possible from the video by listing them in any order. In the seventh question participants had to state what the brand name was, if they remembered, while the last question asked them to state what the brand slogan was. Blank versions of both types of questionnaires are available in Appendices 2 and 3.

Procedure

Participants were approached and asked whether they wished to participate in an undergraduate psychology study. They were told that they would be shown a relatively short video clip, and then they would be asked several questions about the video. They were sat down at a table in a quiet area (library or a private room). Before the experiment began they were asked to fill out a consent form and indicate their age and gender. When the consent form was completed a portable personal computer was placed in front of the participant and they were asked to wear headphones. The participants were asked to pay attention and when they were ready to begin, the video was played. When the video clip was over the participants were asked to take off the headphones and they were given the first part of the questionnaire containing the first 5 questions (3 questions in the 'no music' condition). After they completed the first part they were then given the final part of the questionnaire which included the content recall question. The sixth question did not require the participants to describe the scenes in detail, however if they made a clear indication to which scene they were referring to, it was counted as an accurate recall (e.g. if a participant wrote 'skydivers', it was clear that they were referring to the scene which showed skydivers jumping out of the plane).

Ethical Considerations

There were no ethical implications to be considered in this study. However, before participants took part, they were asked to sign a consent form (see Appendix 4 for the original). Participants were told that their data would be treated with confidentiality and that they could withdraw from the study at any time. After the participants completed the questionnaire they were thanked for taking part and were debriefed about the study. If they wished to find out more about the study or the results they were given the researcher's contact details.

Results

The results from 6 participants were excluded from this study: 1 had failed to indicate their perceived duration of the video clip; 3 selected either 40 second or 60 seconds, but verbally stated that they did so because they assumed that these are the normal length of advertisements; the final 2 got distracted by their mobile phones while watching the video clip.Noneof the participants reported seeing the video clip before. Four participants reported hearing the fast tempo song (Sky and Sand). However, there were no significant differences between their results and those of other participants. Figure 1 represents a comparison of mean duration estimations in the three conditions.

Participants on average tended to underestimate the duration of the video clip (M = 51.1, SD = 17.79). However, in the fast tempo condition the participants gave the lowest duration estimates (M = 39.0, SD = 9.76). Duration underestimation was lower in the 'no music' condition (M = 56.3, SD = 15.96), and the most accurate (highest) duration estimates were in the 'slow tempo' condition (M = 58.2, SD = 19.95). A One-way ANOVA test showed that there was a statistically significant difference between the conditions -$F(2,57) = 8.93$, $p < 0.001$. The Tukey HSD post-hoc test showed that video clip duration estimation was significantly shorter in the 'fast tempo' condition than in 'slow tempo' ($p = 0.003$) and in 'no music' ($p = 0.001$) conditions. There were no significant differences found between the 'slow tempo' and 'no music' conditions. Figure 2 shows the comparison of the average number of scenes recalled by participants in the three conditions.

The participants on average recalled approximately 5 out of 11 scenes from the video clip (M = 4.8, SD = 1.55). The least recall occurred in the 'slow tempo' condition (M = 4.2, SD = 1.14). In the 'no music' condition, participants were able to recall 5/10 words (M = 5.1, SD = 1.67), while the scene recall was the highest in the 'fast tempo' condition (M = 5.3, SD = 1.625). A One-way ANOVA test revealed that there were significant differences between the conditions - $F(2,57) = 3.27$, $p = 0.045$. The Tukey HSD post-hoc test showed that more scenes were correctly recalled in the 'fast tempo' condition compared to the 'slow tempo' condition ($p = 0.047$). However, there were no significant differences between the 'no music' and 'fast tempo' conditions, and between the 'no music' and 'slow tempo' conditions.

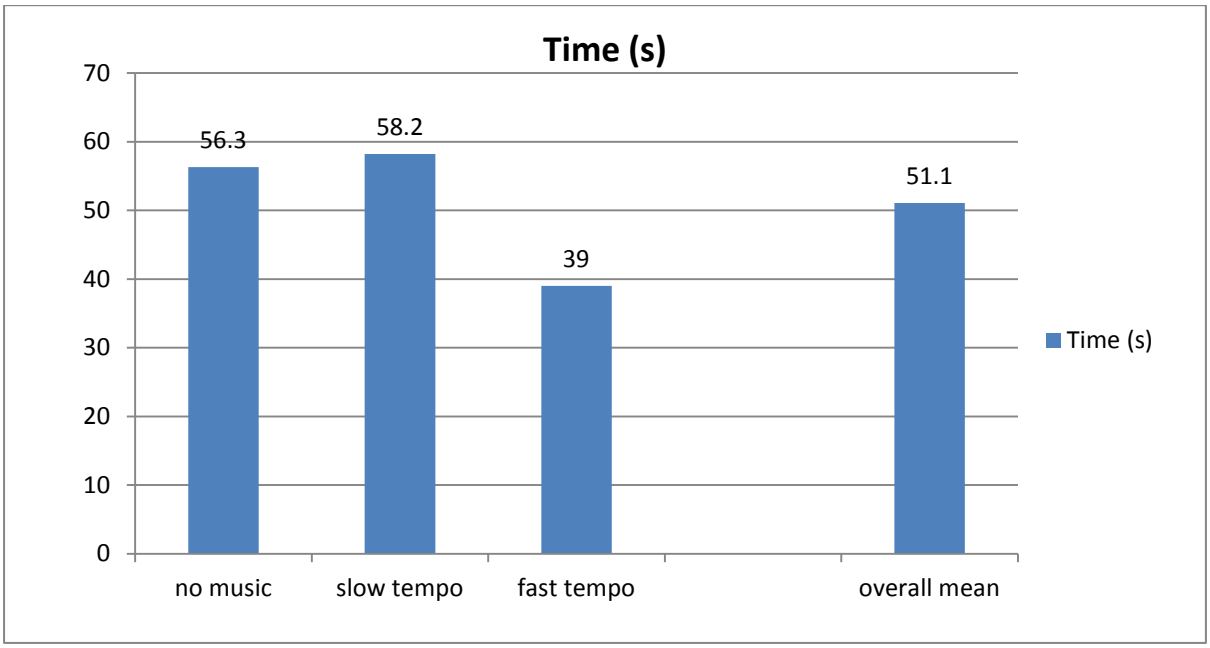

Figure 1. Mean duration estimations given by the participants in the three conditions

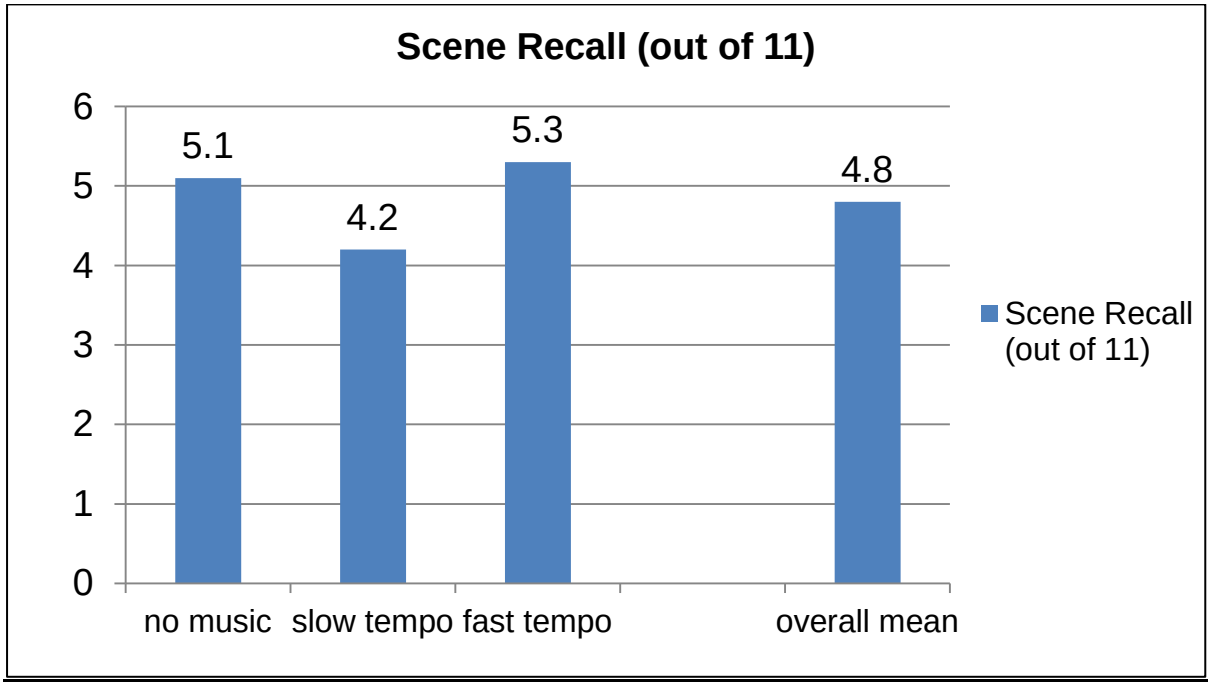

Figure 2. Mean number of scenes correctly recalled by the participants in the three conditions

Participants on average recalled less scenes in the condition where the music accompanied the video clip (*M* = 4.7, *SD* = 1.50) than when they saw the video clip in silence (*M* = 5.1, *SD* = 1.67). However, an independent-samples t-test showed that there were no significant differences between these 2 conditions –t(58) = 0.761, *p*= 0.45.

In terms of being able to remember the brand name (Chivas), 58% (35/60) participants remembered it accurately. A One-way ANOVA showed that there were no significant differences between all conditions – $F(2,57) = 0.07$, $p = 0.94$. The slogan of the brand seemed to be particularly hard for participants to remember as only 13% (8/60) of them were able to recall it. A One-way ANOVA again showed that there were no significant differences in slogan recall between all conditions – $F(2,57) = 0.14$, $p = 0.87$.

Participants who heard fast tempo music reported liking the video clip the most ($M = 6.4$, $SD = 1.96$), liking was less in the 'slow tempo' condition ($M = 6.3$, $SD = 1.78$), while those who saw the video clip in the 'no music' condition reported liking the video the least ($M = 5.8$, $SD = 2.17$). However, a One-Way ANOVA revealed no significant differences between the conditions – $F(2,57) = 0.50$, $p = 0.61$.

Participants liked fast tempo music the most ($M = 7.3$, $SD = 2.25$) and slow tempo music slightly less ($M = 6.2$, $SD = 1.82$), although an independent-samples t-test showed that the difference was not statistically significant – $t(38) = -1.62$, $p = 0.11$. Table 1 shows a more detailed account of the secondary results of the study.

Table 1.

The number of participants correctly recalling the brand and the slogan, and the average ratings of the video and the music

	Brand name recall	Slogan recall	Video rating (out of 10)	Music rating (out of 10)
Slow tempo	11/20 (55%)	3/20 (15%)	6.25	6.20
Fast tempo	12/20 (60%	2/20 (10%)	6.40	7.25
No music	12/20 (60%)	2/20 (10%)	5.80	N/A
Average	35/60 (58%)	7/60 (12%)	6.15	6.73

In order to assess whether music-liking had an impact on duration estimations or content recall a One-way ANCOVA was carried out. The test showed that there was no significant effect of music-liking on video duration estimations ($F(2,36) < 0.001$, $p = 0.98$) or on content recall ($F(2,36) = 1.31$, $p = 0.26$).

Discussion

The statistical analysis of the date showed that two out of three hypotheses of this study were supported. Participants who listened to fast tempo music while watching the video clip perceived its duration to be substantially shorter than those who saw the clip in silence, or those who listened to slow tempo music. Therefore, the first hypothesis that there will be a difference in length duration estimates given by the participants exposed to the fast tempo music, compared to those exposed to the slow tempo music is supported. These findings suggest that tempo indeed affects people's time perception, especially the event duration estimates. More importantly

there seems to be a negative relationship between the pace of tempo and duration estimates and similar effects were found by Noseworthy & Finlay (2009).

In terms of being able to recall the scenes from the video, participants who were exposed to the slow tempo music seemed to remember slightly less than in the other conditions. Although there were no differences between the participants' recall in the 'fast tempo' and 'no music' conditions, the second hypothesis that there will be a difference in the amount of content recalled by the participants exposed to the fast tempo music, compared to those exposed to the slow tempo music is supported. This shows that musical tempo has an effect on memory and that there is a positive relationship between the pace of the tempo and the ability to recall content, although most previous research found opposing results (Wakshlag et al., 1982; Oakes & North, 2006).

When the results of the scene recall in the two conditions where music was present were combined to compare with the recall in the control (no music) condition, no significant difference was found. Thus, the third hypothesis that the participants who saw the video clip accompanied by music will be able to recall less information compared to the participants who heard the video clip in silence is not supported. These results suggest that even though memory may be affected by the speed of the musical tempo, in this case (contrary to previous findings (Kellaris et al., 1993; Furnham & Bradley, 1997)), the presence of music did not impact memory any more or less than its absence.

The results of this study do not replicate the most common findings reported in the past (Kellaris et al., 1993; Hahn & Hwang, 1999; Oakes, 2003; Oakes & North 2006). However, most previous research has been conducted using designs where music was presented with stimuli other than videos, or stimuli that were much longer than 1 minute in duration. For example, in the study conducted by Wearden (2005), a 10 minute video clip/ waiting period were used. Furthermore, in that study, the participants were only asked to estimate the duration of the video/wait after a certain amount of time, rather than straight away. Oakes & North (2006) used a radio advertisement rather than a video, which means that when participants heard the radio message it might have been distorted by the music played at the same time. This could have made it hard for them to clearly comprehend the advertisement, thus resulting in poorer recall compared to when the radio ad was presented alone. Moreover, Oakes & North (2006) used two identical songs differing only in their tempi. However, in their study, the faster version was 170BPM which is very rarely used in advertisements or media in general. In an attempt to create a more life-like experience, the present study used two different songs and with much slower tempi than in the other study.Nevertheless, although both songs were entirely instrumental and featured repetitive rhythmical patterns, the fact that they were of different genres might have had an impact on the results (Oakes, 2000). Another study compared how music tempo would affect content recall from video advertisements (Hahn & Hwang, 1999). However, the information which had to be recalled was presented verbally in the video rather than visually, which is again different to the current study where there was no verbal information. More importantly, Hahn & Hwang (1999) only found that higher tempo led to diminished recall when the participants were exposed to familiar music. In contrast, only 4 participants in this experiment recognised the fast tempo song and that did not produce any significant differences. Differences such as these may explain why in the current study similar results were not obtained.

It is evident that the results from this study do not support the storage-size memory model (Ornstein, 1969), which suggests that higher memory load would result in longer duration estimates. Nor do the results support the theory in terms of its suggestion that increased processing requirements caused by faster tempi would reduce content recall (Oakes & North, 2006). Interestingly, in the current study, the faster musical tempo resulted in shorter duration estimates but higher content recall, and vice versa in the slow tempo condition. There could be various explanations for this.

As mentioned in the introduction, the levels-of-processing theory has been used to explain how more information processing results in shorter duration estimates. However, the theory cannot be applied to the effect of musical tempo on time perception in this study because participants were not tasked with paying attention to the music, but rather to the video. In other words the faster tempo music cannot be considered as being any more deeply processed than the slower tempo music.

The theory that is, however, supported by the results, at least in terms of time perception, is the cognitive-timer model proposed by Frankenhauser (1959). Although it is has been proposed that this model is most useful in explaining findings from experiments involving prospective methods, this has not been conclusively ascertained (Block, Hancock & Zakay, 2010). Therefore, it is possible that the internal timekeeper may be affected in retrospective conditions as well.

According to this model increased information processing brought about by high tempo should distract the internal timer more than slower tempo. In this study, given that the tempo in the fast condition was very high, there was a need for participants to allocate more cognitive resources to keep up with the internal timer. However, at the same time participants had to concentrate on the video which was their original task. Given that paying attention to the video would be perceived by the participants as a requirement of the experiment, it can be assumed that participants allocated most of their cognitive resources towards processing (and as a consequence, remembering) the information in the video, rather than attending to the high tempo music which would place increased demands on the cognitive internal timer. It could be suggested that participants became aware that high tempo music might distract them from the actual task, thus prompting them to allocate more cognitive resources towards focusing on the video. Moreover, combining the high information loads from processing high tempo music as well as the video should have placed an even higher demand on the internal timekeeper than in the other conditions, further compromising the duration estimates. This might explain why the participants in the fast tempo condition were better at remembering more scenes while also giving shorter duration estimates. On the other hand, participants in the 'slow tempo' condition should experience less distraction of the internal time keeper because processing slower music requires less cognitive resources. However, this means thatparticipants could pay attention to both the timer and the video, without needing to allocate most of their cognitive resources to the video. This might explain why they were better at estimating time (gave longer duration estimates) but remembered fewer scenes than the participants who heard the fast tempo music. Contrary to the conditions where the music was present, in the 'no music' condition, participants did not experience any distraction of the cognitive timer by the music. Therefore they could allocate their processing resources towards watching the video, which they were asked to do. This allowed them to remember more scenes from the video as well as being relatively more accurate at estimating time.

However, this reasoning does not explain why there were no differences in duration estimation between the ‘slow tempo’ and ‘no music’ conditions. It may be suggested that because the tempo of the music in the slow condition was 60BPM, when each beat is aligned with each second, it might have assisted participants' internal time keeper. That might be why the participants who heard the slow song were also good at estimating the duration of the video clip. Another reason for this could be that the slower music was more congruent with the video than the fast tempo music. According to North & Hargreaves (1998), more congruent music leads to more accurate time estimations than the incongruent music does. The song which was chosen by the marketers for the original advertisement had 74BPM - relatively close to the song used in the 'slow condition' (60BPM), which means that it might have been more congruent with the advertisement. Even though the results indicated that there were no differences in music liking between the two conditions, it may have been that the participants still found the slower song more congruent with the advertisement than the fast song. In order to address the issue of congruency more effectively, it may have been useful to ask the participants a question such as 'How well do you think the music fits with the advertisement?'.

It is important to consider that the present study had a number of important limitations which might have affected the results. First of all, there were two different songs of different genres used in this study. Even though, neither contained any lyrics, the slow-tempo song featured electric guitars while the fast-tempo song predominantly featured electronic sounds and a synthesizer. As discussed before, certain participants could have been more distracted by either type of music, depending on whether they found it pleasant or not. In addition, the fast-tempo song might have distracted the participants’ internal timekeeper more than slow music because they may have found it to be less congruent with the advertisement. This in turn could have resulted in shorter or less accurate duration estimations in the fast-tempo condition. At the same time, because faster music may have aroused the participants more than slower music, it could have increased their alertness and attention. This could explain why the participants in the fast-tempo condition tended to remember more scenes than those who heard slow-tempo music.

Another limitation comes from the relatively small sample size. Majority of the studies investigating the effects of music tempo on time perception or memory have used much larger sample sizes (Hahn & Hwang, 1999; Gueguen & Jacob, 2002; Oakes, 2003; Oakes & North, 2006). Using a larger sample may have resulted in significant differences between the ‘music present’ and the ‘no music’ conditions (hypothesis 3), particularly because the results (although non-significant) were in the predicted direction (i.e. participants recalled less when the music was present).

Those participants who heard fast tempo music seemed to give much shorter duration estimates than those in the other conditions. As discussed above, there could be various explanations for this. However, some of the participants in the ‘fast tempo’ condition may have simply selected 40 seconds as the duration of the advertisement clip, due to the assumption that most television advertisements are approximately 40 seconds (Oakes & North, 2006), thus giving lower duration estimation means for that condition.

The experiment required participants to pay attention to the video clip in order to appropriately answer the content recall question. However, some participants may

not have been paying full attention to the clip, for reasons other than being distracted by the music (e.g. being in a hurry). Being distracted might have caused the participants to not be able to intake as much information from the video, thus reducing scene recall and creating overall insignificant resultsbetween the 'no music' and 'music present conditions'. To support this argument, it may be useful to point out that on average the participants only recalled approximately5 out of 11 scenes. In addition, although the participants in the slow tempo condition remembered fewer scenes than in other conditions, the differences were barely significant. Neither were there any significant differences in brand or slogan recall across all conditions.

It may be argued that the advertisement used in this experiment was not directed at the general population but rather at young to middle age, sophisticated and risk taking males. Moreover, the scenes in the advertisement mainly featured predominantly male-related subjects such as rugby, fire-fighters and rowers. However, the results showed that there were no significant gender differencesfor any of the responses, including time perception, content recall or video-liking, suggesting that the advertisement did not appeal to males more than it did to females.

The outcomes of this study may prove useful in various fields including marketing and education. To start with, it was found that slower tempo music led to poorer content recall and longer duration estimates. If these results were found to be replicated in future research, it could be suggested that using slower tempo music in television advertisements may not be beneficial, as people will more likely get distracted by it and not retain much information about the advertised product. Furthermore, it has been argued that the shorter the perceived duration of an event, the more likely are the people to spend time attending to it (Gueguen & Jacob, 2002). Therefore, if it was confirmed that faster tempo does lead to shorter duration estimates (as well as higher recall) it might be more useful to use it, rather than slower tempo, to keep people's attention.

In educational settings, considering the findings of this research, listening to slower music while studying may be undesirable as it will most likely result in poorer recall of learned material. Additionally, past research has found that exposure to music generally reduced content recall (Kellaris et al., 1993; Oakes & North, 2006), which suggests that studying in silence may probably be the most efficient way to remember more information.

There are a number of research propositions which can be derived from the findings of this study.First of all, it is likely that using a larger sample size (e.g. 200 participants) would produce far more reliable and valid results. It may also be interesting to see whether music tempo would have a similar effect on duration estimation and recall of stimuli other than video, for example, still images. Furthermore, in order to reliably measure the effect of musical tempo on time perception and memory, it is necessary to control other musical variables such as genre and rhythm. Creating music that is identical in all aspects with the sole exception of tempo (as in Oakes & North, 2006), may indeed be more preferable.

In order to fully investigate the differences between various methods in time perception research, it may be useful to replicate this study using the prospective method, as well as retrospective. Letting the participants know that they will be asked to estimate time, may indeed produce different results. Giving participants different types of tasks may also be necessary to further explore the effects of music tempo on time perception. For example, asking one group of participants to estimate

the duration of the video, while asking another group to state how fast the time went while they watched the video. Previous research has shown that changing the task (duration judgments or passage-of-time judgments) may produce contrasting findings (Wearden, 2005). Due to lack of substantial research, it is important to carry out studies which compare duration judgments to passage-of-time judgments and prospective timings to retrospective timings, especially using musical tempo as an independent variable.

Much of previous research has used events or stimuli that lasted longer than 1 minute (usually 5 to 15 minutes), or asked the participants to estimate time after a short delay (e.g. after 5 minutes) (Gueguen & Jacob, 2002; Oakes, 2003; Wearden, 2005). Whether changing the length of the video clip, or waiting a certain period of time before asking the participants to estimate the video duration or recall information would produce any different findings, should also be investigated.

Finally, for the purposes of marketing research, it is interesting to find out whether showing participants advertisements with different musical tempi, would make the products seem more appealing. This could be achieved by asking participants how likely they are to purchase the advertised product.

The presented study aimed to investigate whether musical tempo or music presence would have an effect on time perception or memory. Contrary to the majority of the past research, it was found that faster musical tempo leads to shorter duration estimates and better content recall, than slower tempo. No effects of musical presence were found on duration estimations or content recall. Future studies should aim to keep all the musical variables, apart from tempo, constant; introduce other methods and tasks (e.g. prospective timings and passage-of-time estimates); use other stimuli other than videos. It is evident that more research is required in order to gain more knowledge and understanding of how music may affect time perception and memory.

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