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Research report

Context matters: Anterior and posterior cortical midline responses to sad movie scenes

L.H. Schlochtermeier [a,*], C. Pehrs [a,e], J.-H. Bakels [d], A.M. Jacobs [a,b], H. Kappelhoff [d], L. Kuchinke [c]

[a] Department of Education and Psychology, Freie Universität Berlin, Berlin, Germany
[b] Dahlem Institute for Neuroimaging of Emotion, Freie Universität Berlin, Germany
[c] Methods und Evaluation, International Psychoanalytic University Berlin, Germany
[d] Department of Humanities, Freie Universität Berlin, Berlin, Germany
[e] Department of Psychology, Northwestern University, Evanston, IL 60208, USA

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ABSTRACT

Narrative movies can create powerful emotional responses. While recent research has advanced the understanding of neural networks involved in immersive movie viewing, their modulation within a movie's dynamic context remains inconclusive. In this study, 24 healthy participants passively watched sad scene climaxes taken from 24 romantic comedies, while brain activity was measured using functional magnetic resonance (fMRI). To study effects of context, the sad scene climaxes were presented with either coherent scene context, replaced non-coherent context or without context. In a second viewing, the same clips were rated continuously for sadness. The ratings varied over time with peaks of experienced sadness within the assumed climax intervals. Activations in anterior and posterior cortical midline regions increased if presented with both coherent and replaced context, while activation in the temporal gyri decreased. This difference was more pronounced for the coherent context condition. Psycho-Physiological interactions (PPI) analyses showed a context-dependent coupling of midline regions with occipital visual and sub-cortical reward regions. Our results demonstrate the pivotal role of midline structures and their interaction with perceptual and reward areas in processing contextually embedded socio-emotional information in movies.

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1. Introduction

When the earliest motion pictures were presented around the turn of the 20th century, they were silent and in black and white. While being very popular from the beginning, movies have since progressed to a highly composed and edited medium, depicting fictional worlds and stories (Cutting et al., 2012). A reason for their high popularity is their ability to make the viewer experience and feel strongly with highly complex social and emotional events (Schlochtermeier et al., 2015; Kuchinke et al., 2013; Pehrs et al., 2015). Even though they are fictional, they can be highly immersive (Appel and Richter, 2010; Jacobs, 2015a,b; Jacobs and Schrott, 2015; Tan, 1996; Visch et al., 2010), and perceived similar to real life events (Gallese and Guerra, 2012). A main feature of movies is their ability to show dynamic patterns, i.e. continuous alterations of visual and auditory information in time and space, which result in an audiovisual composition. The powerful immersive effects of emotionally charged movies may therefore at least partly depend upon a movie's dynamic audiovisual composition. Immersion is defined as a psychological state of being absorbed by a fictional world (e.g. Jacobs, 2015a). The immersion potential is hence referring to the potential of a medium to induce immersive processes. The composition of movies has previously been proposed to be particularly effective in capturing attention and controlling our brain activations (Hasson et al., 2008a). Considerable progress has been made to understand the neural mechanisms subserving responses to complex audiovisual materials (e.g. Hasson et al., 2008a; Nummenmaa et al., 2012; Zacks et al., 2010; Pehrs et al., 2014, 2015). Besides recruiting (multi-) sensory networks, complex audiovisual stimuli have been shown to engage widespread parietal and prefrontal, limbic as well as default mode network (DMN) areas (Hasson et al., 2008b; Jääskeläinen et al., 2008; Nummenmaa et al., 2012; Raz et al., 2014). The midline core of the DMN, which includes anterior and posterior midline structures, the posterior cingulate cortex (PCC) and medial prefrontal cortex (mPFC) (Andrews-Hanna et al., 2010), usually shows relative deactivations under external stimulation (Christoff, 2012)

* Corresponding author.
E-mail address: l.schlochtermeier@fu-berlin.de (L.H. Schlochtermeier).

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and is associated with an intrinsic processing mode (Gusnard and Raichle, 2001; Greicius et al., 2003). It is assumed to represent internal awareness, indicating self-referential and mentalizing processes, as opposed to extrinsic networks, which are usually anti-correlated, represent external awareness, such as perceptual and attention processes (Raichle et al., 2001; Raichle and Snyder, 2007). The parallel activation of intrinsic and extrinsic networks, is suggested to be possible if both require a balanced amount of cognitive load with minimal interference (Dixon et al., 2014), while an interplay of intrinsic and extrinsic networks has been suggested as pivotal for immersion into virtual worlds (Christoff et al., 2009; Christoff, 2012).

Providing an explanation for the involvement of intrinsic networks in movie processing, midline DMN regions are also recruited in multiple tasks, like in socio-emotional working memory (Spreng et al., 2009; Spreng and Schacter, 2012; Meyer et al., 2012), processing of self and others (Uddin et al., 2007; Qin and Northoff, 2011), theory of mind (Gallagher and Frith, 2003; Saxe and Kanwisher, 2003), or semantic processing and narrative comprehension (Fairhall and Caramazza, 2013; Ferstl et al., 2008; Altmann et al., 2012, 2014; Tamir et al., 2015). Indeed, DMN brain regions were especially shown to be recruited during the presentation of complex and dynamic materials, for example when watching movies but also when reading and listening to narratives (Altmann et al., 2012, 2014; Nummenmaa et al., 2012, 2014, also Raz et al., 2014; Viinikainen et al., 2012). Furthermore, recent research indicates that core regions of the DMN play a role in the integration of complex context information (Lerner et al., 2011; Hasson et al., 2009; Ames et al., 2015). The role of parts of the DMN, such as the parietal cortex, precuneus, PCC and ACC, has also been highlighted as cortical network hubs that integrate information over time and across segregated neural brain regions (Sporns, 2013). Of further note is that coherent (e.g. thematically related sentence pairs) rather than incoherent linguistic stimuli elicit increased activation in midline brain regions (PCC, mPFC and precuneus) (Ferstl and von Cramon, 2001; Ferstl et al., 2008). Also,

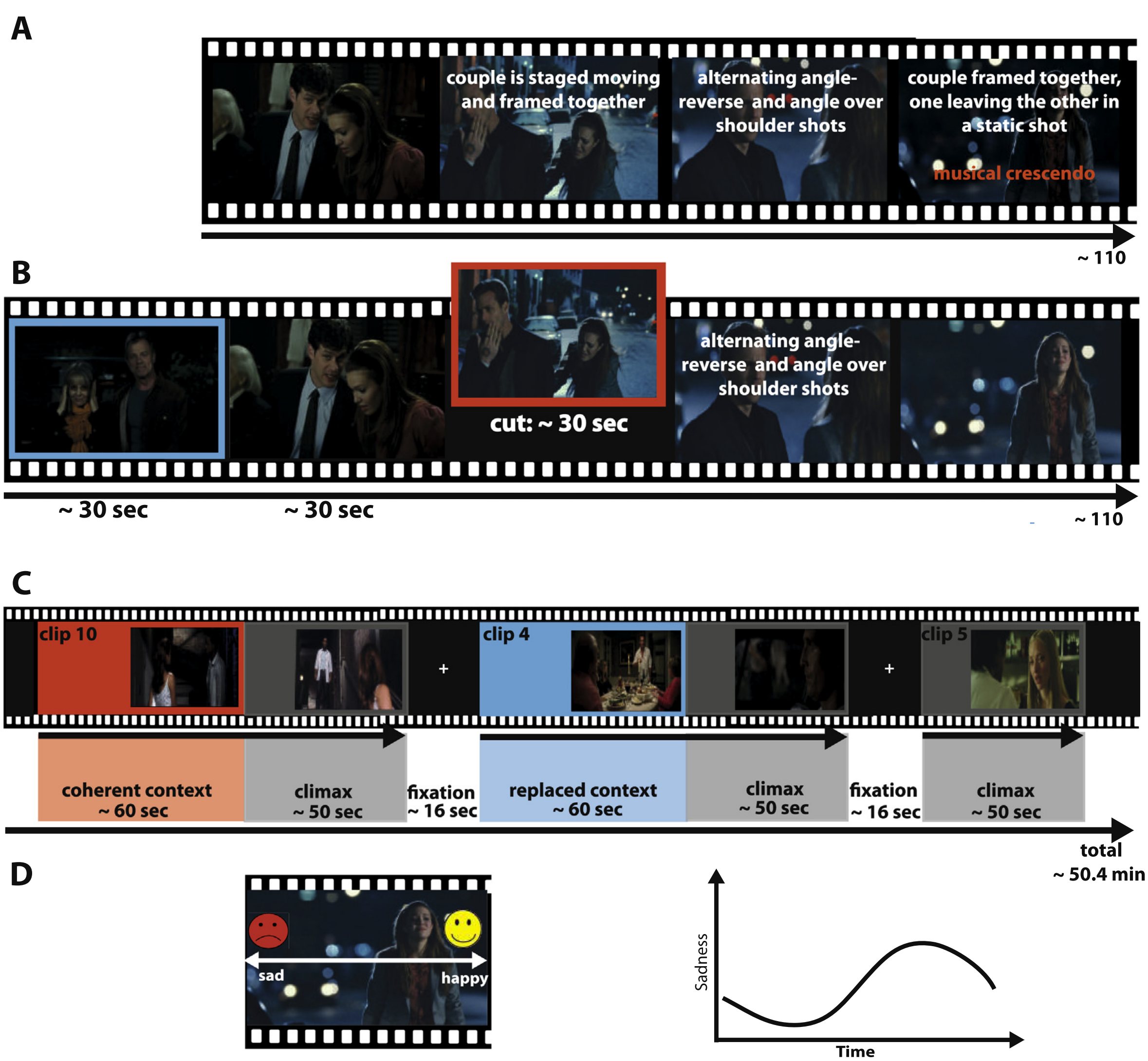

Fig. 1. An illustration of the compositional structure of the coherent, un-replaced clips (original scene structure) is shown at the top (**A**). **B** illustrates the replacement of the scene contexts (cut and removal of 30 s. and replacement with preceding movie excerpt) keeping the **scene climaxes** identical across conditions. The design of the scanner experiment (first viewing) with the stimulus conditions coherent, replaced (30 s removed and replaced) and no context (presented in randomized order with a total scanning time of approx. 50.4 min) is depicted below (**C**). **D** shows an illustration of the dynamic rating procedure (left: the rating with a smiley that is moved on an axis on the screen; right a putative random sadness rating time-course), which was conducted after the scanner experiment and consisted of the same order and randomization as during the scanner presentation (Nagel et al., 2007).

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