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Event segmentation during first-person continuous events

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An important aspect of event cognition is the segmentation of activity into events. However, much of the research of event segmentation has involved materials that are very highly structured narratives or well-scripted everyday activities. The aim of the current work was to assess whether similar event segmentation would occur in first-person perspective events that were more continuous, weak in narrative structure, and less scripted. In this study, people viewed a series of videos of a first-person interactive environment and were asked to make event segmentation judgements. A content analysis of the videos was also done to compare with the event segmentation judgements. The data indicated that viewers monitored multiple dimensions of continuity when viewing the videos. Moreover, the perception of event boundaries was similar to research on narrative text and film, although there were some notable differences. Finally, there was evidence that viewers perceived a hierarchical structure of implicit goals such that shifts in the superordinate goals had a larger impact on event segmentation than subordinate goals. These data suggest that people construct event models for these sorts of events and speak to the generalisability of the event model construct to real-world experiences.

Keywords: Continuous events; Event segmentation; First-person experiences.

Life is just one thing after another, and to succeed in the world, we need to break this stream of action into its component parts by the process of event segmentation. Event segmentation is a fundamental idea for multiple theories of event cognition. For example, Event Segmentation Theory (Swallow, Zacks, & Abrams, 2009; Zacks, Speer, & Reynolds, 2009) suggests that when discontinuities in experience occur, this results in the identification of an *event boundary* and the creation of a new event model. The Event Indexing Model (Zwaan, Langston, & Graesser, 1995; Zwaan, Magliano, & Graesser, 1995; Zwaan & Radvansky, 1998) provides some suggestions about the dimensions of experience people monitor, such as agents, goals, causality, space, and time. When shifts along these dimensions occur, people are likely to experience an event boundary and update their event models, which

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may result in an increase in processing time. The Event Horizon Model (Radvansky, 2012; Radvansky, Krawietz, & Tamplin, 2011; Radvansky & Zacks, 2011, 2014) suggests that the segmentation of activities into events influences both what is currently available in working memory and the ease with which information is later retrieved from long-term memory.

Events are comprehended through the processes of event model construction and processing. Event models are a form of mental models (Johnson-Laird, 1983; Van Dijk & Kintsch, 1983; Zwaan & Radvansky, 1998) that refer to specific events, as compared to system models that refer to one's more general understanding of how a system works (such as a device or mathematical procedure) (Radvansky & Zacks, 2014). Event models themselves are divided into *situation models*, following the current research tradition, which are derived during language comprehension, and *experience models*, which are derived from perceptual/motor experiences, such as film or interactive events. For our purposes, we use the term *event model* here because our concern is the mental representation of specific events, and we wish to assess ideas that are not strongly tied to either language or perceptual/motor experience, but which may cut across them.

A number of studies of event cognition have involved assessing the influence of event segmentation on cognition for highly structured activity, such as narrative texts (Zwaan & Radvansky, 1998), narrative film (Magliano, Miller, & Zwaan, 2001; Magliano, Taylor, & Kim, 2005), or films of highly scripted everyday events (e.g., washing dishes, building a cabinet, washing a car) (Newtson, 1973; Newtson & Engquist, 1976; Zacks, Braver et al., 2001; Zacks, Speer, Swallow, Braver, & Reynolds, 2007). These studies suggest that people segment events using prior knowledge (Bower, Black, & Turner, 1979; Graesser & Nakamura, 1982), implicit and explicit features of the event (Magliano et al., 2001; Zacks, Tversky, & Iyer, 2001; Zwaan, Langston, et al., 1995; Zwaan, Magliano, et al., 1995) and formal characteristics of a narration, such as tense and aspect (Magliano & Schliech, 2000) or cinematic form (Magliano et al., 2001).

However, many events that people deal with on an everyday basis are more fluid, autobiographical and outside of the highly structured context of a guided narrative. It seems unlikely that the segmentation processes involved in parsing a stream of activity into separate events derive from processes created for narrative comprehension. Instead, it seems more likely that our understanding of narrative structure derives from how we parse up the stream of everyday activity and events. The purpose of the current study was to assess whether this segmentation that is observed with highly structured activities, such as narratives (e.g., Magliano, Kopp, McNerney, Radvansky, & Zacks, 2011) and stereotypical, generic activities (e.g., washing dishes), would also be observed in less crafted scenarios. An alternative possibility is that the event segmentation that has been observed in prior work is a reflection of the high degree of structure provided by an existing narrative or by the structure of a strong pre-existing script in long-term semantic memory, and will not be found in less structured action.

There is already some support for the idea that event segmentation influences cognition in less structured events. For example, it has been found that memory is impaired when people move from one room to another (Radvansky & Copeland, 2006; Radvansky et al., 2011; Radvansky, Tamplin, & Krawietz, 2010), and, in other circumstances, the distribution of information across events can improve memory (Pettijohn, Krawietz, Tamplin, Thompson, & Radvansky, in press). Thus, the segmentation of events outside of a highly structured context can influence performance. However, the degree to which the segmentation itself resembles that observed with more structured scenarios is unclear. What is absent here is an extensive assessment of how people segment activity across a range of event changes.

So, the aim of the current study was to assess segmentation during ongoing events in which a person is passively viewing, but not playing, a continuous, less scripted event. To this end, we assessed performance in the context of a first-person videogame (*Quake II*). There are several reasons why the use of captured video from first-person gameplay in this study would extend our understanding of segmentation for episodic experiences relative to materials used in prior research. First, with narrative films, the events are filmed and camera shots are edited in such a way that there are strong exogenous forces on the attentional control of eye movements (Loschky, Larson, Magliano, & Smith, 2013; Magliano, Loschky, Clinton, & Larson, 2013; Smith, 2012; Smith & Henderson, 2008). As such, viewers are directed towards features of a film that are most central to the event structure of the plot. In contrast, first-person games require the player to move through the virtual environment and they have a relatively greater degree of freedom as to where they look in the virtual environment. We see video of first-person gameplay as a step closer to how people segment events when they navigate through the real world than previously used materials.

Second, along with the freedom to look wherever they wanted to look, game players chose what actions to take at any moment in time. Moreover, the sequence of movement and action is not as strongly guided by pre-existing scripts for everyday activities (e.g., doing the dishes, fixing a meal, getting ready for work), and as such, their use is a departure from the everyday activities that have been used in prior segmentation studies (e.g., Zacks & Tversky, 2001). Certainly, there are game schemas that would be developed for first-person games through extended experience. While there is a underlying storyline for the game, it is revealed through cut scenes (i.e., short films that occur between gameplay) that are unrelated, 5-minute clips of gameplay that involve players moving through rooms and responding to enemies and objects that appear as they do so. Therefore, its use was a departure from studies that used commercially produced narrative films that contain a crafted narrative plot corresponding to a stereotypical story schema (e.g., Magliano et al., 2001; Zacks et al., 2009).

Third, there is a growing body of evidence that perspective in narrative affects the nature of mental models that are constructed for texts (Brunye, Ditman, Mahoney, & Taylor, 2011; Brunye, Ditman, Mahoney, Augustyn, & Taylor, 2009; Ditman, Brunye, Mahoney, & Taylor, 2010). These studies show that the use of second-person pronouns (i.e., you) leads readers to simulate events from a first-person perspective (i.e., from the perspective of the actor; Brunye et al., 2009), which has implications on the details of spatial relationships and affective states of characters that get represented and remembered in a mental model (Brunye et al., 2011). If perspective affects the processing of some dimensions of mental models in texts, it raises the question as to whether it matters for visually based events. It is important to note that to our knowledge, there are no studies that explore the impact of perspective on event segmentation.

Finally, one of the salient and interesting aspects of video gameplay is that players have a range of actions they can take from moment to moment, a characteristic that is absent from much of the other prior work on event cognition. We adopted a view that the cognitive processes involved in processing such less structured events are also involved in the processing of formal narrative events (Copeland, Magliano, & Radvansky, 2006; Magliano, Radvansky, & Copeland, 2007; Magliano et al., 2001). This is also consistent with the idea that memory representations for narrative experiences can serve as vicarious autobiographical memories and presumably are similar to episodic memories for real-world experiences (Copeland et al., 2006; Radvansky, Copeland, & Zwaan, 2005). As such, there is reason to believe that theories of event cognition will apply equally well to both more free-form and more formal narrative event sequences.

1.1. Event model structure

To assess whether less pre-structured events are segmented in a manner consistent with those more highly scripted or formal narrative events used in prior research, as we believe to be the case (Copeland et al., 2006; Magliano, Skowronski, Britt, Güss, & Forsythe, 2008), we need to understand what kinds of event changes have been thought to indicate where event segmentation might occur. According to the Event Indexing Model (Zwaan & Radvansky, 1998), there are a number of dimensions that people monitor for event changes (see also Rapp & Taylor, 2004; Rinck & Weber, 2003; Scott-Rich & Taylor, 2000; Therriault & Rinck, 2007; Zacks et al., 2009). First, the *spatial–temporal framework* is the time and place where the event takes place (e.g., Morrow, 1990; Radvansky & Zacks, 1991; Radvansky, Zwaan, Federico, & Franklin, 1998).

Second, event models contain tokens that reflect the salient *entities* that are part of an event. These entities may be agents (people or animals), objects or abstract concepts. When the situations involve goal-directed or functionally interacting agents, then these agents are more strongly represented (Radvansky, Spieler, & Zacks, 1993; Radvansky & Copeland, 2000; Scott-Rich & Taylor, 2000).

Third, an important part of event model structure is causal relations. This reflects the prevailing importance of the derivation of causal connections (or their near approximations) across a wide range of cognitive phenomena, including perception (e.g., Michotte, 1945), learning (e.g., Pawlow, 1923), memory (Radvansky & Copeland, 2000), problem solving (Pennington & Hastie, 1993), language comprehension (Myers, Shinjo, & Duffy, 1987) and social judgements (Hastie, 1983).

When intentional entities are involved, these causal relations may be reflected in the structure of an organised set of *goal episodes* (see also

Graesser & Clark, 1985; Suh & Trabasso, 1993; Trabasso, van den Broek, & Suh, 1989). For narratives, characters typically have a set of goals and subgoals that are the basis for the plot structure (Goldman, & Varnhagen, 1986; Mandler & Johnson, 1977; Thorndyke, 1977; Trabasso et al., 1989). These goal episodes can be broken down into an *initiating event* that causes an agent to *psychologically react* (e.g., affectively respond) and formulate *goals* to solve a conflict that was created by the initiating event, leading agents to engage in *actions* directed towards accomplishing the goals, which then lead to *outcomes* that will either reflect goal failures or goal successes (Trabasso et al., 1989; Stein & Glenn, 1979). Goal episodes are monitored closely when readers comprehend a text, generating inferences about the goals of characters (Long & Golding, 1993; Lutz & Radvansky, 1997; Radvansky & Curiel, 1998; Suh & Trabasso, 1993; Trabasso & Suh, 1993), and the availability of these goals waxes and wanes throughout the narrative in accordance with its status (i.e., whether it is accomplished) (Lutz & Radvansky, 1997; Suh & Trabasso, 1993) and the number of goals a reader is tracking (Magliano & Radvansky, 2001).

Finally, event models may be joined by *linking relations*, such as temporal and causal relations that provide a basis for achieving coherence (Zwaan & Radvansky, 1998). Temporal and causal relationships are particularly well monitored during reading. Additionally, causal and temporal connectivity are strong predictors of sentence fit judgements made while reading (Magliano, Zwaan, & Graesser, 1999).

In sum, event models are multidimensional and people monitor changes along these dimensions as an event unfolds. Shifts along these dimensions indicate that the current model is no longer relevant. As such, the model needs to be modified, or a new one constructed. When these changes are detected, an event boundary occurs, and the event model is updated.

1.2. Overview of the current study

In this study, people watched videos of the gameplay from a first-person shooter videogame (*Quake II*) and we assessed the extent to which the event features influenced the perceptions of event segmentation. A formal analysis of the event structure of the videos was guided by the Event-Indexing Model (Zwaan, Magliano, et al., 1995; Zwaan & Radvansky, 1998).

The most direct way of assessing event segmentation is to ask people to indicate where the boundaries between unfolding events occur (Magliano et al. 2001; Newtson, 1973; Newtson & Engquist, 1976; Zacks & Tversky, 2001). Previous work has used this approach to study the segmentation of third-person videos or films (Magliano et al., 2001, 2005; Newtson, 1973; Newtson & Engquist, 1976; Zacks et al., 2007) as well as texts (Magliano et al., 2011; Speer & Zacks, 2005). In these studies, there was considerable agreement across people as to the locations of event boundaries, and this segmentation occurred at theoretically defined locations (Zacks et al., 2007; Magliano et al., 2001, 2005).

If event segmentation is part and parcel of our interpretation of the flow of activity in the world, then we would expect to find evidence that viewers monitor changes in multiple dimensions, as with narrative text and film (e.g., Magliano et al., 2001; Zwaan, Magliano, et al., 1995), and segment the videos accordingly. Moreover, there should be evidence of a hierarchy of importance of dimensions akin to what is seen in narratives (Magliano et al., 1999; Rapp & Taylor, 2004; Rinck & Weber, 2003; Zwaan, Magliano, et al., 1995). Finally, there should be evidence for additivity with the likelihood of perceiving an event boundary increasing as a function of the number of dimensional shifts (Magliano et al., 2001; Rinck & Weber, 2003; Zwaan, Radvansky, Hilliard, & Curiel, 1998).

In contrast to this view, if the segmentation of events in prior work is tied to the strong narrative structure or heavily scripted action, then the absence of these qualities would reduce the consistency of the segmentation of these videos. As such, it is possible that with these non-narrative events, the larger understanding of the structure is de-emphasised, and the sorts of updating processes that have been observed in narrative contexts would be reduced or absent.

2. METHOD

2.1. Participants

Thirty-six undergraduates from Northern Illinois University participated for course credit.

2.2. Materials

People watched eight videos of gameplay from *Quake II*, which is a first-person shooter computer game by ID Software and distributed by Activision. Consistent with first-person shooter games, gameplay is viewed from the visual perspective of the main character. During gameplay (on a computer), the player navigated through a series of levels containing several rooms. The rooms contained objects (e.g., weapons, ammunition, health packs) that were critical for successful outcomes as well as agents (i.e., enemies) that attacked the player when the player came in contact with them. The player's goals were to (1) navigate the virtual space, (2) kill as many enemy agents as possible, (3) avoid getting killed, and (4) acquire useful objects. Of these our goals, Goal (2) is a superordinate goal, whereas Goals (1), (3), and (4) are subordinate goals. While one may initially think that (3) might be a superordinate goal, this was less of a priority because players were allowed to restart the game if they were killed. Their primary objective was to kill the enemy agents.

In the game, enemies and objects were generated by algorithms that make their appearance seemingly random to the player, thereby making the structure of the events that make up the gameplay not conform to the constraints of a typical formal story schema. Enemies and objects were distinct from features of the environment with which the player could not interact. Objects were picked up by walking over them and disappeared when they were acquired. Likewise, enemies fell to the ground when they were killed. Finally, player health was indicated by a value at the bottom of the screen. As such, the game was designed so that the major events that make up gameplay were clearly depicted to the player in the videos used in this study.

The gameplay was recorded as part of another study that focused on the impact of coaches on player performances (Copeland et al., 2006; Magliano et al., 2007). Eight participants in the coaching study played the video game *Quake II*. Rather than playing the game from the beginning, the game was set up so that a person started at different levels on different days. The player was seated in a small room at a desk with a computer on it. In a separate room, the gameplay was recorded to DVD video for later analysis, which yielded eight separate videos.

In the context of the present study, people watched approximately 5 minutes of gameplay from each of the eight videos from the coaching study. Each video was selected from a different portion of the game, and from different player–coach dyads. Because the audio from the gameplay included player–coach dialogues, we presented the videos without sound because we were not interested in the impact of that dialogue on performance in the event segmentation task.

2.3. Apparatus

People viewed the videos on a computer screen. A modified version of Media Player Classic was used to present the videos and to collect participant responses. As the video was played, people pressed the space bar on the computer to indicate when an event shift occurred. This program created a file that indicated the time since the start of the video when each space bar press occurred. These times were then compared to the formal analysis of the videos.

2.4. Procedure

Participants were run in groups of one to six and the Appendix contains the instructions given to them. People were told that we were interested in understanding how humans recognise event changes that occur in virtual environments, such as those in video games. They were not given specific instructions about what constituted a change in circumstances, but were told that it was up to them to define what that meant. A modified event segmentation task was used that was similar to the one used by Magliano et al. (2001). Specifically, people were told to keep their right hand on the spacebar and to press it whenever they felt that the situation had changed in the video. The time of these presses were recorded within each game segment to be compared later with the videos.

2.5. Analysis

Before beginning the experiment, the videos of the gameplay were submitted to formal analysis. The videos were segmented into 5-second time bins, which were the unit of analysis for the formal analysis, and there were 600 time bins across all of the videos. The videos were then coded for structural changes in the ongoing situation, player actions, player outcomes and coaches' comments (which were not considered here). With respect to the structural changes in the situation, the time bins were coded for changes in the spatial–temporal framework and the introduction of entities.

Two variables captured changes in the spatial–temporal framework. The first was the time bin itself, which captured the progression of time. Given that time was a continuous variable, time bins were coded for their serial order. The second was movement into a new spatial location, which was defined as a new room in the virtual environment. This was coded as a dichotomous variable such that time bins that contained a new location were coded as a "1," whereas time bins that did not were coded as "0." The remaining variables were also coded as dichotomous variables. For the introduction of new entities, the recordings were coded for the introduction of enemy agents, health packs, ammunition and other objects (e.g., new weapons that could be picked up by the player).

Player actions and outcomes were coded to capture the goal episodes that occurred in the segments. Two categories of player actions were identified. One was if the player acquired items (e.g., health packs, ammunition, or other items) within a time bin. There were separate variables for each object type. The other pertained to gunplay; specifically if the player started or stopped firing a weapon. For player outcomes, the time bins were coded for whether the player got wounded, as indicated by changes in the health bar and the screen gaining a red tint, or killed an enemy agent.

Table 1 contains the frequency of the time bins containing the presence of the predictor variables as well as the bivariate correlation coefficients between the predictor variables. The coefficients revealed low to moderate relations and ranged from −.16 to .61.

3. RESULTS

There were several analyses done on the segmentation data. First a series of regression analyses assessed whether viewers were sensitive to changes in the events identified via the formal analyses. Second, follow-up analyses were done on the mean *b*-weight's to determine the relative impact of changes in the components specified by the Event Indexing Model (Zwaan & Radvansky, 1998) on the event change judgements. Third, other follow-up analyses were done to assess the relative impact of changes in goal episodes on the event change judgements.

For the first analysis of the segmentation data, an approach developed by Lorch and Myers (1990) was used that involved conducting separate logistic regression analyses on each person's data. The unit of analysis was the time bin and the dependent variable was whether the participant indicated an event change. There were 13 predictor variables: time bin, player location shift, appearance of an enemy agent, appearance of health packs, appearance of ammunition, appearance of other items, picking up a health pack, picking up ammunition, picking up other items, start firing a weapon, stop firing a weapon, getting wounded and killing an enemy fighter. These predictor variables were simultaneously entered into the regression equations, *b*-weights were

TABLE 1
Frequency of occurrence and bivariate correlations between the predictor variables

	Frequency	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
1. Time bin	–	−0.05	**−0.12**	−0.07	**−0.16**	−0.06	**−0.12**	**−0.12**	−0.02	−0.10	−0.03	−0.05	**−0.09**
2. New Space	93		**0.11**	**0.09**	0.05	**0.11**	−0.01	−0.04	0.06	−0.03	0.00	0.00	−0.08
3. Enemy	77			−0.03	**0.11**	**0.09**	**0.41**	**0.2**	−0.10	0.01	0.02	**0.24**	**0.27**
4. Health	50				0.08	**0.12**	−0.07	−0.05	**0.28**	0.00	−0.03	−0.04	−0.01
5. Ammunition	42					**0.14**	0.10	**0.09**	−0.01	**0.33**	0.01	0.06	**0.16**
6. Other items	31						−0.10	0.04	0.04	0.04	0.18	−0.04	**0.08**
7. Gun start	116							**0.59**	**−0.12**	−0.01	−0.06	**0.33**	**0.38**
8. Gun stop	113								**−0.11**	0.01	−0.06	**0.29**	**0.61**
9. Pick up health	49									−0.02	0.03	−0.07	**−0.10**
10. Pick up ammunition	34										0.06	−0.07	0.05
11. Pick up other	25											−0.05	−0.01
12. Wounded	73												**0.26**
13. Kill	81												–

Bolded coefficients had an alpha <.05.

TABLE 2
Mean *b*-weights from the logistic regression analyses

Predictor variables		*Mean b-weight*	*SD*	*t* (1, 35)
Situational variables				
Spatial–temporal framework				
	Time bin	−0.02	0.01	**8.59**
	Space	0.40	0.32	**7.77**
Entity				
	Enemy	0.51	0.55	**5.78**
	Health	0.23	0.44	**3.22**
	Ammunition	−0.25	0.37	**4.25**
	Other items	−0.20	0.58	**2.17**
Player action variables				
Primary goal (kill enemy)				
	Gun start	0.18	0.34	**3.27**
	Gun stop	0.22	0.49	**2.75**
Secondary goals (acquire items)				
	Pick up health	−0.12	0.44	1.69
	Pick up ammunition	−0.21	0.68	1.93
	Pick up item	−0.02	1.12	0.03
Player outcomes variables				
	Wounded	−0.02	0.39	1.12
	Kill enemy	0.10	0.57	0.38

Bolded *b*-weights indicate that $p < .05$.

extracted from the regression analyses, and then mean *b*-weights were tested against 0 to determine if a predictor was significant.

Table 2 contains the mean *b*-weights derived from the regression analyses. The likelihood of perceiving a change in situation increased as a function of the presence of a spatial shift, the introduction of an enemy, introduction of health packs, starting gunfire and ending of gunfire. The likelihood of perceiving a change in situation decreased as time progressed, the presence of ammunition and the presence of other items.[1]

A subsequent analysis was done to assess the relative impact of the dimension shifts. Specifically, average *b*-weights were computed for the variables associated with the spatial–temporal framework (i.e., space and time bin), entity–agent (i.e., enemy agent), entity–object (i.e., health packs, ammunition, other objects), actions associated with the superordinate goal (i.e., gunfire starting and stopping) and actions associated with the subordinate goals (i.e., pick up health, pick up ammunition and pick up other items). The mean *b*-weights for the dimensions were .19, .52, −.08, .20, and −.10, respectively.

A one-way, repeated-measures ANOVA using these mean *b*-weights, was significant, $F(4, 152) = 21.39$, mean square error (MSE) = .145, $p < .01$. Post hoc analyses (Tukey) revealed that the mean *b*-weight for enemy agents was greater than that of the other dimensions. The mean *b*-weights for shifts in the spatial–temporal framework were not statistically different than shifts associated with the primary goal, but were different than shifts for entity–objects and subordinate goals. The mean *b*-weights for shifts in the superordinate goal, subordinate goal and entity–objects were not statistically different. These results indicate that the perception of event boundaries was differentially affected by situational shifts. The introduction of an enemy agent had the greatest impact on event boundary perceptions, followed by shifts in spatial–temporal framework and superordinate

[1] An analysis was done to determine if there were lag effects. That is, did the impact of a change in an event dimension influence the perception of a boundary in the subsequent time bin. Lag effect variables were created for each dimension and the same procedure was followed for the regression analyses reported in Table 1. There was a significant increase in the likelihood of perceiving a boundary for spatial shifts (Mean $b = .22$, $SD = .38$, $t\ (1, 38) = 3.52$, $p < .01$) and starting gunplay (Mean $b = .36$, $SD = .43$, $t\ (1, 38) = 4.99$, $p < .01$). These two variables were also significant in the analyses reported in Table 2. Finally, there was a significant decrease in the perception of event boundaries as a function of getting wounded during gunplay (Mean $b = -.26$, $SD = .35$, $t\ (1, 38) = 4.31$, $p < .01$). Players tended to get wounded in the context of a gun battle and as such, it was not likely that viewers perceived an event boundary in the subsequent time bin.

goal actions. Subjective event boundaries were not influenced by the introduction of objects and actions associated with the subordinate goal.

A third analysis was done to determine the impact of the type of episode (i.e., superordinate and subordinate goal episodes) and the relative importance of episode boundaries (i.e., the beginning and end of episodes) on the situation change scores. Type of episode referred to superordinate (kill enemy agents) and subordinate (acquire item) goal episodes. The results of the analyses reported above suggest that the acquisition of health packs was the only subordinate goal that had a significant positive impact on the identification of event boundaries and so, it was the only subordinate goal used here. With respect to episode boundaries, we identified time bins that contained the initiating events that started the episode and the outcomes that concluded the episode. The initiating events for the superordinate goal were the appearance of enemy agents and the outcomes were the killing of them. The initiation event of the subordinate goal was the appearance of health packs and the outcomes were their acquisition. A 2 (episode type: superordinate vs. subordinate) × 2 (position: initiating events vs. outcomes) repeated-measures ANOVA was done. The analyses revealed a main effect of episode type, with larger *b*-weights for superordinate (M = .32) than subordinate goal episodes (M = .05), $F(1, 36) = 8.91$, $MSE = .132$, $p < .01$. There was also a main effect of position in the episode, with larger *b*-weights for variables associated with the initiating events (M = .37) than the outcomes (M = .00), $F(1, 36) = 26.16$, $MSE = .132$, $p < .01$. The episode type × position interaction was not significant.

A fourth and final analysis was done to test the additivity assumption. The number of event shifts present in each time bin was computed. Because the frequency of time bins that contained multiple shifts dropped dramatically from two to three shifts, we classified four types of time bins: No shifts ($N = 257$), one ($N = 137$), two ($N = 112$), and three or more shifts ($N = 94$). We computed the proportion of time bins within each level of shift that contained an event segmentation judgement for each participant. A one-way ANOVA indicated that there was a significant increase in the likelihood of perceiving an event boundary as a function of the number of shifts, $F(3, 114) = 74.01$, $MSE = .00273$, $p < .01$. Post hoc tests (Tukey) revealed that time bins with three or more shifts had the highest likelihood of event segmentation judgements (M = .37, SE = .031), followed by bins with two shifts (M = .29, SE = .028), followed by bins with one shift (M = .26, SE = .028), followed by bins with no shifts (M = .21, SE = .021).

4. DISCUSSION

In this study, we assessed the extent that event models for less structured and scripted experiences have similar structural features as event models for formal narrative and well-scripted experiences. The Event Indexing Model provided the theoretical framework that guided a content analysis of our videos. The data showed that viewers perceived event structures akin to that seen with more highly structured experiences. Specifically, people perceived event boundaries when salient and important new entities were introduced (enemy agents and health packs), when there was movement to a new distinct region of space and when the first-person agents started or stopped actions associated with the superordinate goal. This is consistent with the idea that readers monitor multiple aspects of continuity when building event models (Magliano et al., 1999; Rapp & Taylor, 2004; Rinck & Weber, 2003; Zwaan, Langston et al., 1995; Zwaan, Magliano, et al., 1995; Zwaan & Radvansky, 1998).

The current data also suggest that viewers segmented these events along the lines found with more formal narratives (e.g., Zwaan, Magliano, et al., 1995). Moreover, there is also some use of a hierarchical goal structure, consistent with research on narrative texts and film (e.g., Suh & Trabasso, 1993; Magliano et al., 2005) and videos of everyday activities (Zacks & Tversky, 2001). Specifically, changes in the superordinate goal (kill enemy agent) had a larger impact on event boundary perception than changes in a subordinate goal (e.g., pick up objects). Moreover, the beginning of goal episodes had a larger impact on event boundary perception than episode endings. This can be explained in terms of differences in the level of uncertainty of future events at the beginning and ending of goal episodes. There was a high level of uncertainty regarding the outcome of a goal episode at the beginning, but there was a high level of certainty at the end (e.g., after killing all the enemies in a room, the player was fairly certain of the outcome of going to the next room).

The results of the current study are consistent with prior research on text comprehension that indicates that comprehenders monitor superordinate goals more closely than subordinate goals (Long &

Golding, 1993; Long, Golding, & Graesser, 1992; Suh & Trabasso, 1993). However, the extent to which segmentation judgements are sensitive to changes in subordinate action is clearly affected by the nature of the instructions (Zacks & Tversky, 2001). Zacks and colleagues typically have people make segmentation judgements in two ways, using coarse- or fine-grained criteria. Coarse-grained judgements involve people considering the largest meaningful event, whereas fine-grained judgements involve people considering the smallest meaningful unit. Fine-grained judgements are nested within coarse-grain judgements with fine-grained judgements reflecting changes in subordinate actions and coarse-grained judgements reflecting changes at a superordinate level (Zacks & Tversky, 2001). In the present study, people considered changes at the level of the situation. The instruction used here has also been used by Magliano and colleagues in previous event segmentation studies that explored the relationships between situational dimensions in narrative text and film (Magliano et al., 2001, 2005, 2011). Importantly, there is evidence that both the instructions used in this study (Magliano et al., 2001, 2005, 2011) and those used by Zacks et al. (2009) are correlated with shifts in situational dimensions.

Additionally, there was support for the presence of additivity in the influence of more than one event break during viewing. Specifically, there was an increase in the likelihood of perceiving an event boundary as a function of the number of event shifts. This is consistent with the Magliano et al. (2001) study that examined narrative film. In addition, there is evidence that there are interactive effects between dimensions (Magliano et al., 2001; Rapp & Taylor, 2004; Rinck & Weber, 2003). Magliano et al. (2001) found evidence that spatial shifts at cut points in a narrative film only had an impact on the perception of an event boundary when they co-occurred with shifts in time. The nature of these videos does not afford a manageable exploration of such interactive effects, but it is likely that they operate here as well.

Given our conclusion that first-person experiences are segmented along many of the same principles as other perspectives on an event, is it the case that perspective does not matter for cognition more generally? We think that it does because there is a growing body of research suggesting that perspective does matter for some aspects of situation model processing for narrative text (Brunye et al., 2009, 2011; Ditman et al., 2010), such as picture–description matching, and off-line measures such as the speed and accuracy of recognition probe or comprehension questions answering. It is important to note that to date there are no studies of the impact of perspective on online event segmentation, and our study does not compare segmentation for first- and third-person experiences. This remains an issue that needs to be explored; although given the parallels between our work and existing third-person perspective event segmentation studies (Magliano et al., 2001, 2005; Zacks et al., 2009), the likelihood of finding any meaningful differences is slight. Still, it is possible that, as with texts, perspective may serve to push around the relative prominence of various event dimensions (Brunye et al., 2011), depending on the nature of the particular events at hand.

It is important to acknowledge that the shifts in dimensions occurred at different frequencies (see Table 1), as will happen when using naturalistic materials (see Magliano et al., 2001). While close examination of the frequencies reported in Table 1 and pattern of significance does not suggest a serious confound, the relationship between the frequency in which a shift occurs and its impact on segmentation warrants further investigation. It is possible that how often shifts in a particular dimension occur could affect salience and therefore affect segmentation judgements. However, the current data do not afford a close examination of this issue.

The fact that we used gameplay from a first-person shooter video game begs the question as to whether experience with these games matters. Indeed, it is well documented that prior knowledge of complex events (e.g., baseball) affects comprehension for texts about those events (Voss, Vesonder, & Spilich, 1980). Data on expertise with first-person shooter games or *Quake* was not available in the present study. However, while prior knowledge can affect narrative text comprehension and memory (e.g., Long & Prat, 2002; Voss et al., 1980), this seems unlikely in the current study given the simplistic nature of the goal episodes of the game and the fact that situational changes tend to be fairly prominent here. Moreover, prior gaming experience is more likely to influence what actions should be taken when one is an active participant in the game (e.g., Frey, Hartig, Ketzel, Zinkernagel, & Moosbrugger, 2007), not when one is a viewer simply deciding where one event ends and another begins. Expertise would play a more important and influential role in segmenting complex and dynamic events that do not have an immediately apparent rule structure for novice viewers, such as some sporting events (e.g., cricket games, hockey games).

In sum, this is the first study to explore event models in the context of non-narrative, non-scripted experiences. Viewers construct event models that share many features with those models constructed to comprehend more structured events. This is consistent with the idea of narrative comprehension as a simulated autobiographical experience (Copeland et al., 2006; Magliano et al., 2008). It seems sensible that language comprehension would rely on systems that are involved in understanding the real world. Nonetheless, demonstrating that such an understanding is similar across modalities of experience is important to make, and this has implications as to whether it is possible to have viable general theories of event comprehension (Kintsch, 1998; Gernsbacher, 1990; McNamara & Magliano, 2009; Radvansky & Zacks, 2014) or whether specific theories must be used to address different types of presentation and modality. The present study adds to a growing literature that suggests that such an endeavour is worth exploring (see also Magliano et al., 2011).

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APPENDIX

UNDERSTANDING QUAKE: MAKING SENSE OF VIRTUAL VIDEOGAME ENVIRONMENTS

Thank you for agreeing to participate in this experiment. We are interested in learning about how people understand and make sense of virtual environments, like the kind you find in video games. As one plays a video game, he or she encounters lots of different situations as the game unfolds. Success in the game often depends on how quickly one recognises that the situation has changed and then responds.

We are particularly interested in how people recognise and understand changes in situations that occur as a computer game unfolds. In this experiment, you will watch actual segments of gameplay for the video game *Quake*. If you are not familiar with *Quake*, it is a first-person shooter game. You will watch a character navigate through a building as the game unfolds. You will watch eight segments and each segment is about 5 minutes of gameplay.

While you are watching each segment, we want you to identify when you think that the situation has changed for the player. In particular, we want you to determine if there is a significant change in the game environment that may have implications for the player. Any changes in the game environment may constitute a change in situation. It's really up to you to decide which kinds of changes are worth noting. With that said, it is important to recognise that *Quake* will contain lots of situation changes, as most games of its type.

You will make your decisions by pressing the space bar. YOU MUST KEEP YOUR HAND ON THE SPACE BAR AT ALL TIMES SO THAT YOU CAN PRESS IT AS SOON AS YOU THINK THERE IS A CHANGE IN SITUATION.

In between gameplay segments, there will be a brief blank screen. You will also see a box below the game screen that shows you which mission you are viewing. As such, the box and the blank screen will indicate that there is a new segment of gameplay to consider.

Again, we want you to consider each segment and indicate whenever you think there is a change in situation for the player—you will do so by pressing the spacebar. Please keep your hand on the spacebar at all times.

If there are no questions, you can begin.