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Exercise and Time Perception: An exploration of the impact of high intensity cardio exercise (Zumba) on human timing

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Abstract

Time is an important aspect of people's lives and how it is perceived has a great impact on how we function, which includes whether we engage in activities such as exercise that are beneficial for our health. These activities can also have impact on our experience of time. The current study aims to investigate human interval timing after completion of one of two tasks: listening to an audiobook, or engaging in a Zumba workout. Participants in this study completed two temporal bisection tasks (pre and post intervention). Bisection points (point of subjective equality) and Weber's ratios (sensitivity to time) were examined. It was hypothesised that individuals in the Zumba condition would experience a distortion in their timing post workout consistent with an increase in pacemaker speed. Unexpectedly there appeared to be no significant difference in bisection points across or within (pre/post) the conditions, suggesting that neither intervention had an impact on an internal pacemaker. However, there were significant differences in sensitivity to timing after Zumba Fitness suggesting a potential attentional focus post workout. Implications and future directions are also discussed.

Key Words

Time perception, Zumba Fitness, temporal bisection task, timing sensitivity

1. Introduction

We live in a world where time is one of the most basic and important components. Many stimuli have been linked to distortions in accuracy of timing and some specific features of stimuli have also been shown to impact on human time perception. For example brighter, louder, larger and more numerous stimuli are perceived as subjectively longer than stimuli of smaller magnitudes but equal length (Xuan, Zhang, He, & Chen, 2007), auditory stimuli appear to be judged as longer than visual stimuli (Jones & Wearden, 2003; Noulhiane, Pouthas, & Samson, 2009; Ogden & Jones, 2009), and research has also shown that emotional stimuli can impact our experience of duration. For example, angry faces appear to last longer than neutral ones (Droit-Volet, Brunot, & Niedenthal, 2004). Other research has suggested that stimuli can create a state change, which alter the way a person actually experiences time for some period after. For example, presentation of a series of "clicks" can cause an individual to overestimate a duration interval that follows (Jones, Allely, & Wearden, 2011) indicating a short lasting change in perception of the individual. Further research in the area of emotions and timing found that in order for emotional stimuli to impact on the timing of the individual, the individual needs to be able to imitate the emotion that they have seen (Effron, Niedenthal, Gil, and Droit-Volet, 2006) again indicating a short term change in the individual. These findings are generally explained through the well-established arousal mechanism, within the pacemaker style internal clock framework (Gibbon, Church & Meck, 1984).

Research has also suggested that engaging with certain activities such as mindfulness (Kramer et al., 2013) can lead to overestimation of duration. Kramer et al. (2013) compared the time estimations of individuals who had completed 10 minutes of guided mindfulness, with individuals who had passively listened to an audio recording of "The Hobbit". They found that individuals in the mindfulness condition overestimated duration more than those in the passive listening condition. Taken together these findings appear to suggest a dynamic relationship between our perception and our environment (Fayolle, Lamotte, Droit-Volet, & Gil, 2013) highlighting that the situations in which we find ourselves can have lingering effects on our timing.

A common environment where people report feeling a distorted experience of time is during exercise. People anecdotally report feeling that time is going very slowly when they are working out and fatigued, unless they have reached some type of flow state or can be successfully distracted from time. These passage of time judgements (Wearden, 2005) appear to be linked to the relevance of time to the situation, and can be explained using Zakay's Temporal Awareness Model (1992). However these types of timing judgements are notoriously difficult to systematically study as they are entirely subjective, and the language used to describe the passage of time can make it very hard to quantify responses in a meaningful way. For example, if an individual says that time feels as though it is passing very quickly it is difficult to know if this means they feel more, or less, time has passed in comparison to normal. Therefore rather than focus on the impact of exercise on passage of time judgements during exercise itself, it is beneficial to first investigate the impact of exercise on prospective timing judgments and the internal timing system of the individual, and to ascertain whether exercise causes a short term impact on subjective timing using a pre/post intervention task as per Kramer et al. (2013).

Many different exercise regimes have become popular over time. In recent years there has been a huge surge of interest in Zumba Fitness, a Latin-inspired, dance-fitness program created in the 1990s ("Zumba Classes - Dance fitness classes that are fun and effective.," n.d.). It incorporates Latin and international music and dance movements such as salsa, samba, merengue and hip hop that create a dynamic and effective fitness system. It is widely heralded as an enjoyable, engaging workout that can be completed by individuals with varying levels of fitness and as it doesn't involve the use of any specialised equipment, it is an ideal cardio exercise to study. There are two aspects of Zumba fitness which may cause the internal pacemaker to become aroused: use of music, and change in body temperature.

As with many workouts an integral aspect of Zumba is the music listened to during the workout. According to previous research, music captures attention, lifts spirits, triggers and alters thoughts and emotions, increases work output, heightens arousal and encourages rhythmic movements (Karageorghis, 2008; Lucaccini & Kreit, 1972; Terry & Karageorghis, 2011; as cited in Karageorghis & Priest, 2012). Research looking at the effect of music on exercise performance in obese children found that they ran better when they listened to music (De Bourdeaudhuij et al., 2002) and Potteiger, Schroeder, and Goff (2000) suggested that different kinds of music can act as an effective passive distractor during physical activity and can help reduce perceived exertion. A study conducted by Crust (2004) revealed that listening to music during muscular endurance trials led to participants enduring for significantly longer times. Listening to music during exercise is overwhelming believed to have positive effects. This may be because time appears to be underestimated when there is music leading individuals to spend longer engaging with their workout. For example, waiting time is considered much shorter when there is music playing in the background as compared to silence (Guéguen & Jacob, 2002) and especially when people enjoy the music they are listening to (Cameron, Baker, Peterson, & Braunsberger, 2003). This process appears straight forward. When listening to music, attention is diverted away from the processing of time, and fewer pulses are accumulated within the internal clock system causing duration to be underestimated (Zakay & Block, 1995). However what happens once the exercise and music has stopped and the attention is no longer oriented away from time? As mentioned above, music has been shown to increase arousal (Karageorghis & Priest, 2012). An increase in arousal has often been linked to an increase in the pacemaker of an internal clock system

(Gibbon et al., 1984). Therefore it would follow that an arousal state, induced by listening to music during exercise, would lead individuals to overestimate time once they have completed their exercise.

The second aspect of Zumba which may create short lasting arousal within the internal clock system is body temperature. During and after a workout body temperature is higher as some of the heat produced is stored, raising the core temperature of the body by a few degrees (Gleeson, 1998). Historically it was suggested that time estimates were directly dependent on internal body temperature. This was due to the belief that timing was based on some type bodily chemical reaction. It was reasoned that if some underlying chemical process provided 'pulses' with which to estimate time, then it would speed up when heated and slow down when cooled just like any other chemical process (Hoagland, 1933). Research in this area has been succinctly reviewed by Wearden and Penton-Voak (1995). Their meta-analysis highlighted that most participants tend to overestimate duration when their body temperatures are increased, and that participants underestimate duration when their body temperature is lowered. Although human timing is no longer thought to be connected to a chemical reaction within the body, Wearden and Penton-Voak explain that temperature appears to have an arousing effect on the pacemaker of the internal clock system. Therefore raising body temperature through Zumba Fitness should lead individuals to overestimate duration post workout.

The current study investigated the impact of Zumba fitness on perception of time through a temporal bisection task administered pre and post workout, a methodology based on Kramer et al. (2013). Participants completed a baseline bisection task then engaged with an intervention stage (Zumba Fitness or audiotape) for ten minutes. After this intervention they proceeded immediately to complete another bisection task. In line with the research presented above it is hypothesised that Zumba Fitness will lead to an increase in short term arousal in the pacemaker of the internal clock and that this will cause participants to overestimate time post workout.

2. Method

2.1.Participants

The study consisted of 60 participants (Mean age = 22.90, *SD* = 2.44, Age range = 19 to 31, 45 females, 15 males). 86.7% of the participants were university students and the remainder consisted of participants from various other occupations. Students from James Cook University (Singapore) who participated to fulfil their course requirements were awarded credit points. Their ethnic backgrounds were 56.7% Indian, 33.3% Chinese, 1.7% Malay, and 8.3% from other ethnic backgrounds.

2.2. Design

Participants were randomly assigned to one of the two conditions (between-subjects factor); the audio book condition (*n*=30) and the Zumba Fitness condition (*n*=30). They also completed temporal bisection tasks before and after the ten minute intervention tasks (within-subjects factor).

2.3.Materials

Participants signed an informed consent form and completed basic demographic information (age, gender, ethnicity, and occupation), and participant's assigned to the Zumba condition filled the Physical Activity Readiness Questionnaire (PAR-Q) (Canadian Society for Exercise Physiology, 2002) form. The PAR-Q form is an easy and convenient questionnaire designed for individuals to assess their physical ability before participating in any physical activity at that particular moment. It was utilised in this study to ascertain if participants were physically capable of taking part in the Zumba activity. It is applicable to individuals between the age range of 15 to 69 years old. The instructions in the PAR-Q form were modified to suit the study and type of activity.

2.3.1. Temporal bisection task

Participants were tested individually in a soundproofed cubicle in front of a computer that used E-prime software to present the stimuli. Participants used a set of Logitech H800 wireless headphones to listen and judge tones that were used in the experiment. The “S” and “L” keys on the computer’s keyboard were used to indicate “short and “long” responses respectively for the temporal bisection task (outlined in more detail in the procedure).

2.3.2. State Change Intervention

There were two 10 minute intervention tasks utilised. Each task was 10 minutes long. As per Kramer et al. (2013), an excerpt from the audiobook version of “The Hobbit” was used in the passive listening condition. Participants listened to Chapter 1:An Unexpected Party,Part 1, written by J. R. R. Tolkien and read by Peter Avastrat (2014). This was presented through E-Prime software. In the Zumba Fitness condition, participants worked-out to three Zumba Fitness songs (“Metala Sacala“ by El Chevo, “Drop it On Me” by Ricky martin and Daddy Yankee and “La La La” by Shakira) which were played through an iPhone connected to a portable speaker. The Zumba Fitness session was led by the researcher who is a qualified Zumba instructor.

2.4.Procedure

After receiving ethics approval participants were recruited through a mixture of convenience sampling, snowball sampling and chain sampling. Each participant regardless of condition was sent a message regarding time, venue and things to bring (which included shoes, comfortable clothing and a water bottle).

Upon arrival participants were randomly assigned to one of two conditions (audiotape or Zumba Fitness). All participants were given an information sheet and signed an informed consent form. Participants randomly assigned to the Zumba Fitness condition were asked to fill up a PAR-Q form in addition to the other forms. Those who were found by the PAR-Q to be unfit to participate in a physical activity at the particular moment were then assigned to the other condition. After completing the forms, the experimenter removed the forms and instructed them to put on their headphones and follow the instructions on the computer screen.

The baseline estimate of time perception was obtained for each participant via the first temporal bisection task. The temporal bisection task consisted of a training phase where participants listened to "short" (400ms) and "long" (1600ms) tones which were the reference stimuli. This was immediately followed by the testing phase where participants were introduced to probe durations (400, 600, 800, 1000, 1200, 1400 and 1600ms) which they compared to the two reference stimuli. They responded by pressing the "S" and "L" keys on the keyboard according to whether they thought the probe durations were more similar to the "short" or "long" durations which they previously learned. Eight blocks of seven trials (56 trials) were presented in random order with no accuracy feedback. The inter-trial interval was randomly chosen between 1 and 3 seconds.

Next the participants engaged in a 10 minute intervention according to the condition they were randomly assigned to. Participants in the audiobook condition listened to a 10 minute audio recording of "The Hobbit" (Avastrat, 2014) played through the E-prime software while participants in the Zumba Fitness condition were asked to come out of the room to do a 10 minute workout led by the experimenter who is a licensed Zumba Fitness instructor. The 10 minute activity in each condition was followed immediately by another round of the testing phase of temporal bisection task to see if there was a change in subjective timing. After completing the study, participants were thanked and given a debrief sheet.

After all data had been collected the bisection points and Weber ratios for the bisection task (pre and post intervention) were calculated using a pseudo-logistic model (Killeen et al., 1997) through GraphPad Prism. The bisection point is the point of subjective equality and represents the point at which participants were equally likely to respond “long” or “short” to a duration. The Weber ratio is based on the difference limen, divided by the bisection point. It represents variance and accuracy of responses, or the sensitivity of the participants to duration.

3. Results

3.1.Temporal Bisection and Subjective Timing

The bisection point (BP) was analysed as one measure of subjective timing. The proportion of long responses for each condition were plotted against the seven durations in the two bisection tasks before and after participating in the 10 minute activity. It was expected that an increase in arousal would lead to an overestimation of duration post intervention in the bisection task (Gil & Droit-Volet, 2011) and that this would be represented by a lower BP value.

A mixed between-within subject analysis of variance was performed to assess participants’ BP pre and post intervention for each. There was no significant interaction between condition and BP pre and post intervention, Wilks’ Lambda = .98, F (1, 58) = 1.36, p = .25. There was no main effect for BPs pre and post intervention, Wilks’ Lambda = .97, F (1, 58) = 1.55, p = .22, with neither of the conditions showing a significant change in BPs pre and post intervention. This indicates that there was no effect on the BPs after either two interventions.

3.2.Temporal Bisection and Sensitivity to Timing

Although BP is often the main variable investigated within bisection tasks, the Weber ratio (WR) was also calculated to explore the participants' sensitivity to time. According to Weber's law the size of the difference threshold should remain proportional to the original value of the stimulus (Namboodiri, Mihalas, & Hussain Shuler, 2014). A lower WR indicates that participants' temporal discrimination does not vary and therefore indicates a higher temporal sensitivity (Droit-Volet, Fayolle, & Gil, 2011).

A mixed between within subjects analysis was also conducted to assess the participants' WR pre and post intervention for each condition. There was no significant interaction between the conditions and WR pre and post intervention, Wilks' Lambda = .98, F (1, 58) = 1.45, p = .23. There was however a significant main effect for WR pre and post intervention, Wilks' Lambda = .94, F (1, 58) = 4.06, p = .05, showing a change in WR pre and post intervention within conditions. In order to examine this effect in more detail a paired sample T-Test was conducted for each condition. It was found that there was no significant change in WR in the audiotape condition pre (M=0.16, SD=0.12) and post intervention (M=0.14, SD=0.10), t (29) = .51, p = .614. However for the Zumba Fitness condition, there was a statistically significant change in WR pre (M=0.18, SD=14) and post intervention (M=13, SD=13), t (29) = 2.65, p = .01. This suggests that participants in the Zumba condition were more sensitive to time after Zumba than participants in the control conditions. The implications of this are discussed below.

4. Discussion

The present study is the first to explore links between Zumba Fitness and altered subjective timing. In terms of subjective timing, the current study showed that there was no change in the bisection points elicited before and after intervention. Although results in the audiobook condition are in line with Kramer et al. (2013) it was expected that there would be a decrease in the bisection point in the Zumba condition. This was expected as physical exercise in general has been shown to increase body temperature (Gleeson, 1998) and also to increase general arousal (Karageorghis & Priest, 2012). These stimuli have previously been shown to cause short term changes in the subjective timing of the individual, by impacting on the arousal sensitive pacemaker of an internal clock mechanism (Gibbon et al., 1984). It is worth noting that although Kramer et al., (2013) found a significant decrease in the bisection point in their study, they ruled out arousal as the cause of the decrease. They noted that the alteration in timing did not show the classic multiplicative effect expected with pacemaker speed effects. Therefore they interpreted their results within an attentional framework rather than arousal mechanism. They argue that mindfulness may help to increase focused attention and monitoring, and causes a short term change in timing ability. Although there was no change in the bisection point after Zumba in the current study, it is also possible that the attentional framework is responsible for the overall findings. This becomes clearer when looking at the significant impact of Zumba on sensitivity to timing.

Changes in timing sensitivity have been seen to be linked to allocation of attention (Mackintosh, 1974; as cited in Ferrara, Lejeune, & Wearden, 1997). As exhibited in previous research the processing of time demands a certain amount of sustained attention which requires upholding a significant amount of focus to the passage of time (Coull, 2004; Coull, Vidal, Nazarian, & Macar, 2004; Droit-Volet, Clément, & Fayol, 2008). Psychological resources are allocated when paying particular attention to an event so that the event is processed with precision (Kahneman, 1973). Therefore a higher sensitivity to time has previously been explained as an improved encoding of time as a result of adequate allocation of attention or working memory abilities to the timing task. (Delgado & Droit-Volet, 2007; Droit-Volet et al., 2008). As highlighted above, Kramer et al. (2013) explain their findings within the attentional framework claiming that mindfulness meditation led to improved attentional abilities (Brefczynski-Lewis, Lutz, Schaefer, Levinson, & Davidson, 2007), allowing for more available resources to be allocated during the proceeding timing task. Recent research by De Bruin, van der Zwan and Bogels (2016) has shown that physical exercise is as effective as mindfulness meditation in improving attention control. This suggests that the findings in the current study may also be linked to the attentional framework, with Zumba Fitness leading to greater attention control in the post test task. Indeed, previous research has highlighted that aerobic exercise can have a significant effect on attentional tasks in adults (Hawkins, Kramer and Capaldi, 1992). Research has shown a 50% reduction in disruptive behaviours in boys with behavioural problems such as ADHD on days that they were asked to jog as compared to days where there was no jogging activity with teachers reporting an improvement in attention span and impulse control (Gapin, Labban, & Etnier, 2011). This also highlights that there may be important implications of the current findings within the area of productivity.

There are of course some limitations in the current study which should be addressed in future research. Firstly it is not possible to know from the data collected if arousal had no impact on bisection point, or if there simply was no increase in arousal in participants post Zumba. A longer duration of Zumba Fitness should be considered in future studies in order to allow more time for body temperature and arousal to occur. Future research could also include the measurement of arousal, attention and body temperature levels in order to ensure that a state change has occurred. A Perceived Stress Scale (Cohen, Kamarck, & Mermelstein, 1983) and a Perceived Arousal Scale (Anderson, Deuser, & DeNeve, 1995) or Felt arousal Scale (Svebak & Murgatroyd, 1985) could be added to quantify the level of stress and arousal before and after Zumba Fitness to see if there were changes in arousal. Also, the study focused on the temporal judgements of participants *after* they had engaged with Zumba or the

Audiotape intervention. This is because its methodology was based on Kramer et al. (2013) and the state change research that has been of some focus in the literature. It would be beneficial to address the impact of this type of fitness activity on timing *during* exercise itself. Due to methodological constraints a between subject design was used, and although there was no significant difference in timing in the pre intervention task it is possible that individual differences may impact the outcomes of the study. For example future research may include information on participants' fitness level and experience.

In conclusion, the present findings highlight a short term effect of Zumba Fitness on timing sensitivity, but not on pacemaker speed. The increase in sensitivity to timing post Zumba Fitness adds to the burgeoning research claiming improvement of attentional focus post workout, although it remains to be seen whether this improved focus could generalise to other activities such as work responsibilities or other assignments.

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