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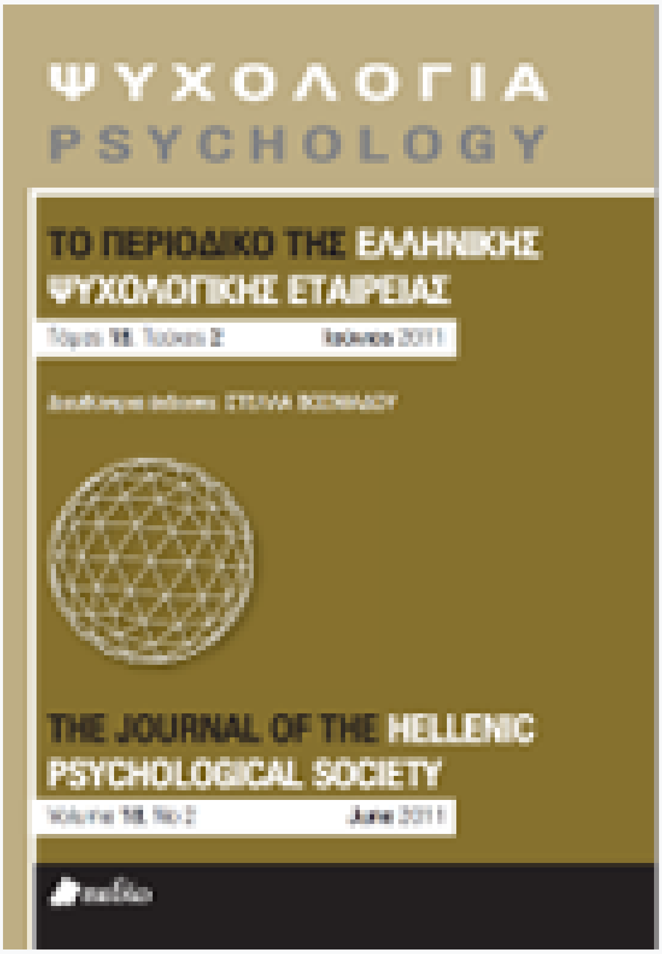

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Interactive relations among time, music and emotion

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ABSTRACT Research so far has shown that the emotional content of information affects time perception, through the mechanism of subjectivisation (i.e. shrinking or expanding temporal duration as a result of positive and negative emotional valence, respectively). Additionally, preliminary studies suggest that musically trained individuals compared to untrained ones tend to make more accurate duration judgements. Finally, it is known that music can induce specific moods; two of the main factors that determine the relationship between music and emotion are the structural features of the song and the features of the listener. However, it is not clear whether any interactive relations exist among these factors. In this study we attempted to address this particular gap in our current knowledge. As neuroscience studies show, when non musicians are listening to music there is activation of right cerebral areas while musicians show left hemispheric dominance. Right cerebral areas are related to the recognition and the expression of emotions and their activation suggests a cognitive processing based on the emotional valence of songs. Thus, it seems that musical training affects emotion (by inducing certain moods) that, consecutively, affects time estimation.

Key-Words: Time estimation, Music training, Music, Emotion.

1. Introduction

Various scientific approaches attempt to investigate the particularly complex concept of time. In common thought, time is usually associated with physics, which considers time as an objective magnitude that can be accurately measured with specific organs (i.e. clocks). Time is also studied by psychologists. In psychology, it is approached in relation to human cognitive behavior and refers to either temporal reasoning or the perception of the temporal duration of experienced events. Consequently, psychological (subjective) time can have longer or shorter

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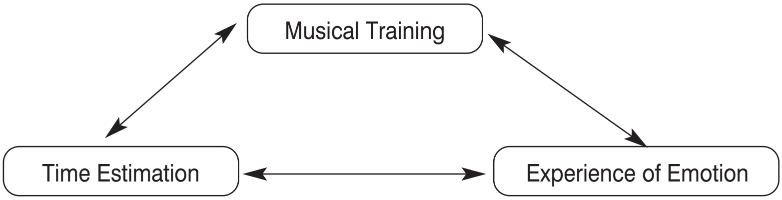

Figure 1
Relationships among time estimation, musical training and emotion

duration than objective time (Roeckelein, 2000), depending on a number of factors. A crucial factor affecting the perception and estimation of temporal duration is the emotional content of the information to be processed (Droit-Volet & Meck, 2007; Flaherty, 2001; Wittmann & van Wassenhove, 2009). In music, emotion is related to the mood of the individual, resulting, among others, from the emotional valence of the musical piece. On the other hand, many studies suggest that the subjectivisation of time is modulated by musical training (Bigand & Poulin-Charronnat, 2006; Repp, 2005; Repp & Doggett, 2007; Sevinç, 2007; Thompson, Schellenberg, & Husain, 2001).

Apart from the knowledge about dual relations between these parameters, an interesting question is to investigate and to describe the relationships which possibly exist among the three of them (Figure 1).

2. Psychological time

Psychological time theories stand between two extremes: the biological and the cognitive (Block, 1990). The biological models propose that psychological time is the product of brain mechanisms, which involve one or more internal clocks that allow the individual to measure and judge time duration. Cognitive models propose that psychological time is a product of information processing that involves memory and attention (Roeckelein, 2000). Other psychological models attempt to merge these extremes. One of the most prevalent models was developed by the philosopher Jean-Marie Guyau, who considered time as an acquired organization of mental representations which enable individuals to store and remember past events (Michon, 1992). As such, subjective time is the result of incoming information processing by the individual (Zakay, 1990) and of a long adaptation and evolutionary process to the environment and the social context (Michon, 1992; Roeckelein, 2000).

Psychological time consists of three major aspects: succession, duration and temporal perspective. Duration refers to the temporal length of events. As far as perception and estimation of duration are concerned, it should be noted that: First, an event can be successfully perceived by humans, if its duration is longer than a few milliseconds. Second, in order to perceive two events as being “different”, they must be separated by a temporal interval long enough (Block, 1990). If the interval is too short, the two events are perceived as a single “instantaneous” event. The lowest threshold that we can perceive depends on the sensory system involved. Visual stimuli must be longer than 110-130 ms and auditory 10-50 ms with a frequency of 500Hz (Fraisse, 1957). Furthermore, when the interval that separates the different stimuli exceeds 1.5 s (or 1500ms), listeners have difficulty in grouping the sounds, which seem disconnected from one another (Krumhansl, 1997). On the other hand, it is known that when estimating the duration of a previous task, people overestimate short durations and underestimate long ones (Vierordt's law, 1868). This hypothesis was recently tested by Roy (2008), by using time periods of 1 to 15 minutes and showing that intervals shorter than 2 minutes were mostly overestimated, while longer intervals lasting more than 3 minutes were underestimated. Similar results occur in time production tasks (Sternberg, Knoll, & Zukofsky, 1982). Furthermore, Vieordt's law seems to be supported by research performed by Campbell (1990) in time estimation of long events. However, the cut-off point between what is considered as "short" and "long" – and, therefore, between overestimation and underestimation – is estimated to be 2-10 minutes, it is not always consistent and depends on the task and the frame of reference (Roy, 2008; Yarmey, 2000).

A crucial factor that can significantly affect estimation of stimulus duration is the mood of the individual; It is a common belief that time flies during pleasant events, but drags when unpleasant events are experienced (Chambon, Gil, Niedenthal, & Droit-Volet, 2005; Droit-Volet & Meck, 2007). These experiences are confirmed by numerous studies. Stimuli or events that evoke positive feelings are underestimated, while stimuli or events that evoke negative feelings are overestimated (Droit-Volet & Meck, 2007; Flaherty, 2001; Wittmann & van Wassenhove, 2009). Other studies suggest that moods influence the processing capacity, leading to selectivity in attention, learning and recall of information (Gupta & Khosla, 2006). Hancock, Szalma & Oron-Gilad (2005) suggest that emotion affects time estimation, by influencing the organism's clock mechanism. Emotion provides information on the valence level of a stimulus, increasing the efficiency of the recognition mechanisms so that we can respond to possible threats faster. Campbell and Bryant (2007) studied novice skydivers and showed that increased excitement is associated with the perception of time passing quickly. Increased fear, anxiety, waiting or having high expectations are associated with the perception of time passing slowly (Campbell & Bryant, 2007; Friedman, 1990; de Wied, Tan & Frijda, 1992). Overestimation of time duration is also reported during brief, dangerous or possibly life threatening events, like car accidents, robberies or attacks (Eagleman Tse, Buonomano, Janssen, Nobre & Holcombe, 2005). Recent studies consider subjective time as composed of several subcomponents and the slowing of time that is reported, as a function of our recollection and not perception (Stetson, Fiesta & Eagleman, 2007). Moreover, we experience a longer duration while expecting an unpleasant event to occur and a shorter duration for a pleasant event, that is, we overestimate or underestimate the actual temporal interval, respectively (Geoffard & Luchini, 2007). Subjectivisation of time is also evident on the events that we experience when we watch a film (Samartzi, 2003; de Wied, Tan, & Frijda, 1992). Finally, temporal processing of auditory stimuli can also be affected by emotion: Negative sounds are judged as having longer duration than positive ones (Noulhiane, Mella, Samson, & Ragot, 2007). On the other hand, recent findings in text understanding suggest that the emotional valence of a text does not affect the reader's estimation of the duration of the described events (Samartzi & Kazi, submitted). The latter may be due to the fact that text, as it is different than image and sound, probably involving different mental processes in time estimation. Consequently, the findings concerning subjectivisation should be interpreted with caution, as they do not allow generalization.

3. Music and emotion

Music is an important non-verbal tool of emotion communication and expression. The recent advances in neuroimaging methods, which enable neuroscientists and psychologists to study the effects of music on the brain of healthy individuals and patients, have driven a new interest in research in the relationship between music perception and emotion. This particular relationship between music and emotion is one of the main reasons that music is so popular and prevalent in the human species. According to Sloboda (2005) we listen to music for two main reasons: to alter our mood from an unpleasant to a more pleasant one and to discover or make stronger our existent emotions. The ancient Greek philosopher Plato recommended to soldiers to listen to songs written in specifics modes and avoid others, in order to be stronger and well prepared for the battle. Aristotle (1984) supports in "Politics" that each mode represents certain human expressions and is capable of arousing appropriate emotions or moods in the listeners.

The relationship between music and emotion depends on four key factors (Scherer & Zentner, 2001): (a) *the structural features*; referring to the qualities of a song as specified by the composer such as the mode, the melody, the tempo, the rhythm, the harmonics and the pitch, (b) *the performance features*; referring to the way the piece is executed by the performer which depends on the performers' training and skill, (c) *the listener features*; consisting of musical expertise, including cultural expectations about musical meaning, and stable dispositions unrelated to music, such as personality or perceptual habits, and (d) *the contextual features*; referring to the listening situation (e.g., the event and the location).

Many studies have shown (Hunter, Schellenberg & Schimmack, 2008; Livingstone, Mühlberger, Brown, & Loch, 2007; Peretz, Gagnon & Bouchard, 1998; Smith & Noon, 1999) that the emotional valence of music depends on the mode (major or minor) and the tempo (slow or fast). *Mode* in music is a series of notes/sounds, which vary from scale to scale, and it's used by musicians as a guide to create and perform songs. The music notes of every scale are positioned in a specific order (i.e. the acoustic intervals between the music notes). The most widely used modes in European music are the Major and the Minor Modes. *Tempo* refers to the speed of the musical piece (i.e., beats per minute, bpm; Schellenberg, Peretz & Vieillard, 2007). Tempo guides the musician to play music notes faster or slower and it determines their absolute duration. The concept of tempo is closely related to rhythm (i.e., the way the music notes are organized in time). According to Moelants (2002) we tend to find a tempo pleasant when it's value is 90-120 bpm (the interval between two beats is 500 to 600 ms). In rhythm production tasks the same time interval (600 ms) has been identified between two values. The pattern of a 540 ms interval is also observed in "neutral" walking in humans (Palmer, 1997). One possible explanation of our tendency to prefer tempos from 90 to 120 bpm may be its similarity to the human heart's beating pattern (70–120 bpm) (Samartzi, 2003). Mode and tempo are then, crucial in the perception of the emotional content of music. Major mode and fast tempo define "happy" songs, while minor mode and slow tempo define "sad" songs. The importance of mode and tempo in the perception of emotion in music is shown by the interesting case study of I.R., who after sustaining brain damage was left severely impaired in processing music (Peretz et al., 1998). However, her ability to respond emotionally to music was remarkably spared. Peretz and her colleagues investigated the origin of this neuropsychological dissociation and concluded that I.R. could perform close to normal in tasks that the change affected the mode and the tempo of the excerpt.

Even though the importance of tempo and mode in the emotional appreciation of music has been established, it's not yet known which one is more important in perceiving emotion in music. In certain studies tempo seems to be salient in the judgment of a "happy" versus "sad" song (Gagnon & Peretz, 2003; Bachorik et al., 2009). Findings from other studies contradict this statement and suggest that mode affects mood, but tempo affects only arousal, since fast tempo can increase arousal levels (Husain, Thompson, & Schellenberg, 2002). Laukka & Gabrielsson (2000) showed that by modifying the tempo and sound volume level, musicians (i.e., drummers) can express different emotions (happiness, sadness, anger, fear) which are successfully recognized by most people. Music can elicit different physiological reactions depending on its emotional content. When we listen to a "sad" song, the heart rate decreases significantly more as compared to when we listen to a "happy" song.

Furthermore, listening to a "sad" song produces major changes in skin conductance, temperature and blood pressure, while "happy" songs affect mostly the measures of respiration (Krumhansl, 1997). Bartlett (1999) also indicates that heart and respiration rates generally increase when we listen to "happy" or "sad" excerpts. It is also suggested that coupling between internal biophysiological oscillators and external auditory rhythms may underlie the physiological emotion-inducing effects of music and could induce distinguishing patterns of physiological responses to "happy" and "sad" music, respectively (Khalfa, Roy, Rainville, Dalla Bella, & Peretz, 2008). Finally, Gomez & Danuser (2007) support that the physiological responses to music are strongly determined by changes in tempo, accentuation, and rhythmic articulation.

In the last decade many studies examined the perception of the emotional content in music by children and babies. It is shown that 6 to 8 years old children use the same properties as adults (i.e., tempo and mode) in determining whether music sounds "happy" or "sad", whereas from the age of 5 children use tempo as the sole determinant (Dalla Bella, Peretz, Rousseau, & Gosselin, 2001). Furthermore, 6-year old children are as capable as adults in interpreting emotions in instrumentally-presented melodies (Esposito & Serio, 2007). Other studies suggest that infants are born with the ability to perceive music and that they are neurologically mature to recognize and respond to elements particularly exploited in music in order to communicate with their mothers (Malloch, 1999).

As mentioned above, one of the main factors that define the relationship between music and emotion is the background of the listener. Musical training is crucial, because it affects the perception of emotion in music. Since prosody enables us to express emotion, the influence of musical training on decoding speech prosody was therefore examined (i.e., the musical aspects of speech including its melody-intonation- and its rhythm-stress and timing; Thompson et al., 2001). Results showed that adults without musical training are less capable of decoding emotions expressed through speech prosody than adults or even 7-year old children with only a few years of musical training. Even less experienced musicians could identify more accurately emotions conveyed through speech prosody compared to their peers without musical training. Frequent exposure to music, without the help of explicit training, can also affect our ability to perceive emotion. Bigand and Poulin-Charronnat (2006) showed that untrained listeners who are frequently exposed to music can respond to music as well as "musically experienced listeners" do. Experience with music, as well as memory seem to be amongst the main factors that influence our ability to estimate different emotions expressed through music (Slodoba, 2005).

4. Musical training and time estimation

Musical training does not only affects the perception of emotion in music but, as music is patterned and structured in time, it may also influence positively our abilities to estimate temporal duration (Repp, 2005; Repp & Doggett, 2007). In previous research musicians were found to be better at auditory and tactile time estimation tasks than non musicians (Servinç, 2007). Panagiotidi & Samartzi (2010) in a recent study investigated the ability of musicians and non musicians to estimate time using "happy" and "sad" pieces of classical music (Kreutz, Ott, Teichmann, Osawa, & Vaitl, 2008 support that instrumental and especially classical music is effective for the induction of basic emotions in listeners). The "happy" song (major mode and fast tempo) used was Mozart's "Eine kleine nachtmusik (1st mvt)", which is written in G Maj mode and its tempo is 154 bpm. The "sad" song (minor mode and slow tempo) was Albinoni's Adagio, written in G min mode and its tempo is 48 bpm. Both songs were previously used in other studies (Peretz et al., 1998; Schellenberg, Nakata, Hunter, & Tamoto, 2007; Thompson et al., 2001) and their capacity to evoke a sense of happiness or sadness, respectively, as well as to affect arousal levels of participants, was verified. Panagiotidi & Samartzi (2010) show that musical training affects significantly the estimation of time: Musicians estimate accurately the duration of the "happy" song, while non musicians underestimate it. Furthermore, a larger number of musicians seem to accurately estimate the "sad" song's duration compared to non musicians, who overestimate it. In addition, although musicians are not accurate in the estimating the duration of the "sad" song, they do not tend to overestimate it, as non musicians do.

According to Clark & Krumhansl (1990) the perception of time in music is extremely complex and probably the result of convergent information from different sources, with one or the other source dominating in different conditions. The perception of time in music can be partially the outcome of learning. In the case of musicians it indicates a top-down process (McGraw, 2008). In general, the perception of music is affected by the previous knowledge of the listener: well-learned schemas or acquired knowledge of tonal or metrical relationships. Schemas also influence the listener's expectations and aid memory (Palmer & Jungers, 2003). Other studies show significant improvements in relative timing (temporal continuity, underlying beat, metrical structure) as musicians practice and become more skilled (Drake & Palmer, 2000). The considerable difference between musicians' and non musicians' time estimation abilities become more evident in a number of studies that examine time estimation through time production tasks (Repp, 2005; Repp & Doggett, 2007; Snyder, Hannon, Large, & Christiansen, 2006).

As it is already mentioned, rhythm is one of the basic structural features of music. Vorberg and Hambuch (1978) suggest that music performed without accurate temporal control is considered deficient because it lacks the property of rhythm. Rhythm in music resembles a pattern of durations. The essence of rhythm in music is the coherence and the transformation of time relations. People with musical training constantly practise on tasks that are based on such relationships. Thus, it is possible for them to be more accurate in estimating time durations than people without musical training. Repp and Doggett (2007) showed that musicians are much better than non musicians in time production tasks. People with musical training were able to synchronise their taps with the required sequences, while those without training made many anticipation errors. Furthermore, the estimation of short time intervals and synchronisation is essential in performers who participate in choirs and orchestras (Repp, 2005). Another factor that differentiates musicians from non musicians is their familiarity with external organs of time estimation such as the metronome, which is an essential part of their training to playing to a particular tempo.

Humans are able to entrain their movements to an external timekeeper (i.e., a drum). This ability is an important condition for music and dance perception and production. Research on human motor timing has shown that, when structural information of music enter into the motor system, it evokes a temporal constructed behavior, probably by the activation of internal clocks or timekeepers mechanisms (Wallin, Merker, & Brown, 2000)."Internal clocks" are held responsible for behaviors like waiting, coordination of movements or other actions (i.e., the tapping of the foot or hand to a beat). Actions like accompaniment/chords are the product of the coordination of music perception and music production. The main role of internal timekeepers in music is the control and the coordination of complicated time sequences, like those between two music performers. According to Shaffer (1984), timing in musical performance is best modeled by assuming two levels of timekeeping, one pacing the meter and the other contained in the movement trajectories of note production, computed by motor procedure in relation to the meter.

The difference observed in behaviors between musicians and non musicians are reflected also in findings of modern neuroscience studies (for a review see Stewart, 2008). It is shown that brain structures like cerebellum and basal ganglia involved in motor timing (Rubia & Smith, 2004), time perception (Riesen & Schnider, 2001), temporal processing (Grahn & Brett, 2007; Harrington, Haaland & Hermanowicz, 1998; Wild-Wall, Willemssen, Falkenstein & Beste, 2008) and time estimation (Rao, Mayer & Harrington, 2001; Toplak & Tannock, 2005) are more developed in musicians than non musicians' (Hutchinson, Lee, Gaab & Schlaug, 2003). The role of the basal ganglia in time estimation is shown by studies in patients with Parkinson's disease (PD), who are significantly impaired in tasks requiring accurate time estimation (Rao, Mayer, & Harrington, 2001). Furthermore, the basal ganglia are implicated in the perception of tempo and rhythm in musical excerpts (Grahn & Brett, 2007).

Additionally, brain differences have been found between musicians and non musicians in areas not directly implicated in time estimation. Musical training in childhood can provoke structural brain changes after only 15 months, which can lead to improvements in musically relevant motor and auditory skills (Hyde et al., 2009). Another well known example is lateralization (Ohnishi et al., 2001; Bever & Chiarello, 1974). Recent research in music-syntactic incongruities using MEG has shown that non musicians seem to use similar areas when processing linguistic and music stimuli. This finding may permit to suggest that non musicians' brains are less lateralised than the musicians' (Maess, Koelsch, Gunter, & Friederici, 2001).

5. Conclusion

Music is an important non verbal tool of communication and expression and an important element of human life. Emotion is a fundamental parameter of our behavior. Additionally, time is present in most common everyday activities. The current study tried to combine these three important parameters in order to investigate and shed light on the relationships among music (musical training), emotion (emotional valence), and time (temporal estimation).

We formulated our questions based on three main findings from previous studies: First, research so far has shown that the emotional content of information affects the perception and the estimation of experienced time, through a mechanism of *subjectivisation*, that is, shrinking or expanding temporal duration as a result of positive and negative emotional valence, respectively (Chambon et al., 2005; de Wied, Tan & Frijda, 1992). Second, it is shown that the listener's musical training affects the estimation of a song's duration and that musicians make more accurate temporal judgements compared to non musicians' (Panagiotidi & Samartzi, 2010; Repp & Doggett, 2007; Servinç, 2007). Third, music listening can affect the mood of the individual (Sloboda, 2005). In this context, the relationship between music and emotion depends on several factors referring equally to the features of the song and the features of the listener (Scherer & Zentner, 2001).

By analysing and combining findings from previous studies that attempted to examine those factors, we investigated whether subjectivisation of time is experienced in the context of music. In addition to that, we attempted to examine the conditions (musical training) which possibly affect this mechanism. Our review revealed that musical training significantly affects time estimation by reducing the effects of the emotional content of music in time perception and allowing individuals to make more accurate estimations of time durations. Furthermore, even though some musicians are inaccurate in the estimation of the duration of songs with sad content, they show no specific tendencies and are evenly likely to underestimate or overestimate time. In other words, in the case of musicians, time estimation is not only more accurate than the non musicians (Repp, 2005; Repp & Doggett, 2007; Sevinç, 2007) but also less dependent on the emotional content effects (Panagiotidi & Samartzi, 2010). Music training mediates people's moods and may protect them from emotional "traps". The mediating role of experience with music is very interesting as we know that music training is a crucial factor that influences our ability to estimate

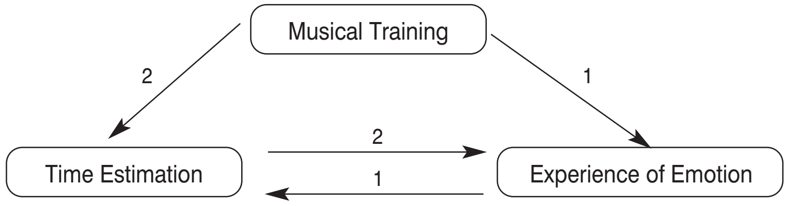

Figure 2
The direction of influence: music induces emotional states that alter time estimation (path 1) or music affects experience of emotion through time estimation (path 2)?

different emotions expressed through music (Scherer & Zentner, 2001; Slodoba, 2005). It seems finally, that the emotional content of the information affects time estimation only under particular conditions, such as in the absence of musical training.

Thus, a new question emerges: does musical training affects estimation of time through the experience of emotion (Figure 2, path 1) or, in reverse, it affects experience of emotion through time estimation (figure 2, path 2)? Musical excerpts used in previous studies are usually songs from contemporary and classical music (Peretz et al., 1998; Thompon et al., 2001; Schellenberg, Peretz & Vieillard, 2007). These compositions consist of a large amount of information such as mode, melody, tempo, rhythm, harmonics and pitch and cannot be conceived as “simple musical stimuli” (simple melodies, scale of tones, etc.). Stimuli of such a high complexity are elaborated in a cognitive level involving semantic representations. Additionally, recent studies further investigating the relationship between music and language (Patel, 2008) showed that music can, like language, determine physiological indices of semantic processing (Koelsch et al., 2004). This is more relevant in the case of musicians who usually process music as text (Sergent, Zuch, Terriah, & MacDonald, 1992). Music as cognitive information can induce moods to the listener. The following schema can be conceived; music (training) induces emotional states (mood) that alter time estimation (that is, path 1 of the figure 2). In this context, time estimation can be conceived as a cognitive parameter of emotion. This reasoning leads to the answer of the question we posed earlier: musical training affects time estimation through the experience of emotion.

The effect of musical training is also supported by findings from neurophysiological studies that show that stimuli are differently processed by people with and without musical training. “Musicians” show left hemispheric dominance when listening to music, while “non musicians” show right hemispheric dominance (Andrade & Bhattacharya, 2003). Right cerebral areas are related to the recognition and the expression of emotions. Activation of these areas suggests a cognitive processing based on the emotional valence of songs while processing of musical stimuli by the “musicians” probably reduces the song’s emotional valence effects. This hypothesis is also supported by studies on patients with brain injury or congenital disorders, which show that emotional and non-emotional judgments in music might be the products of distinct neural pathways (Peretz et al., 1998; Griffiths, Warren, Dean, & Howard, 2004). Findings from previous studies investigating the relationship between music and language (Koelsch et al., 2004; Patel, 2008; Sergent, Zuch, Terriah & MacDonald, 1992) suggest that musicians may process music as text and this may be one of the reasons why they are less sensitive to the song’s emotional valence. This suggestion is consistent with the findings coming from a recent study showing that the emotional valence of a text does not seem to affect the reader's estimation of the duration of the described events (Samartzi & Kazi, submitted).

In conclusion, as far as the relation among music, emotion and time estimation is concerned, the link seems to be the degree of musical training of people. Musical training affects emotion that, in turns, affects temporal accuracy.

A number of questions that need to be addressed by future studies emerge from the findings of the present review:

It is assumed that mode and tempo are crucial for the perception of the emotional content of music (major mode and fast tempo define "happy" songs, while minor mode and slow tempo define "sad" songs). Since we know that these two variables interact but it is not yet clear whether tempo or mode is more important in perceiving emotion in music, it would be interesting to use experimental conditions manipulating each variable separately.

Also, these findings that shed light on the relationship between music and time estimation should be applied in education and other areas of everyday life. For instance, this relation may support the development of possible tools in treatments aiming at improving time perception, which is affected in relatively common disorders like dyslexia (Forgeard, Schlaug, Norton & Winner, 2008. Overy, 2000).

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Αλληλεπιδρασιακές σχέσεις μεταξύ χρόνου, μουσικής και συναισθήματος

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ΠΕΡΙΛΗΨΗ

Το συναισθηματικό περιεχόμενο της πληροφορίας επηρεάζει, μέσω της υποκειμενικοποίησης, την ικανότητα αντίληψης και εκτίμησης της χρονικής διάρκειας (συστολή ή διαστολή της χρονικής διάρκειας γεγονότων ευχάριστης ή δυσάρεστης συναισθηματικής χροιάς, αντίστοιχα). Γνωρίζουμε επίσης ότι η εκτίμηση της χρονικής διάρκειας των μουσικών κομματιών επηρεάζεται από τη μουσική εμπειρία, με τους μουσικούς να κάνουν ακριβέστερες εκτιμήσεις από τους μη μουσικούς. Τέλος, είναι γνωστό ότι η μουσική επηρεάζει τη διάθεσή μας και ότι η σχέση μουσικής-συναισθήματος εξαρτάται από παράγοντες που αφορούν χαρακτηριστικά τόσο της μουσικής όσο και του ακροατή. Ωστόσο, εκτός από τις επιμέρους αυτές δυαδικές σχέσεις, δεν γνωρίζουμε εάν οι τρεις παράμετροι συνδέονται μεταξύ τους με τρόπο αλληλεπιδρασιακό και ποιος είναι αυτός. Η παρούσα μελέτη επιχειρεί να διερευνήσει και να περιγράψει μια τέτοια πιθανή σχέση. Όπως δείχνουν μελέτες από το χώρο των νευροεπιστημών, όταν ακούν μουσική άτομα χωρίς μουσική εκπαίδευση, ενεργοποιείται το δεξί εγκεφαλικό τους ημισφαίριο, ενώ όταν πρόκειται για άτομα με μουσική εκπαίδευση, ενεργοποιείται το αριστερό. Καθώς η δεξιά εγκεφαλική περιοχή συνδέεται με την αναγνώριση και την έκφραση συναισθημάτων, η ενεργοποίησή της είναι ενδεικτική μιας γνωστικής επεξεργασίας βασισμένης στη συναισθηματική χροιά της πληροφορίας. Φαίνεται λοιπόν ότι η μουσική εμπειρία επηρεάζει το συναίσθημα (παρεμβαίνοντας στη διάθεση), το οποίο με τη σειρά του επηρεάζει την ακρίβεια της χρονικής εκτίμησης.

Λέξεις-κλειδιά: Χρονική εκτίμηση, Μουσική εκπαίδευση, Μουσική, Συναίσθημα.

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