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Perceiving Movement Across Film Edits: A Psychocinematic Analysis

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Film editors have developed techniques that create seamless, virtually invisible, shot transitions. One technique is the match-action edit in which a cut occurs in the middle of an action. We assessed the way smooth movement is perceived across such edits. Participants viewed an action (e.g., woman drinking a mug) that included an edit that either ran in real time (straight cut), jumped ahead in time, or overlapped the action. When asked to select the clip with the smoothest movement, participants chose clips that contained a brief overlap in action (~125 ms). When a pattern mask was inserted between shots, the overlap bias persisted and even occurred when the same camera angle was used across the edit. These findings suggest that film edits disrupt cognitive processing such that viewers act as if they are momentarily "blind" and must be shown a repetition of the action to perceive smooth movements.

Keywords: aesthetics, motion, psychocinematics, psychology of film

Recently, there has been a growing interest in the psychological underpinnings of our movie experience—or what has been coined *psychocinematics* (Shimamura, 2013). Filmmakers, largely through trial and error, have developed techniques that drive our attention, thoughts, and feelings (see Anderson, 1998; Bordwell & Thompson, 2009), though how these techniques engage our cognitive processes are not well understood. One feature that enhances the aesthetic quality of movies is the manner in which edits occur as smooth, virtually invisible, transitions in time. Even today, with the fast-paced action of many Hollywood features (Bordwell, 2002; Cutting, DeLong, & Brunick, 2011), we seldom notice the thousands of edits that occur as we watch a movie.

One might expect edits to be a rather jarring perceptual event as the entire visual array shifts or completely changes. How do filmmakers create such seamless transitions? The noted director, John Huston, and film editor, Walter Murch, likened the psychological experience of a film edit to a blink (Murch, 2001; Sweeney, 1973). Both blinks and film edits are usually invisible to us, unless we specifically pay attention to them. Perhaps film edits induce sensory suppression or masking effects similar to those that occur during blinks or saccadic eye movements (Enns & DiLollo, 2000; Higgins, Irwin, Wang, & Thomas, 2009; Matin, 1974).

In an empirical analysis of film edits (Smith & Henderson, 2008), participants watched excerpts from Hollywood movies and made a keypress whenever they detected an edit. Quite often, participants experienced "edit blindness" because they often failed to even notice that an edit had occurred. One editing method, the *match-action* edit, was particularly potent in inducing edit blindness. In a match-action edit, a shot transition occurs while a character is in midaction, such as a shot that begins with a person reaching for the door and cutting to a close-up of a hand grabbing the doorknob. Film editors have suggested that match-action edits conceal shot transitions because the viewer's attention is focused on the movement (Anderson, 1998; Dmytryk, 1984). Indeed, participants failed to notice a third of the match-action edits in the Smith and Henderson (2008) study.

Considering the intuition of film editors (Dmytryk, 1984; Murch, 2001), attentional influences may contribute to the appearance of smooth transitions across edits. In a study of eye movement behavior while watching movies (Mital, Smith, Hill, & Henderson, 2011), there was a strong coherence in fixation pattern among viewers as they all appeared to be focused on the same moving objects. Smith (2013) referred to this effect as *attentional synchrony*, because nearly all viewers appeared to be attending to the same objects at the same moment. Such attentional effects may be similar to change blindness (Levin & Simons, 1997), as when individuals fail to notice missing or displaced objects across edits (Levin & Varakin, 2004).

How do we perceive smooth movements across match-action edits? One might expect that the smoothest movement would be perceived when the action proceeds in real time (i.e., a *straight* cut). In this way, the movement observed after the edit continues as if one were actually watching a person performing the action. Yet considering that an edit disrupts visual processing, akin to a blink or saccade, or draws on attentional demands, akin to change blindness, the perceived smoothness of movement may require some adjustment from real time. In fact, film editors have noted that smooth match-action edits often require the second shot to repeat or overlap the action by several frames (approximately 100 ms; Anderson, 1998; Dmytryk, 1984). By this *overlap edit* hypothesis, viewers are functionally "blind" to information just before or after an edit and as a result the action must be repeated to perceive smooth movement.

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An alternative hypothesis is that viewers sense that time has elapsed across a film edit and thus expect a moving object to be further displaced after the edit. By this view, a smooth match-action edit would involve the second shot to begin with a jump ahead in movement (i.e., a jump cut) to account for the perceived elapsed time of the edit. In an empirical study of match-action edits, Hecht and Kalkofen (2009) found support for this *jump edit* hypothesis because viewers preferred a moving object to be displaced ahead of its pre-edit location to create smooth movement. The visual display used in that study involved an animated blimp that moved slowly across a screen, which then cut to the blimp viewed from a different angle. Because these findings were based on a slowly moving object in a rather sparse setting, they may not be representative of typical match-action edits.

In the present study, participants viewed brief video clips in which a match-action edit was inserted during an actor's movement (e.g., a woman drinking from a mug). The shot before the edit was the same for all of the clips. The shot after the edit was taken from a different angle and either continued the action in real time, overlapped the action at various increments (i.e., addition of earlier frames of the action), or jumped the action at various increments (i.e., removal of later frames of the action). Participants were asked to select the clip that presented the smoothest movement across the edit.

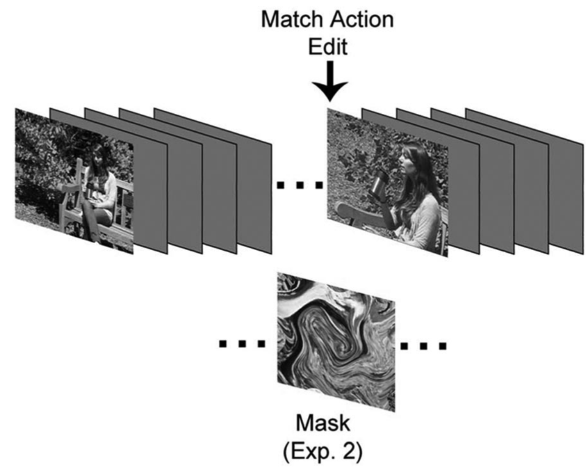

Figure 1. Participants viewed video clips of a woman drinking from a mug in which a match-action edit occurred that continued the movement from a different camera angle. In Experiment 2, a 167-ms pattern mask was inserted between shots.

Experiment 1

Method

Participants. Forty-eight undergraduates (20 women and 28 men, mean age = 20.9 years) received course credit through the Research Participation Program administered by the Department of Psychology, University of California, Berkeley, or were paid for participation.

Stimuli and design. Two different actions were recorded by using two cameras each mounted on a tripod running simultaneously. One action depicted a seated woman drinking from a mug (approximate 5 s). The other action depicted a standing woman receiving a call from her cell phone (approximately 3.8 s). For each action sequence, one camera was placed in front of the woman with the image framed as a long shot. The second camera was placed to the right with the image framed as a medium shot. For each action, 31 stimulus clips were trimmed and edited with each presenting the same portion of the long shot followed by a variable portion of the medium shot. The long shot began with the woman in a stationary position and ended approximate 500 ms after the initiation of the action (i.e., lifting of the mug or cell phone). The cutpoint of the first shot was selected by one of us with film editing expertise (T.A.S.) as a reasonable point for a typical match-action edit. The second shot continued the motion (Figure 1). For each action sequence, one of the clips showed the action in real time so that the second shot continued without any temporal interruption (i.e., a straight cut). A set of 15 overlap cuts were constructed by adding earlier frames to the second shot such that each consecutive clip presented an extra frame (42 ms) of the action. For another 15 clips, succeeding frames after the cut were removed from the second shot. These clips "jumped" the action ahead in time one frame (42 ms) at a time.

Procedure. Participants were seated approximately 20 in in front of PC-controlled 18-inch cathode ray tube (CRT) monitor with the stimulus clips embedded as pages within a HTML-based computer program. The first clip shown was one with the greatest amount of overlap or jump. This initial clip was easily perceived as disjointed in movement, and participants were told that they would be viewing other clips and selecting the one with the smoothest movement. On the screen were arrow buttons that were used to advance to different versions that either added more frames after the edit (right arrows) or deleted frames after the edit (left arrows). Participants could add or delete frames in large (five frames) or small increments (one frame) by clicking a button with two arrows or one arrow, respectively. Participants were not told precisely how many frames were actually advanced for each button press.

Participants were allowed to view a clip as often as needed and decided whether the clip depicted a smooth action or whether it was necessary to add or remove frames from the second shot. Participants were told that there was no right or wrong answer and to click the "Best" button when a clip was perceived as depicting the smoothest action. Following the first "Best" decision, participants started with the other extreme clip (most overlap or most jump cut) and again advanced to various clips until they determined the "Best" clip. The order of the two starting positions was counterbalanced across participants. Half of the participants judged the smoothest action for the drinking sequence, and the other half judged the smoothest action for the phone answering sequence.

Results and Discussion

Participants' determination of the smoothest action was based on the average of the two "Best" measures, with zero referring to a preference for a straight cut (no bias), negative numbers referring to the number of frames taken away from the second shot to perceive a smooth edit (jump-cut bias), and positive numbers referring to the number of frames added to the second shot (i.e., overlap bias). There was a significant overlap bias in the perception of smooth movement for both the drinking and phone answering action. For the drinking action, the average overlap bias was 3.0 frames (125 ms), which was significantly above a zero bias, $t = 5.09$, $p < .01$, $SD = 2.89$. For the phone-answering action, the average overlap bias was 3.1, which was also significantly above a zero bias, $t = 6.80$, $p < .01$, $SD = 2.21$. Figure 2 shows the combined frequency distribution of scores ($n = 48$) for the two action sequences. As shown in the figure, 40 of 48 participants exhibited an overlap bias, which affirmed by a binomial test ($p < .0001$), exemplifies the significant overlap bias in perceiving smooth movement across match-action edits.

Experiment 2

The findings from Experiment 1 suggested that match-action edits disrupt cognitive processing such that the viewers appeared "blind" to sensory information across the edit. As a result, the perception of smooth movement required a repetition or overlap of the action. Typical match-action edits, however, involve rather large changes in camera angle (usually greater than 30º), thus the entire visual array appears shifted across shots. Perhaps it is this disruptive shift in visual angle that demands an overlap in action across edits. Conversely, it may be that the focus of movement across match-action edits drives attention so strongly that any disruptive change in the visual input is not seen or appreciated. In this experiment, a brief but noticeable (167 ms) pattern mask was inserted between match-action edits. A second set showed the same first shot (woman drinking), but after the mask the action continued without any change in camera angle, though with varying amounts of temporal alignment (i.e., overlap, straight, or jump cuts).

Method

Participants. A total of 48 undergraduates (27 women and 21 men, mean age = 22.6 years) received course credit through the Research Participation Program administered by the Department of Psychology, University of California, Berkeley or were paid for participation.

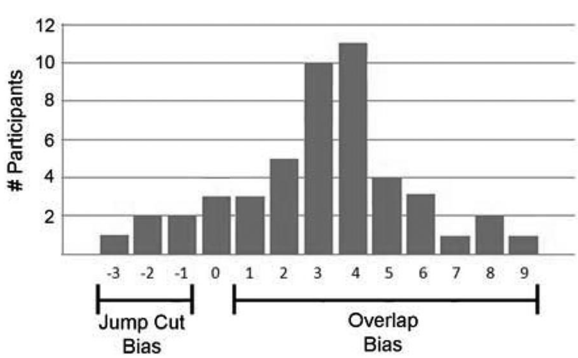

Figure 2. Frequency distribution of the video clip judged as depicting the smoothest movement across edits with respect to movement occurring in real time (straight cut, 0 bias), jumping ahead in time (jump cut bias, negative numbers), or repeating itself (overlap bias, positive numbers).

Stimuli and design. From the drinking action video used in Experiment 1, the 31 clips were modified by inserting a 4-frame (167-ms) mask between the initial long shot and medium shot. The mask was an abstract pattern that included the same colors as the initial frame used in the video clip (Figure 1). Another set of 31 clips was constructed by using the same initial long shot and pattern mask, but instead of shifting to the medium shot, the clips simply continued the action using continuing portions of the long shot. One clip in this set showed the action in real time (except for the addition of the mask), 15 clips added consecutive frames after the mask (overlap edits), and 15 clips removed consecutive frames after the mask (jump cut edits). We will refer to the set of clips with the match-action edits (i.e., those used in Experiment 1) as the *match-action* clips and the newly constructed set that continued with the same camera angle shot after the mask as the *continuation* clips. Using a between-subjects design, we obtained judgments of the clip with the smoothest movement separately for the *match-action* ($N = 24$) and *continuation* clips ($N = 24$).

Procedure. The task was essentially the same as that used in Experiment 1. Participants were first shown the clip with the most overlap or most jump cut and instructed to remove or add frames to the shot after the mask and select the clip that showed the smoothest action. Participants were instructed to ignore the mask and consider the smoothest motion as if the mask were not present. Participants made two "Best" judgments, once starting with the most extreme overlap clip and again starting with the most extreme jump cut. The order of the initial starting positions was counterbalanced across participants.

Results and Discussion

For both the *match-action* and *continuation* clips, participants exhibited an overlap bias. Indeed, the *match-action* clips produced a comparable amount of overlap bias as was observed in Experiment 1 in which the same clips were used but without the mask. Specifically, 19 of 24 participants preferred clips with an overlap, and six preferred jump cuts (binomial test, 19 of 24, $p < .01$). The overlap bias averaged 2.92 frames and was significantly different from a zero bias, $t = 2.80$, $p = .01$, $SD = 5.10$. Likewise, for the *continuation* clips, 19 of 24 participants preferred clips with overlap, five preferred jump cuts, and one preferred a straight cut (binomial test, 19 of 24, $p < .01$). The average overlap bias for these clips was 2.31 frames and significantly different from chance, $t = 3.51$, $p < .01$, $SD = 3.51$. A between-subjects t test between the *match-action* and *continuation* clips showed no significant difference in the magnitude of the overlap bias between the two sets, $t = 0.48$, $p = .63$.

These findings demonstrated that a mask interspersed between a match-action edit does not significantly change the magnitude of the overlap bias compared with that observed without a mask. Indeed, the elapsed time taken by the mask was not even appreciated or considered. Moreover, a comparable overlap bias occurred even when the movement after the mask continued with the spatial viewpoint (i.e., same camera angle).

General Discussion

When edits occurred in the middle of an action, the perception of smooth movement required a brief repetition or overlap of the action across edits. Participants appeared to have missed the action across the edit and thus needed repetition of the action in order to perceive smooth movement. When a pattern mask was inserted between edits, participants still required a repetition to perceive smooth movement. This overlap bias was observed even when the same shot (i.e., constant camera angle) continued after the mask.

Participants did not sense that any time had elapsed during the edit, because if they had, they would have preferred jump-cut edits. Consider the following scenario: you see a person walking from left to right, and as the person passes by, you close your eyes for a second. When you open your eyes, you expect the person to have advanced (jumped) ahead to the right, because you are aware that time had elapsed while you eyes were closed and during that time the person's movement continued. Unlike this scenario, participants did not sense that any time had elapsed across edits even when a noticeable mask was inserted. Instead, the movement following the edit had to be repeated rather than jump ahead, as if the abrupt visual change—from the edit alone or with a mask—caused cognitive processes to be momentarily disrupted.

In a previous study of match-action edits, Hecht and Kalkofen (2009) found support for the jump-edit hypothesis. Several differences in the visual display and method may have accounted for the discrepancy between that study and ours. Whereas we used a rather typical match-action edit involving a shot transition in the middle of a body movement, Hecht and Kalkofen (2009) presented an animation depicting a blimp moving slowly from left to right. Also, our participants could make fine adjustments on the order of 42 ms (i.e., one frame) increments, whereas adjustments of the blimp's movement were made in 200-ms increments. Because the observed overlap bias in our study was 125 ms, the measurement sensitivity of the prior study may have limited its effectiveness in observing such bias effects. Finally, it may be that a blimp moving slowly across the screen is similar to the experience of closing your eyes for a moment as a person walks by. If one perceived that time had elapsed across the edit, then a jump-cut bias would be expected.

The present study considered typical match-action edits and found that a three-frame overlap was required for viewers to perceive smooth movement across edits. It is possible, however, that the magnitude and even the direction of this bias could depend on contextual factors, such as the degree to which an edit disrupts the spatial frame of reference or amplifies the emotional impact of the drama. In a match-action edit that occurred in *The Unbearable Lightness of Being,* the film editor inserted a 10-frame overlap of the action (W. Murch, personal communication, November 8, 2011). In this case, a camera shot of the character, Sabina (Lena Olin), bending down, cut to a shot of her reflection in a mirror. It may be that higher-order attentional and spatial representational processes were needed to be invoked, which took time, and thus required significant overlap in action to be perceived as a natural movement. Another factor is that we have become acclimated to "intensified" editing (see Bordwell, 2002), such as the rapid and often jerky editing style in contemporary action movies, and we may prefer jump-cut editing if the emotional context (e.g., chase scene or erratic fight sequence) suggests such influences. Thus, cognitive factors beyond mere sensory suppression effects associated with blinks, saccades, or pattern masking may play a significant role in the way we respond to film editing techniques.

As described by attentional synchrony (Smith, 2013) and change blindness (Levin & Simons, 1997; Levin & Varakin, 2004), filmmakers rely on movement as a potent attractor of eye gaze and insert "invisible" edits at moments when attention is particularly focused on a movement. By playing on the viewer's attentional focus, they create a sort of magician's sleight of hand, drawing on optimal moments when attention can be distracted away from shot transitions. In this way, filmmakers have acquired knowledge about the cognitive demands of viewing movies and know when to insert an edit just as a magician knows when to conceal a coin or reveal a playing card.

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