Key topics in film editing related to cognitive processes

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Abstract

A film engages the viewer's brain to confront with a multitude of sensory stimuli. Therefore, it needs the mechanism of attention; that is necessary for perception. This research is a study of the key topics in film editing and its cognitive effects on the brain. Film editing shapes the reaction of the viewers. Most research shows that the viewer's perceptual continuity requires cinematic continuity. At the same time, the discontinuity of the film can create complex meanings, which, of course, imposes a greater cognitive load on the brain. This study first examined the definitions of film editing and related key words, and then categorized the results of cognitive research related to film editing. Finally, the cognitive effects of different types of editing, along with the related neural networks are considered. The results indicate that the ability to control the mind of the viewer is directly related to the way the film is directed. The level of identification with the film and brain activity of the viewer depends on how the director uses cinematic components to activate the viewer's imagination.

Keywords: Film Editing, Neurocinematics, Cognitive process, Film perception, Cinematic attention

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1. **Introduction**

In this study, first, cinematic studies related to neuroscience and cognitive sciences were collected. Keywords such as: film and cognition, camera movements and neuroscience, emotions, memory, cinema imagination, perceptual-cinematic continuity, film editing and neurocinematics were used to obtain related papers. Research on these keywords was conducted on scientific websites. This paper provides a summary of useful information obtained for researchers interested in this field (Fig.1).
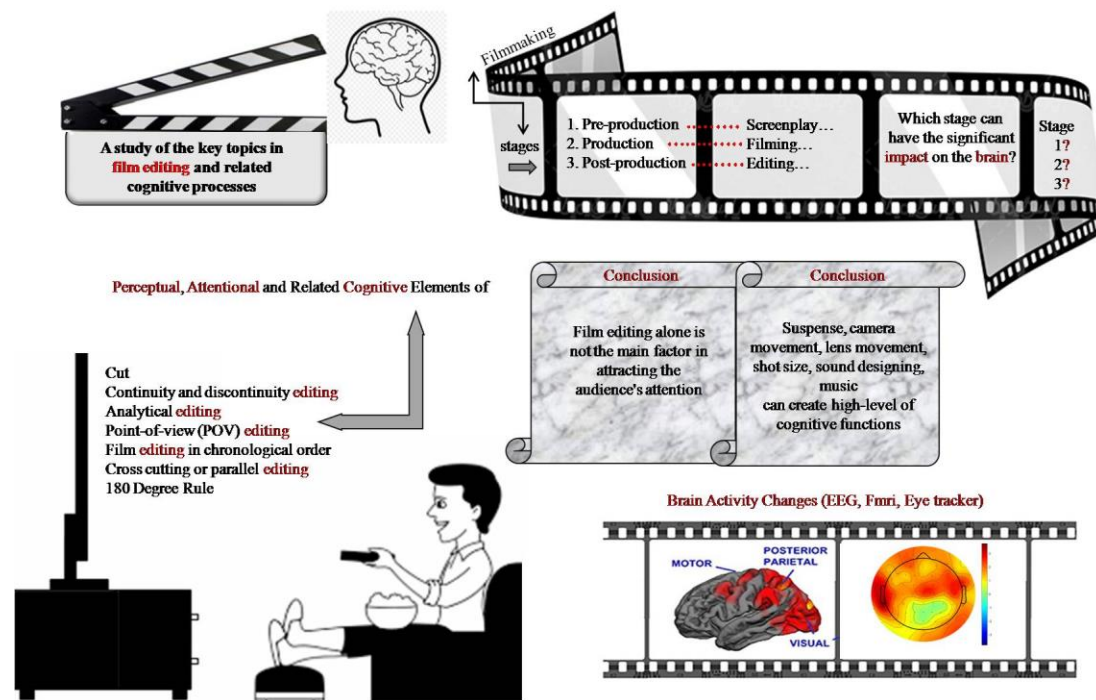

Figure 1 *The Graphical abstract of the study*

Realism in film depends on how accurately it represents social relations. (Metz, 1982) believed that the essence of going to the cinema is to identify with characters in the film – the viewer's identification with everything he/she watches on the screen(Turner & Duckham, 2006). Professional filmmaking is divided into three stages:(1) Pre-production, which includes screenplay, cast and the selection of technicians, planning the filming, and film cost estimates;(2) Production, which includes filming of scenes and preparation of raw materials;(3)Post-production, which includes mixing, looping, dubbing, editing and special effects. Editing is often considered the essential element of filmmaking, because in this process, film clearly separates itself from other arts (Monaco, 1981).The process of organizing sounds and shots is called film editing (Thompson and Bowen, 2009b). An editor's decision-making to move from one scene to the next is one of the important processes of film editing. There are two golden rules in applying the technique to achieve good structure. A cut should be done in such a way that it does not catch the viewer's attention; It could disrupt the connection between the audience and the film (Crittenden, 2003).

Each film consists of a series of discontinuous shots which are connected to each other. There are evident gaps between them(Lindgren, 1970). The gaps are connected to how the decoupage parameters are displayed(Bordwell et al., 1993; Zettl, 1999). Directors must to successfully control these discontinuities; therefore the audience can follow the film as a continuous audio-visual stream.

Editors should generally consider various components in film editing, including the composition of each shot, the 180-degree rule, the camera angle, the 30-degree rule, and continuity editing, such as continuity in action, dialogue, content, movement, position and sound that gives rise to all kinds of film editing such as analytical editing, point-of-view (POV) editing, parallel editing or cross cutting, transitions (cut, dissolve, wipe, fade in/fade out),lighting, rhythm and the speed of each shot(Thompson and Bowen, 2009a; Hayward, 2017). Cognitive researchers have dealt with some of the concepts of film editing in cinema.

2. Film editing in cinema

Cut: Cut means attaching two shots together to create a fast transition between one time and place to another time and place. Depending on the essence of the cut, this transition would have a variety of meanings(Hayward, 2017). Cut is the most common transitions among all transitions (Serrano et al., 2017).

Continuity and discontinuity film editing: Basically, the concept of continuity in filmmaking means a smooth and natural transition, passing from one scene to another until the end of the story (Zabeti Jahromi, 2013a). In this way, continuity editing means creating the feeling in the viewer that despite watching separate scenes, they accept that they are watching a film without interruption(Reisz & Millar, 1968). Film directors believe that by following the rules of continuity editing, they can make the cuts appear invisible (Dmytryk, 2018). The two principles of continuity editing are that its usage appears invisible (Bordwell et al., 1993; Dmytryk, 2018; Reisz & Millar, 1968; Smith, 2006). The aim of continuity editing is that the viewer should not face complexity or difficulty in understanding the story. The viewer's perceptual ease of film events is the main goal of continuity editing(Zabeti Jahromi, 2013a) cf. (Corrigan & White, 2012). The rules of continuity are violated in discontinuity editing. In general, meaning is not easily transferred in discontinuity editing: Meaning is conveyed sometimes symbolically and sometimes as an interpretation of the event (Zabeti Jahromi, 2013b).

Analytical editing: Organizing the shots according to the narrative information, so that the viewers could deduce the logical relations between the shots. For example, a scene in which someone confesses to a murder followed by a flashback in which the audience witnesses his/her murder. In the viewer's perception, these two scenes are logically related to each other (Bordwell et al., 1985).

Point-of-view (POV) editing: Expressing the information of the story by depicting what the character sees. Matching the angle view where it shows a shot of a character looking at something, and the next shot shows what the character sees (Bordwell et al., 1993)

Film editing in chronological order: This type of editing is very close to continuity editing. One event follows another. Hence, time and place are logically represented. The beginning and the end of the sequences are quite obvious. The shots in the sequence are placed in such a way that the viewer is justified in terms of time and place. The end of a sequence depicts with certainty where and when the story will be delivered to the next sequence(Hayward, 2017) cf. (Reisz & Millar, 1968).

Cross cutting or* parallel *editing: Joining two sets of actions which occur simultaneously and within the narrative, they are interdependent. Also, parallel editing is an equivalent between two related actions that occur at different times. Both methods are used to advance the narrative; quickly and, of course, to create suspense(Hayward, 2017).

180 Degree Rule: Imaginary line or 180 degree rule is the mother of all cinematic contracts. This rule requires the director to choose the next position of the camera, such that it is within the 180-degree arc that stabilizes the first shot, in order to avoid confusing the audience (Crittenden, 2003). 180 degree rule divides a circle into two halves and it forms a semicircle that the camera has to move inside in which the camera has to move to get the next shot. If the camera crosses the line and takes a close-up of a character, after editing this shot throughout the scene, it would seem that the character has turned around and is looking in the opposite direction. This change of direction would seem incorrect to the audience because this unusual shot does not fit the fixed direction of the screen. Therefore, the director cannot utilize a shot that cross the imaginary line in the editing (Thompson and Bowen, 2009b; Hayward,2017) and cf. (Levin & Wang, 2009; Reisz & Millar, 1968).

3. Perceptual, attentional and related cognitive elements of film editing

Research on perceptual and cognitive processes that support the understanding of cinematic story is on the rise (Shimamura, 2013). This research covers different fields including attentional and perceptual processes(Brunick et al., 2013; Germeys & d'Ydewalle, 2007; Smith, 2013; Swenberg & Eriksson, 2018), event cognition(Huff & Schwan, 2012; Schwan et al., 1998, 2000; Zacks et al., 2009), memory of events (Garsoffky et al., 2007),understanding the narrative (Magliano et al., 1996, 2001, 2020),and the perception of film editing and its psychology(Cutting, 2005, 2014; Cutting et al., 2011). This research has categorized the cognitive-cinematic terms which previous studies have reached, and the results are as follows:

Perceptual elements and the related theories
Film Perception: Film perception describes the viewer's capacity, and evaluates the adaptation of viewer's perceptual function when watching a film (Berliner & Cohen, 2011).

Perceptual phenomena: Perceptual phenomena are explicit audio-visual features that are highlighted as objective features in film; are likely to evoke perception, attention, or awareness in the audience. Cuts are often made by considering several complex perceptual phenomena which present several audio-visual transitions together as signs of film editing(Smith, 2012)

Perceptual continuity: Human perceptual experience of a stable world is perceptual continuity. In other words there are continuous sensory inputs in human beings (Hecht & Kalkofen, 2009)

Perceptual discontinuity: Discontinuity is perceived when an abrupt change in the universe causes sensory transmission (Smith, 2012).

Event segmentation theory: Recent research in cognition and neuroscience indicates that segmentation happens in the real time domain; and divides uninterrupted activity into a chain of events which are meaningful. This leads to the expansion of event segmentation theory (Kurby & Zacks, 2008; Zacks & Swallow, 2007). It is claimed that the human brain uses this clearly separate representation to predict the instant stream of events to make an internal and continuous representation in memory. Recent events are recorded with changes in action, space, or time(Cutting, 2014; Zacks et al., 2010).

Model of Spatial Continuity: A wide range of findings suggest that adults automatically encrypt at least some type of spatial information, they process spatial information whether they need it or not; and this processing requires relatively few cognitive resources(Berliner & Cohen, 2011; Levin & Wang, 2009). A region of the brain, which is related to the encoding of spatial environments, depends on a similar viewer-centric reference frame (Levin & Baker, 2017).

Attention and the cinematic related theories and models
Attention: Capturing the mind in a vivid and clear way, concentrating on one object or chain of thoughts separate from several simultaneous items while giving up some things(James, 1890) cf. (Lamme, 2003; Swenberg & Eriksson, 2018)

Attentional synchrony: To understand a film, many viewers use the same features over and over again, which is called attentional synchrony(Smith & Mital, 2013). The viewer's attention is drawn to common points at the same time.

The signs of cinematic attention: The signs of attention are transitions that catch the viewer's attention, for instance, an unforeseen sound or a fundamental variation in visual data (Swenberg & Eriksson, 2018).

The attentional theory of cinematic continuity: Perceptual continuity in film perception is the viewer's skill and knowledge of a film as the presentation of an uninterrupted continuous stream of audio-visual experience; while continuity in film is the audio-visual structure of film components that is used for perceptual continuity (Swenberg & Eriksson, 2018). Smith's theory of attentional film continuity concentrates on the connection between film and the viewer's perception of that(Smith, 2012)

4. Cognitive impacts of continuity and discontinuity in film editing
Four cognitive techniques are used to develop continuity to limit attention and ignore the cut: Focusing on a constant, expecting a visual change, directing attention internally, and suppressing attention (Smith, 2006). How the film is edited is already recognized by experts and scientists as the key to achieving film continuity (Fairservice, 2001; Smith, 2006, 2012).

   The film editor has the duty to correct continuous editing in an optimal manner so that the audience understands the film continuously. Lack of complete editing correction can jeopardize the continuity of the film perception. Therefore, cognitive researchers examined the impacts of

discontinuity to determine whether continuous editing to perceive a film is important (d'Ydewalle et al., 1998; d'Ydewalle & Vanderbeeken, 1990; Shimamura et al., 2015; Smith & Henderson, 2008).Tam et al. (1995)studied visual cutting overlay effects between two shots on the viewer's perception. They found that the first frame after cutting was obscured by human visual perception. (Carmi, 2007)examined the relationship between attention, cuts and normal vision. The result of this research is that discontinuous cuts focus the viewer's gaze more on the center of the screen. Likewise, studies in television programs have also shown how cuts between shots with relevant and irrelevant content can affect the viewer's attention, respectively. Irrelevant content seems to make it harder for viewers to follow the film; such the cognitive load puts pressure on them(Geiger & Reeves, 1993). This irrelevant content is consistent with discontinuity editing.(Magliano & Zacks, 2011)studied the effects of film events on viewer perception. The results indicate that continuity editing supports not only continuous visual perception, but also event perception(Cutting et al., 2012; Smith & Henderson, 2008).

5. Cognitive effects of the 180-degree rule

The brain perceives spatial coherence when watching the edited film because the perceptual system has evolved to accept incomplete visual information, to reconstruct scattered information in a model of the physical world and to ignore discontinuities(Berliner & Cohen, 2011). Edits containing little camera movements are still close enough to normal vision because it includes little vision discontinuities due to visual suppression during saccade and blinking. But the cuts in the midline make a huge difference. Detection of such changes may lead to impair perception of the subject (Heimann et al., 2017; Magliano & Zacks, 2011); Of course (Germeys & d'Ydewalle, 2007) reported that strength in the narrative structure of the story eliminates the perceptual disruptive effects of cuts in the transition between successive shots.

6. Cognitive effects of rhythm and time of each shot

Human mental experience of time has long been influenced by several factors such as arousal (Penton-Voak et al., 1996), memory (Block, 1978), and attention(Zakay & Block, 1996). Distortion makes a person feel the passage of time more which is caused by how the brain measures time. A cut in the film should take into account these distortions of time; otherwise, the discontinuity of time is perceived (Levin & Simons, 1997; Smith, 2006). Moving in dynamic scenes uniformly catches the viewer's gaze (Mital et al., 2011). Also, the cuts turn the views into pieces that have a different time. Therefore, it is likely that the time allotted to each shot will have special cognitive effects on the viewer's brain. Internal rhythm and speed should be provided for the structure of the scene (Crittenden, 2003). (Lang et al., 2000)believe that editing speeds vary from slow to very fast, and the results of their studies suggest that the faster the editing, the greater the physiological stimulation, self-report arousal, and memory increase.

7. Brain activity changes due to film editing

Research on the study of brain changes has so far been limited to the 180-degree rule and continuity in film editing. Task construction through controlled filmmaking and directing components may be able to highlight frequency band changes and changes in brain activity more prominently.

The effect of continuity and discontinuity on the brain activations

The brain mechanism was studied while watching edited and unedited clips (Kauppi et al., 2014). The subjects watched two solo dances with music while functional magnetic resonance imaging (fMRI) was taken from their brains. Differences were calculated based on inter subject correlation (ISC). This and previous studies showed less inter subject correlation (ISC) for unedited films in solo dance(Jola et al., 2013). This study has also been proven in group studies (Hasson et al., 2008).(Herbec et al., 2015)concluded that the edited film increases inter subject correlation (ISC); it also produces more brain activity (Table 1) in areas of the frontal cortex.

Table1. *Changes in brain activation pattern in edited dance clips as compared to unedited ones as reported in (Herbec et al., 2015)*

Unedited	Edited
- Bilateral areas in parietal cortex-	- multiple clusters in the right prefrontal cortex - voxels with statistically significant Inter Subject Correlation - Significantly larger synchronization in: 1. Right precentral gyrus, left medial frontal gyrus 2. Parietal cortex 3. A large cluster in the right lingual gyrus

Eye movements through cuts have also been considered (Shimamura, 2013; Smith, 2006, 2012, 2013). In a study, (Swenberg & Eriksson, 2018) edited a sequence of a film in two ways: (1)a continuity editing model; and (2a discontinuity one. They examined the subject's gaze in the "areas-of- interest" identified by the editor. The saccade frequency and pupil size increased in the discontinuity version. Consequently, the editor's duty in film editing is a main principle in perceptual accuracy and continuity. Moreover, the principles of continuity editing have been studied with respect to perception (d'Ydewalle & Vanderbeeken, 1990; Shimamura et al., 2015; Smith & Henderson, 2008). d'Ydewalle & Vanderbeeken, (1990)indicated that violations of editing rules have provoked gazing reactions and cognitive responses.

One must not overlook the fact that some cuts may disappear while blinking or having saccadic eye movements, but the majority of them seem to be due to unconscious blindness, because viewers pay attention to the illustrated narrative (Smith & Henderson, 2008) and cf. (Valuch et al., 2017)Cognitive research on eye tracking indicates that viewers coordinate their saccadic eye movements through cuts. The center of the shots is noticed in the majority of scenes (May et al., 2003; Tosi et al., 1997; Treuting, 2006).

The effect of the 180-degree rule on the brain activations

The results of a study by (Francuz & Zabielska-Mendyk, 2013)also demonstrate that for unrelated cuts, slow cortical potential (SCP)has a wider amplitude, indicating increased arousal, attention, and cognitive load generated by these types of stimuli(Magliano & Zacks, 2011)examined blood oxygen-dependent responses when observing continuity editing: A) Edited shots which show the

same scene in progress but are recorded from various camera angles, while not crossing the midline; that is, the 180-degree rule has been observed. B) Discontinuity editing: includes cuts-across-the-line, meaning edited shots which display the same scene in progress but are captured from different camera positions as it crosses the midline; this means that the 180-degree rule has not been observed. They found that in continuity editing, transitions increase activity in cortical regions and decrease activity in some regions (Table 2). The first activity interpreted as stimulus-driven processing in the service of reconstructing visual features at the boundaries of editing. Consequently, cuts are not understood consciously, and the event is perceived without interruption or breakage. Therefore, cuts such as "cross-line cuts" are not completely covered and disrupt the continuity of perception, so that probably leads to their conscious diagnosis. In fact, previous studies have shown that it is simpler to discover cuts that violate the 180-degree rule than cuts that abide by the rule (d'Ydewalle & Vanderbeeken, 1990) and cf. (Heimann et al., 2017).

Table2. *Changes in brain activation pattern when using transitions in continuity editing as reported in (Heimann et al., 2017; Magliano & Zacks, 2011)*

Increased activity	Decreased activity
Inferotemporal cortex	Precentral sulcus
Posterior superior temporal sulcus	Premotor areas
Precuneus	The lateral parietal cortex
Early visual areas	
Spatial-temporal changes in higher order perceptual processing regions	

   Magliano & Zacks(2011)found differences between cuts-across-the-line and continuity editing in the premotor cortex an area normally involved in action planning. They showed a decrease in activity for irrelevant cuts in the lateral parietal cortex an area linked with the representation of act targets(de C. Hamilton & Grafton, 2009). The 180-degree rule seems to structure fundamental spatial representations with cues of meaningful gazes. Cognitive research has shown that sequences that violate the 180-degree rule are less accurately remembered (Frith & Robson, 1975; Hochberg, 1986).Violation of this rule imposes a reaction time cost in the encoding in the scenes(Huff & Schwan, 2012). Findings indicate that spatial encoding is one of the most significant foundations of cinema continuity(Berliner & Cohen, 2011; Kraft, 1987).

8. Conclusion and discussion
According to this study, the researchers focused most of their research on the effects of cinema on the brain in the post-production phase, while special research should also be done on the previous stages. For example, Alfred Hitchcock and Stanley Kubrick consider the pre-production and production stages to be much more important than the post-production phase.

   Film art is a complex equation (Monaco, 1981). The visual style of the film is not something that can be created while editing it. The real function of editing is to reinforce the aesthetic choices the director has made during filming. If the director has not done anything special, naturally, the film editor cannot do anything, either (Crittenden, 2003). There are feature films which have

been made without editing. There are examples of important films which are based on sequence-plan, that is, long takes, which have not been edited, or have had minor editing. For example, 'Rope' (1948) by Alfred Hitchcock, 'Gravity' (2013), and 'Children of Men' (2006) by Alfonso Cuaron, 'Birdman' (2014) by Alejandro G. Iñárritu, and '1917' (2019) by Sam Mendes. These are films that have been praised by critics and have won many awards. The making of these films reflects the fact that despite extensive research on the effects of editing on the brain, film editing alone is not the main factor in attracting the viewer's attention.

There are other important factors involved that require extensive interdisciplinary research. For example, (Germeys & d'Ydewalle, 2007) they examined the impacts of moving objects across cuttings, and deduced that the most prominent region is a moving shots which, regardless of the form of editing, attracts the viewer's attention after editing. This means that movement in the film includes camera movement, lens movement, the actor's movement…all of which can be significant, and can create high-level of cognitive functions alongside professional editing.

Continuity and discontinuity is related to acting, mise-en-scène, camera angle, camera movements, shot size, and sound designing in the film. How to arrange scenes in a sequence, as a series of continuous or discontinuous images, is also a matter on which the editing specifically depends(Swenberg & Eriksson, 2018). One way to look at the role of perceptual continuity in film is to concentrate on positions in which directors deliberately break the rules; because these violations can create meaningful concept that cognitive researchers have not entirely discussed. Violation of perceptual continuity is common in the film, 'Eternal Sunshine of the Spotless Mind'(2004) by Michel Gondry (Levin & Baker, 2017). In addition, some discontinuities produce a kind of reflective meta-awareness (Schooler et al., 2011).Continuity editing structures the stream of shots as a kind of brain mapping for the viewer to communicate with when presenting film on the screen(Zettl, 1999). These mental images also refer to a state of memory: memories which repeat and are outside human consciousness (Mitry, 1997).

According to the attentional theory of cinematic continuity, the viewer's perceptual continuity requires cinematic continuity. The comfort of the viewer is very important in watching a film continuously; it depends on its skillful production in hiding the deviant nature of the media by adapting to the cognitive needs of the viewer; and this is what is called 'continuity editing' (Bordwell et al., 1985, 1993; Cutting, 2005).

Hasson et al. (2008) screened for the participants four films while scanning Functional Magnetic Resonance Imaging and measuring brain activity by detecting Inter Subject Correlation (ISC) in the subjects. The four films are: 'The Good, the Bad and the Ugly,' (1966) by Sergio Leone; 'Bang! You're Dead, '(1961) by Alfred Hitchcock; 'Curb Your Enthusiasm,' (2000) by Larry David; and a one-shot clip of 'Washington Square Park, video (Hasson et al., 2008).

They found that percentage of the cerebral cortex that represents a high Inter Subject Correlation (ISC) can provide a measure of the overall impact, or overall engaging power, of each film in generating similar responses among the viewers. Alfred Hitchcock, meanwhile, was able to elicit similar responses in more than 65 percent of the cerebral cortex in all the viewers, which shows the high level of control in the minds of the viewers. They associate these different influences in film directly with the style of directing. Directors must be able to control the mind of the viewer; but how and to what extent this mind control is created and on what components it depends remains an open question.

The results of film-editing research indicate that when the viewer is watching a film, all

cinematic elements must be carefully controlled by the director. It is not only editing which provides perceptual continuity. Any audio-visual signal that distracts the viewer from the film must be controlled. In a study, Shimamura et al.(2015)concluded that multimodal perception is more reliable than visual perception. The story of a film which must be pleasing to a viewer should have suspense and emotionally engage the viewer. The plot should be enjoyed by the viewer and include events which can be visualized by the viewer(Corrigan & White, 2012; Plantinga, 2009).The discontinuity of the audio-visual flow can make a viewer that is immersed in a film alert and keep him/her extremely aware that he or she is watching a film. Consequently, if the director uses the components of cinema that raises the viewer's awareness, or, in other words, wakes her/him up, it will be considered a kind of failure in the director's work, because the filmmaker has not been able to dominate the viewer's mind and immerse the viewer in the film. Although, the strong structure of a script may be able to compensate for this a little. The certain conclusion of research is that viewer engagement and immersion in a film lead to a high percentage of Inter Subject Correlation (ISC) and brain activity. The purification of the emotions and reaching Aristotelian catharsis (Aristotle, 1943) require the correct use of cinematic components such as suspense in a film, which is one of the important factors in screenwriting cf. (Cheong & Young, 2008; Comisky & Bryant, 1982; Khosravi Khorashad & Khosrowabadi, 2022; Lehne & Koelsch, 2015; Naab & Sukalla, 2019; Tal-Or & Cohen, 2010), precise timing, composition and mise-en-scène, dynamic shots, movements of the actors, camera movement, shot size, sound designing, music, etc. The director must use all these components in a calculated manner (Khosravi Khorashad et al., 2022).

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