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Joseph Magliano [a], Kristopher Kopp [a], M. Windy McNerney [b], Gabriel A. Radvansky [b] & Jeffrey M. Zacks [c]

[a] Department of Psychology, Northern Illinois University, DeKalb, IL, USA

[b] Department of Psychology, University of Notre Dame, Notre Dame, IN, USA

[c] Department of Psychology, Washington University, Saint Louis, MO, USA

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Aging and perceived event structure as a function of modality

Joseph Magliano[1], Kristopher Kopp[1], M. Windy McNerney[2], Gabriel A. Radvansky[2], and Jeffrey M. Zacks[3]

[1]Department of Psychology, Northern Illinois University, DeKalb, IL, USA
[2]Department of Psychology, University of Notre Dame, Notre Dame, IN, USA
[3]Department of Psychology, Washington University, Saint Louis, MO, USA

ABSTRACT

The majority of research on situation model processing in older adults has focused on narrative texts. Much of this research has shown that many important aspects of constructing a situation model for a text are preserved and may even improve with age. However, narratives need not be text-based, and little is known as to whether these findings generalize to visually-based narratives. The present study assessed the impact of story modality on event segmentation, which is a basic component of event comprehension. Older and younger adults viewed picture stories or read text versions of them and segmented them into events. There was comparable alignment between the segmentation judgments and a theoretically guided analysis of shifts in situational features across modalities for both populations. These results suggest that situation models provide older adults with a stable basis for event comprehension across different modalities of expereinces.

Keywords: Aging; Event models; Situation models; Comprehension; Segmentation.

Although there are many declines in cognition associated with cognitive aging such as slower processing speeds (e.g., Salthouse, 1996) and less working memory capacity (Salthouse & Babcock, 1991), there are aspects of cognition that remain stable or even improve that can be used to compensate for areas of decline. The particular focus here is on a relatively preserved ability to process information at the situation model level of language comprehension in the face of well-known declines in processing at

Address correspondence to: Gabe Radvansky, Professor, Department of Psychology, University of Notre Dame, Notre Dame, IN 46556, USA. E-mail: gradvans@nd.edu.

the surface and text-base levels (Radvansky, 1999; Radvansky & Dijkstra, 2007; Radvansky, Zwaan, Curiel, & Copeland, 2001). Situation models are mental representations that capture the underlying referenced event in a narrative (Zwaan & Radvansky, 1998; van dijk & Kintsch, 1983). They consist of inferences that establish how events are related (e.g., causal, temporal, and spatial relationships) and relevant knowledge-based inferences (e.g., schema-based inferences). This is important because older adults may be able to use their relatively preserved processing abilities to compensate for language processing difficulties at other levels. Given that situation models provide a basis for what we typically think of as 'understanding' (Copeland, Magliano, & Radvansky, 2006; Gernsbacher, 1990; Kintsch, 1998; Magliano, Radvansky, & Copleland, 2007), it is encouraging that this aspect of comprehension remains relatively preserved as we age and older adults can use this to compensate for other language comprehension declines.

One important aspect of building a situation model for an event is segmenting it into its component parts (Gernsbacher, 1990; Kurby & Zacks, 2008; Zacks & Tversky, 2001; Zacks, Speer, Swallow, Braver & Reynolds, 2007). Just as everyday events are made up of parts (e.g., washing clothes is made of a series of actions), narratives are comprised of a series of episodes that are hierarchically organized within the narrative plot. Understanding narratives, in part, involves understanding and representing the boundaries between these episodes (Gernsbacher, 1990). The aim of the current study is to explore how event segmentation in both text- and visually-based narratives is influenced by aging. Is this segmentation ability relatively preserved with aging, or is this an aspect of situation model processing that will show declines but has not yet been detected?

Previous results suggest that older adults struggle to segment naturalistic filmed events adaptively (Kurby & Zacks, 2011; Zacks, Speer, Vettel & Jacoby, 2006). In one study, people viewed films of everyday activities (e.g., putting up a tent) and were asked to identify boundaries between events. Each observer segmented each movie twice; once to identify the largest units they found meaningful (*coarse* segmentation), and once to identify the smallest units they found meaningful (*fine* segmentation). People typically show good intersubject and test–retest reliability on this task (Newtson, 1973; Speer, Swallow, & Zacks, 2003). Observers also spontaneously organize fine-grained events hierarchically into larger coarse events (Hard, Tversky, & Lang, 2006; Zacks, Tversky & Iyer, 2001). Compared to younger adults, older adults showed less agreement with group norms (see also Zacks et al., 2006). Older adults also showed less hierarchical organization. These results bear further exploration because segmentation is a basic cognitive process associated with event comprehension, situation models, and memory (e.g., Kurby & Zacks, 2008; Zacks et al., 2007).

Segmentation of everyday activity likely depends on perceptual features such as changes in the position of an actor's hand or the orientation of a cup on a table, and also on conceptual features of the situation such as changes in spatial and temporal location, characters' goals, and emotions (e.g., Zacks et al., 2007; Zacks, Speer, & Reynolds, 2010). If older adults have a preserved ability to process situation-level information, they may segment narrated events more adaptively than naturalistic everyday events, because narration abstracts away extraneous perceptual information. This proposal is related to the finding that older adults are more prone to abstracting from the detailed elements of an event, and processing and retaining information at a more general level (e.g., Koutstaal & Schacter, 1997).

In the current study, we asked whether older adults make use of situation-level information for segmentation in a manner similar to younger adults, or show age-related differences. Specifically, we asked whether younger and older adults' segmentation was sensitive to changes in dimensions of situational processing as proposed by the event-indexing model (Magliano, Zwaan, & Graesser, 1999b; Zwaan, Langston, & Graesser, 1995; Zwaan & Radvansky, 1998). According to the model, the internal structure of a situation model reflects various event dimensions conveyed by a narrative. These dimensions involve entities, their goals, causality, and spatial-temporal framework in which the events take place. When a reader or viewer encounters changes in these dimensions, they must update their model of the situation to deal with the changed information. Thus, understanding and representing a narrative requires that readers are sensitive to changes along these dimensions.

There is evidence that readers and viewers of narratives are sensitive to shifts in situational dimensions. Reading times increase for sentences that convey shifts in event dimensions, including shifts in causal structure (Magliano, Trabasso, & Graesser, 1999a; Magliano et al., 1999b; Zwaan, Magliano, & Graesser, 1995), goals (Magliano et al., 1999a, 1999b; Radvansky & Curiel, 1998), temporal contiguity (Therriault & Rinck, 2007; Zwaan, 1996; Zwaan, Langston et al., 1995), and spatial contiguity (Radvansky & Copeland, 2010; Rinck & Bower, 1995; Zwaan, Magliano et al., 1995). Similarly, there is extensive behavioral and fMRI data indicating that segmentation judgments are highly correlated with shifts in situational dimensions in the context of comprehending a narrative (Magliano & Zacks, 2011; Magliano, Miller, & Zwaan, 2001; Magliano, Taylor, & Kim 2005; Speer, Reynolds, & Zacks, 2007; Zacks et al., 2009; Zacks, Speer, Swallow, & Maley, 2010). Additionally, readers and film viewers are more likely to identify event boundaries when more situational features are changing (Magliano, et al., 2001; Zacks et al., 2010).

Although it is well documented that older adults continue to be sensitive to shifts in situational dimensions as evidenced by reading times (Morrow, Leirer, Altieri, & Fitzsimmons, 1994; Radvansky, Copeland, Berish, & Dijkstra, 2003; Radvansky, Copeland, & Zwaan, 2003; Radvansky & Curiel, 1998; Radvansky et al., 2001; Stine-Morrow, Morrow, & Leno, 2002), to date no studies have investigated the relationship between situational changes and event segmentation in older adults. It should be noted that under some circumstances older adults can have difficulty with situation model processing, such as when there is a need to rely more heavily on text-base information prior to situation model construction (Copeland & Radvansky, 2007) or when a reader needs to keep track of multiple characters (Noh & Stine-Morrow, 2009). Given the importance of segmentation in event comprehension (e.g., Zacks et al., 2007), a study exploring this issue is warranted.

In light of these extensive findings, it is unclear whether this preserved processing with aging are limited to language or text processing, or if there is a more general preservation of event cognition processes. Although, one would expect similar cognitive processes to support comprehension across different media (Baggett, 1979; Copeland et al., 2006; Gernsbacher, 1990; Kintsch, 1998; Magliano et al., 2007), events depicted in text or film may present meaningfully different challenges for comprehension. For example, in texts, linguistic cues direct the readers' attention, thereby facilitation model construction and updating (Givón, 1989; Magliano & Schleich, 2000). In comparison, visual narratives may not explicitly convey information about such things as intentions, knowledge, and characters' emotional states. Moreover, visual narratives are a relatively noisier. It is often the case that visual narratives depict foregrounded actions that occur in the context of a backgrounded field (e.g., in one story used in the present study, a boy is interacting with a frog in the larger context of a pond in the woods). To understand the event in any given illustration, viewers have to identify the event in the foreground from the background, and relate those events to the plot of the story. It is well documented that there are declines in working memory (e.g., Salthouse & Babcock, 1991) and attention (e.g., Hasher & Zacks, 1988) as a function of aging, which could make the derivation of information from visual narratives more challenging for older adults.

The aim of the current study was to further explore the extent of the preservation of situation model processing with aging, which can then be used as a source of compensatory processing for other sorts of age-related declines. Toward this aim, we used a method that can easily compare processing for both visual- and text-based narratives. Specifically, people viewed a series of picture narratives or read text versions of them. The picture versions were commercially produced stories by Mercer Mayer that do not have any printed text. In addition, we derived text versions of these stories such that one or two

sentences were written for each story picture so that it contained the events depicted in the picture.

Identification of event shifts was assessed using a task similar to that used in previous studies of age differences in event segmentation (Kurby & Zacks, 2011; Zacks et al., 2006). In addition, we assessed sensitivity to event changes via a theoretical motivated analysis of narrative structure because event segmentation should correspond to theoretically identified event changes (Magliano et al., 2001, 2005; Zacks et al., 2007). Similarly, we assessed the degree to which segmentation judgments were correlated with a theoretically determined analysis of story structure as a function of modality and age.

If older adults' are sensitive to event structure only for verbal and not visual narratives, then one would expect to observe age-related differences in segmentation judgments for the picture versions but not for the text versions of the stories, consistent with Kurby and Zacks' (2011) finding of age-related differences in event segmentation. However, if narrative event cognition is preserved with aging, more generally, and can be used as a broader source of compensatory processing, then one would expect no age differences in segmentation judgments for narrative event structures.

METHOD

Participants

Fifty-seven younger adults (34 females) were recruited from the undergraduate population from the University of Notre Dame in exchange for course credit in their psychology courses. They ranged in age from 18 to 22 years ($M = 19.63$; $SE = 0.13$). These younger adults were mostly Caucasian (43) with a mean education level of 14.15 years ($SE = 0.14$). Fifty-six older adults (38 female) were recruited from the community in exchange for monetary compensation. The older adults ranged in age from 62 to 92 years ($M = 76.24$; $SE = 0.81$). They were mostly Caucasian (46), with a mean education of level of 15 years ($SE = 0.37$). It appeared that the demographics of the two populations were fairly similar. Eight older adult participants were dropped from the analyses if they did not demonstrate variability in their situation change judgments (i.e., if 90% of the judgments were of one response), but no younger adults were dropped for this reason.

Materials

A set of six stories was prepared as text and picture versions from a series of children's books by Mercer Mayer ('Frog Where are You?'; 'A Boy, a Frog, a Dog and a New Friend'; 'Frog on His Own'; 'A Boy, a Dog, and a Frog'; 'Frog Goes to Dinner'; and 'One Frog Too Many', 1967,

1969, 1971, 1973, 1974, 1975, respectively) that had illustrations depicting the story events with no accompanying text descriptions. The picture version was taken directly from the books and arranged so that each picture was on a separate piece of paper. Each story had a mean length of 26.67 pictures long (range: 24–29). The pictures versions were then arranged in a packet based on publication order. A response sheet was created consisting of numbered thumbnail versions of each picture, and a line next to the thumbnails for responses. The answer sheets held 16 pictures per page, so each story used two pages.

Text story versions were created with a short description (1–2 sentences) for each picture. These were written so that one story was presented on two pages (see the Appendix for an example text version). These text versions conveyed the primary events, actions, outcomes, or reactions that were the foci of the pictures. They contained the same event factors derived from a content analysis of the picture stories (see later).

If there was a temporal ellipsis (missing story time) between two pictures, a temporal adverbial phrase was used (e.g., 'sometime later'). If there was a change in location, a prepositional phrase was used to make the location change apparent (e.g., 'the boy went to a forest'). If there was an event, action, or outcome depicted, the main verb of the text mentioned it. Finally, if a picture depicted a salient affective facial expression, the text described that emotion. The text corresponding to each picture was grouped into units with a blank space after each one (see Appendix). For each story, there was the same number of text units as pictures. About 15 units fit on a piece of paper, and next to each unit was a small box for responses. A separate response sheet was not used for the text versions because the boxes next to the units served this role.

Content Analysis

A content analysis was done on the picture versions to identify the event content. A picture was determined to depict a temporal ellipsis if a substantial amount of story time was missing between it and the prior picture. Nearly all picture pairs depicted some ellipsis because not all actions or events that make up a larger action are depicted. So, temporal ellipsis was judged to occur if more than about 30 seconds were missing from the story. A picture following ellipsis was coded as a 1 and if not it was coded as a 0.

A picture was coded as depicting a change in location if a perceptively different location was present as compared to the just prior picture (e.g., Boy in bedroom in one picture, but in the forest in the next). A new location picture was coded as a 1 and if not it was coded as a 0. With typical narratives, shifts in time and space are low to moderately correlated (Magliano et al., 2001; Zwaan, Langston et al., 1995). However, in these stories they were strongly correlated ($r = .63$) and there were concerns of multi-collinearity. As such,

these two variables were collapsed into one that indicated a shift in time, space or both.

Pictures stories were coded for the introduction of characters. Characters were salient agents who were part of the action depicted in a picture (backgrounded characters in a larger scene did not meet this criteria). Pictures that introduced a new character were assigned a 1 and those that did not were assigned a 0.

Pictures were coded to determine if they depicted a salient affective reaction, based on facial expressions. No distinctions were made with regard to positive or negative valence. If the picture depicted an emotional response it was assigned a 1 and if not it was assigned a 0.

Picture stories were also coded to determine whether the pictures depicted changes in the goal episodes of the primary characters, based on the causal network model (Trabasso, van den Broek, & Suh, 1989). To do this analysis, the first and second authors created verbal descriptions of the goal and sub-goal episodes of the stories. Initiating events were those that happened to the primary character(s). A picture was coded as an initiating event if it depicted an event happening to a character, was unambiguously recognized by the character, and had causal significance on future behaviors. Pictures that were judged to depict initiating events were assigned a 1 and all other pictures were assigned a 0.

Pictures were coded as the beginning of action sequences if they contained either the first action associated with a superordinate or subordinate goal. If the picture was the beginning of a superordinate goal-plan, it was assigned a 2 and if it was the beginning of a subordinate goal-plan, it was assigned a 1. All other pictures were assigned a 0. Pictures were coded as being the end of an action sequence if they depicted either the successful or unsuccessful completion of a superordinate or subordinate goal. If the picture was the end of a superordinate goal-plan, it was assigned a 2 and if it was the end of a subordinate goal-plan, it was assigned a 1. All other pictures were assigned a 0.

Procedure

Story version was treated as a between-participants variable and people were randomly assigned to either the text or picture condition. After informed consent was obtained, the experimenter read a set of instructions. People were told to read or view the six stories following the order they were given and indicate when they thought a change in the story situation occurred. This was done by marking an X either on the line of the picture response sheet or the box next to the text unit. People were not given a definition of a change in situation, but were told that it was up to their own judgment when they sensed that the overall situation was changed. They were told to keep in mind that stories can have many instances of a situation change, although not every

text unit or picture necessarily corresponded to one. Once people had a clear understanding of the procedure, they were given as long as they needed to complete the task.

RESULTS

Three sets of analyses were done. The first assessed whether the frequency of segmentation judgments varied as a function of the modality of the text and population. The second assessed the extent that segmentation agreement varied as a function of these two factors. The third assessed whether there were differences in the correlations between segmentation judgments and theoretically identified situational shifts as a function of these two factors.

Frequency of Segmentation Judgments

The first analysis assessed whether age, modality, and the number of situational shifts influenced the frequency of event boundaries identified. Specifically, we did a 2 (Age: Younger vs. Older adults) × 2 (Modality: Picture vs. Text) × 3 (Number of shifts: Few vs. Moderate vs. Many) mixed ANOVA, with the first two variables being between subjects and the third within. In this analysis, the number of shifts was coded as *Few* (0 or 1; $N = 42$), *Moderate* (2: $N = 34$), or *Many* (3 or more; $N = 22$). The data for this analysis are shown in Table 1.

Older adults identified more event boundaries ($M = 0.40$, $SE = 0.023$) than did younger adults ($M = 0.34$, $SE = 0.022$), F (1, 103) = 4.50, $MSE = 0.079$, $p = .036$, $d = 0.37$. That is, older adults segmented the stories into smaller events. Note that this is the opposite of what was observed by Kurby and Zacks (2011). There were more boundaries identified in picture stories ($M = 0.42$, $SE = 0.022$) than text stories ($M = 0.32$, $SE = 0.022$), F (1, 103) = 9.55, $MSE = 0.079$, $p = .003$, $d = 0.54$. There was a main effect of the number of shifts, F (2, 206) = 254.75, $MSE = 0.005$, $p < .001$,

TABLE 1. Mean proportion of story units containing a situation change judgment as a function of age, story modality, and the number of shifts present in the story units

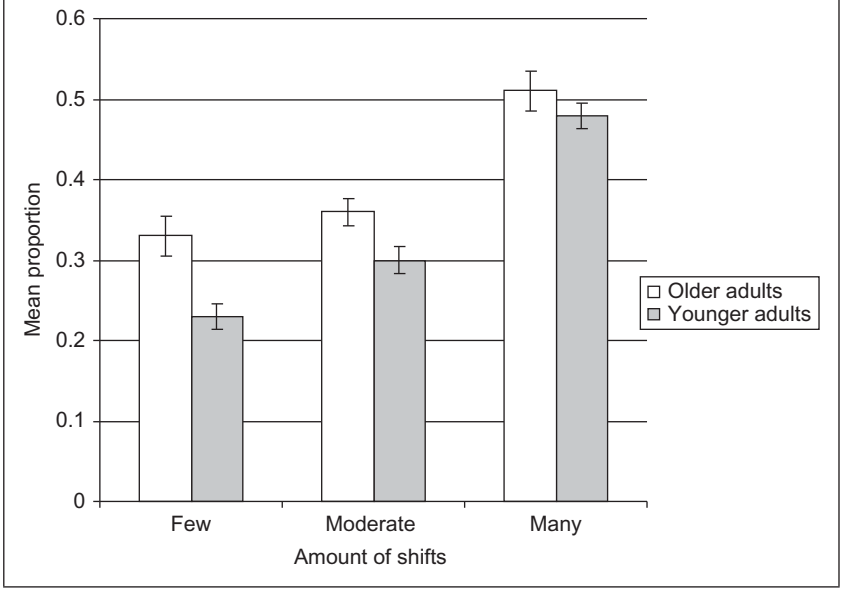
		Number of shifts		
Age	Modality	Few	Moderate	Many
Younger adults	Picture	0.28 (0.03)	0.33 (0.03)	0.53 (0.03)
	Text	0.19 (0.03)	0.26 (0.03)	0.43 (0.03)
Older adults	Picture	0.39 (0.03)	0.42 (0.04)	0.58 (0.04)
	Text	0.28 (0.03)	0.30 (0.04)	0.46 (0.04)

Note: Standard errors are reported in the parentheses.

$\eta^2 = .71$. *Post-hoc* tests (Tukey) revealed that event segmentation judgments increased with an increase in the number of event shifts, paralleling the prior work using reading times (e.g., Radvansky et al., 2001; Zwaan, Langston et al., 1995; Zwaan, Radvansky, Hilliard, & Curiel 1998). Specifically, event segmentation judgments were least frequent when there were few shifts, more frequent when there were moderate shifts, and most frequent when there were many shifts.

As shown in Figure 1, there was a marginally significant Age × Number of Shifts interaction, F (2, 206) = 2.97, $MSE = 0.005$, $p = .053$, $\eta^2 = .01$, indicating that the slopes were different between older and younger adults, although the effect was very small. *Post-hoc* tests (Tukey) revealed that for younger adults, units with few shifts had a smaller proportion of change judgments than units with a moderate proportion, which, in turn, had smaller scores than those with many shifts. For older adults, units with few and moderate shifts had smaller proportion of change score than units with many shifts. We additionally explored differences across groups for the different levels situational change using the Tukey *post-hoc* analysis. Older adults had higher mean proportions for units with few and moderate shifts than younger adults, but they did not differ for units with many shifts. This interaction qualifies the main effect of aging and suggest that older adults were more likely to segment when there were few or moderate shifts than younger adults. No other interactions were significant (all $p > .10$, all $\eta^2 < .001$).

FIGURE 1. The Aging Population × Situation Change interaction. Error bars reflect standard errors.



Segmentation Agreement

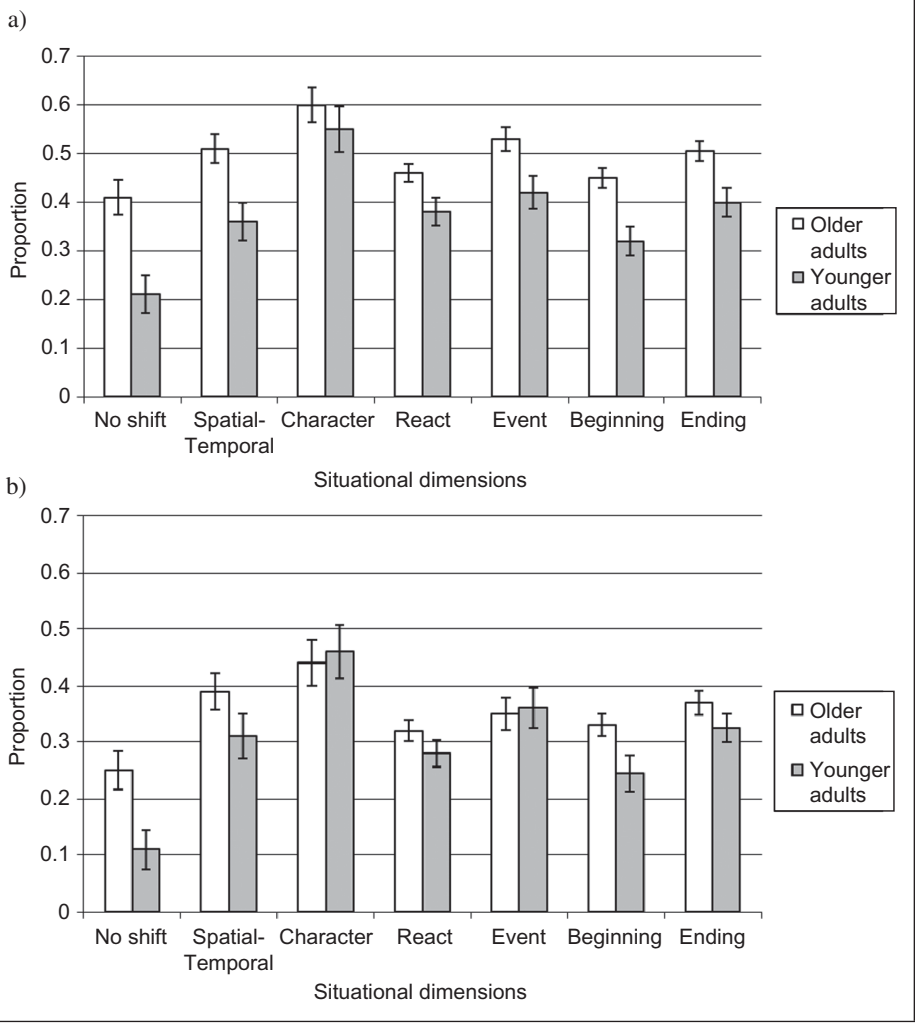
Following Kurby and Zacks (2011), we assessed the degree of agreement in segmentation judgments as a function of population and story modality. This provides an index of how each person agreed with the others of the same age group who viewed the same stimuli (e.g., older adults viewing picture story versions). A representation of the group norm was computed by calculating the proportion of people that indicated that a story unit conveyed a situation change. Separate correlations were computed for each person against this norm. Note that the range of raw correlations is restricted by the number of event changes identified by people. So, the correlations were rescaled to range between 0 and 1; the resulting scores will be referred to as *segmentation agreement* scores. We then submitted to the segmentation agreement scores to a Population $\times$ Modality ANOVA, which revealed a main effect for population such that older adults ($M = 0.75$, $SE = 0.03$) had smaller segmentation agreement scores than younger adults ($M = 0.79$, $SE = 0.03$), F (1, 101) $= 4.22$, $MSE = 0.039$, $p = .04$), $d = 0.24$. There were no other significant effects (all $p > .20$, all $\eta^2 < .001$).

Sensitivity to Situational Shifts

The final set of analyses assessed the extent that segmentation judgments were correlated with shifts in the situational dimension. Figure 2a, b shows the proportion of people that indicated an event change at points containing shifts in the situational dimensions. It is notable that the patterns across ages are very similar, albeit as illustrated earlier, older adults were more likely to make event change judgments than the younger adults. It is important to note that although this figure gives a sense of the relationships between the event shifts and segmentation behavior, it does not enable one to assess the relative impact of a shift dimension on segmentation judgments, while controlling for the impact of the other dimensions. To do so, separate logistic regression analyses were done on each person's judgments. For the picture versions, the unit of analysis was each picture and for the text versions it was the text unit. The dependent variables were the dichotomous decisions that were made. There were seven predictor variables based on the content analyses: changes in the spatial-temporal framework, character, initiating event, beginning of actions sequence, outcome, reaction, and serial order of picture/sentence. Regression coefficients were derived and a series of single sample *t*-test were done to assess if the mean coefficients differed from zero (Lorch & Myers, 1990).

Table 2 reports the mean regression coefficients as a function of story modality and age along with statistical information from the *t*-tests. For the younger adults, for both story versions the probability of indicating

FIGURE 2. Proportion of participants making a segmentation judgment for story units by situational dimension and age for picture (a) and text (b) versions of the stories. Error bars reflect standard errors.



an event boundary increased as a function of the introduction of new characters, initiating events, the beginning of action sequences, outcomes, and character reactions. In addition, for the text versions, the likelihood of perceiving event boundaries significantly increased with changes in the spatial-temporal framework. For the older adults, for both versions, the likelihood of perceiving and event boundary significantly increased as a function of the introduction of new characters, initiating events, beginning of action sequences and outcome. As with the younger adults, the likelihood of indicating an event boundary increased when there was a shift in the spatial-temporal

TABLE 2. Mean coefficients from the regression analyses for younger and older adults

Predictors	Younger adults		Older adults	
	Text version	Picture version	Text version	Picture version
Spatial-temporal				
Mean coefficients	0.47	−0.15	0.56	0.22
SE	0.17	0.19	0.15	0.19
t	2.79	0.78	3.74	1.16
p	0.01	0.44	0.001	0.26
Character				
Mean coefficients	0.92	1.07	0.85	0.85
SE	0.11	0.14	0.12	0.16
t	8.52	7.46	5.88	5.06
p	0.001	0.001	0.001	0.001
Reaction				
Mean coefficients	0.33	0.37	−0.1	−0.04
SE	0.1	0.09	0.15	0.08
t	3.41	4.1	0.78	0.48
p	0.001	0.001	0.44	0.64
Initiating events				
Mean coefficients	0.82	0.82	0.27	0.37
SE	0.13	0.28	0.12	0.08
t	6.42	2.91	2.17	4.91
p	0.001	0.01	0.04	0.001
Beginning action				
Mean coefficients	0.39	0.39	0.18	0.13
SE	0.07	0.06	0.07	0.06
t	5.55	6.07	2.65	2.16
p	0.001	0.001	0.01	0.04
Outcome				
Mean coefficients	0.46	0.43	0.17	0.13
SE	0.07	0.07	0.07	0.05
t	6.99	6.15	2.28	2.81
p	0.001	0.001	0.03	0.01

Note: Exact *p* values are reported unless they are less than .001, and in which case .001 is reported.

framework, but only for the text versions. It is notable that changes in characters' emotional reactions were not consistently identified as event boundaries by the older adults. Apart from this, overall, the older and younger adults showed a similar pattern of sensitivity to event shifts.

DISCUSSION

There is good evidence that aging preserves the ability to build representations of situations described by a text (e.g., Radvansky, 1999; Radvansky & Dijkstra, 2007), and that this can compensate for declines in other areas of cognition. The present study adds to this literature in two ways. First, we explored the extent that situation models guide the comprehension

of the event structure for visually narratives as well as texts. Second, we explored the extent to which situation models affect the perception of the event structure via event segmentation.

Do older adults segment based on changes in the narrated situation similarly to younger adults and for both text and pictures stories? The data show largely preserved performance and show that older adults are similarly sensitive to situational changes when reading and viewing narratives as the younger adults. Although we postulated that the perceptually noisy nature of visually-based narratives (e.g., viewers must identifying the events in the foreground form the details of the background), the data suggests that the modality of the narrative does not present a challenge for older adults in terms of perceiving situational continuities. There was one modest age difference and in particular, older adults' segmentation was not significantly affected by characters' emotional reactions, which is discussed in more detail later.

There were some additional age differences in segmentation that are worth noting. The data indicated that older adults made more segmentation judgments than younger adults, but that this occurred for story units (pictures or sentences) that depicted few to moderate levels of situational change. This is different than what was found by Kurby and Zacks (2011) and suggests that older adults segmented the stories into smaller units than younger adults. This suggests that older adults may perceive changes in a situation more closely than younger adults, and, as such, are more likely to perceive an event boundary with fewer situational changes. This is consistent with the idea that older adults rely on situation models as a compensatory mechanism in narrative understanding although there is a small effect size for the age $\times$ number of shifts interaction.

Additionally, consistent with Kurby and Zacks (2011), we found less agreement in the segmentation judgments across older adults than across younger adults. Unlike Kurby and Zacks (2011), these differences were modest and had a small effect size. Both younger and older adults showed good segmentation agreement, so the older adults' performance can be described as demonstrating preserved processing. It is important to note that the present study used well-structured stories, whereas Kurby and Zacks (2011) used videos of continuous, stereotypically activities (e.g., washing the dishes). One would expect situation models to be more useful in comprehending the former than the later, because story plots are structured around event continuities and discontinuities.

To elaborate this point, the narrative events in these stories spanned multiple activities, with multiple locations, time frames, characters, and superordinate goals. Older adults were able to capitalize on their preserved processing at the situation model level to identify event boundaries when these sorts of changes occurred. This is consistent with other research showing that older adults are more likely to engage in processing that involves

more expansive, gist-based processing. For example, older adults are more likely to draw moral inferences while processing a text than are younger adults (Narvaez, Radvansky, Lynchard, & Copeland, 2011). It should also be noted that there is research showing that older adults' reading times are similarly affected by changes along these sorts of event dimensions (e.g., Radvansky et al., 2001).

Additionally, one important feature of narration is schematization. There is some evidence that older adults have preserved schema use (Arbuckle, Vanderleck, Harsany, & Lapidus, 1990; Hess, 1985), and that this can dominate their cognition, even when it is inappropriate, such as when the schemas refer to unwanted stereotypes of people (Radvansky, Copeland, & von Hippel, 2010). In the stories studied here, events are presented in a discontinuous form as a series of pictures and sentences, a great deal of extraneous surface information is omitted, and some features of the events need to be inferred. What are presented are the critical points needed to help interpret and understand the action, which is a stereotypically approach to creating graphic (McCloud, 1994) and filmed (Bordwell, 1985) narratives. This schematization may help readers and viewers – particularly older ones – to focus on relevant event features and avoid being distracted by extraneous information. This may be part of the reason why age differences in segmentation agreement were smaller here than in previous work (Kurby & Zacks, 2011; Zacks et al., 2006). This would be consistent with the idea that the processing of situation-level changes undergoes relatively less age-related change. Further research is needed to address this important issue.

As an additional point of interest, in this study the older adults were less sensitive to changes in the affective reaction of characters than the younger adults. That is, they were less likely to mark changes in a character's emotional state as a shift in the described events. This is noteworthy given recent evidence suggesting that older adults are relatively sensitive to emotion (e.g., Carstensen, Fung, & Charles, 2003). However, that said, it should also be noted that affective responses (anger, sadness, fear) have been linked to the perceived status of valued goals (Stein, Folkman, Trabasso, & Richards, 1997; Stein & Levine, 1990). It may be that older adults were processing the affective reactions of the characters, but were not using them to identify the event segments. It has been established that older adults effectively track narrative goal-related information (Radvansky & Curiel, 1998).

Finally, it should be noted that, to our knowledge, the current study is one of the few that have investigated event processing across modalities while controlling for content. Building event representations is compulsory for event understanding and, indeed, memory representations of texts and film are similar when content is controlled (Baggett, 1979). As such, it is expected that the processes underlying event processing would also be similar when one controls for content (Gernsbacher, 1990; Magliano et al., 2007). The

present results are consistent with this expectation in that there was comparable agreement in the segmentation judgments within and across modalities and comparable alignment of those judgments with a theoretically guided analysis.

It was surprising that segmentation judgments for both older and younger adults were less correlated with changes in the spatial-temporal framework for the picture versions of the stories than the text versions, given that prior research has shown significant correlations between the two for narrative films (Magliano et al., 2001; Zacks et al., 2010). We caution against making strong inferences here. Nonetheless, there are at least two potential explanations of these findings. First, changes in space and time had to be inferred in the picture versions, whereas in the text versions these changes were explicitly marked with spatial prepositions and temporal adverbs. This is consistent with the idea that changes in space and time are largely implied in visual narratives (Bordwell, 1985; McCloud, 1994), whereas language utilizes morphological and syntactic systems to explicitly signal such information (Givón, 1989; Magliano & Schleich, 2000). Second, a recent finding by Magliano and Zacks (2011) showed that viewers of narrative film are less likely to perceive an event boundary across editing locations that depict changes in space/time when the continuity in action was maintained. This often occurred in the stories used in the current study. For example, in *Frog Where Are You?*, the boy's pet frog runs away. The boy searches in a variety of spatial locations, but with each jump to a new location the boy continues the goal of searching for the frog, which may be more salient in the picture versions.

In conclusion, what is the underlying mechanism for the similarities in the event segmentation data? Virtually all theories of comprehension assume that people must establish how the current event maps onto prior events (McNamara & Magliano, 2009). To do so, they monitor continuities and update representations when discontinuities are perceived (Gernsbacher, 1990, Zwaan & Radvansky 1998). Event segmentation is similar across modalities because it provides a basis for identifying discontinuities between the current event and the prior one, thereby indicating when an event model must be updated (e.g., Kurby & Zacks, 2008). Most importantly, younger and older adults showed largely comparable use of situational change to segment narrative into events. Thus, while there are declines with age in processing at the surface form and text-base levels of comprehension, older adults may able to use the preserved processing at the situation model level as a stable basis to compensate for such declines.

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APPENDIX

Example Text Version of A Boy, a Dog, and a Frog *(Mayer, 1981)*

1. Once there was a boy who had a pet dog. He and the dog went walking one day and the boy was carrying a fishing net and bucket.
2. He set down his bucket and net, and looked down over a tree at a small pond.
3. The boy picked up his bucket and net and noticed a frog sitting on a lily pad looking back at him.

4. The scared frog watched as the boy raised his net and ran with his dog down the hill toward him. The only thing that lie between the boy and the frog was a large tree branch.
5. The boy and the dog both tripped over the tree branch and dropped the bucket and net. The frog was surprised.
6. The boy and the dog fell into the pond right in front of the frog.
7. The boy sat up in the water and stared at the smiling frog.
8. The boy tried to grab the frog, but the frog jumped away from him.
9. The frog sat and stared at the boy from a the large log he had just landed on.
10. The frog frowned as he saw the boy tell the dog to go towards the log.
11. The boy took his net and climbed onto one end of the log, his dog on the other, and the frog was smack dab in the middle of both of them.
12. The boy and the dog were right next to the frog when the boy raised his net.
13. The boy swung the net down on the dog and the frog fell in the pond.
14. The frog angrily hopped on a rock and looked back across the pond at the boy on the log holding the dog in his net.
15. The boy and dog retreated back to the bank of the pond and yelled at the frog.
16. The frog sat on his rock and looked very sad as the boy and his dog walked away.
17. The boy angrily walked back up the hill away from the pond with his dog.
18. The pond looked empty and lonely.
19. The very sad frog continued to sit on his rock.
20. The frog went to the top of the hill and could see footprints.
21. The frog followed the footprints all the way inside a house and could see that they led up a set of stairs.
22. The foot prints lead into an open bathroom with a boy sitting in the bath tub with his dog.
23. The frog sat in the doorway and smiled.
24. The boy and the dog noticed the frog and smiled back at him.
25. The frog jumped into the bathtub at the smiling boy.
26. The frog sat on the dogs head looking at the boy.