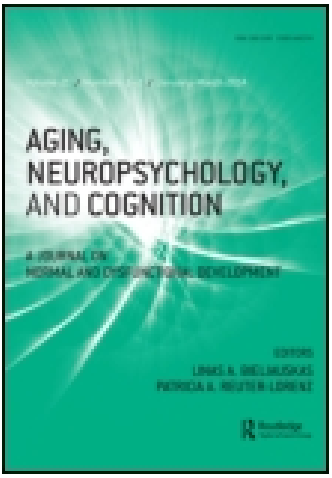

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Aging and the segmentation of narrative film

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ABSTRACT

The perception of event structure in continuous activity is important for everyday comprehension. Although the segmentation of experience into events is a normal concomitant of perceptual processing, previous research has shown age differences in the ability to perceive structure in naturalistic activity, such as a movie of someone washing a car. However, past research has also shown that older adults have a preserved ability to comprehend events in narrative text, which suggests that narrative may improve the event processing of older adults. This study tested whether there are age differences in event segmentation at the intersection of continuous activity and narrative: narrative film. Younger and older adults watched and segmented a narrative film, *The Red Balloon*, into coarse and fine events. Changes in situational features, such as changes in characters, goals, and objects predicted segmentation. Analyses revealed little age-difference in segmentation behavior. This suggests the possibility that narrative structure supports event understanding for older adults.

Keywords: Event segmentation; Aging; Comprehension; Narrative; Event cognition; Film.

The perception of event structure in continuous activity is important for understanding and remembering everyday experience. Everyday experiences are richly structured events composed of parts and subparts (Kurby & Zacks, 2008; Zacks, Speer, Swallow, Braver, & Reynolds, 2007). For example, a trip to the zoo breaks down into entering the gates, buying a ticket, visiting the animals, and exiting. Comprehenders understand such naturalistic activity as well as narratives, in part, by segmenting it into discrete events.

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Individuals' representations of each event, or *event models*, are composed of a number of situational and perceptual features that describe "what is happening now", such as time, spatial location, characters, objects, goals, and so on (Gernsbacher, 1997; Zacks, Speer, & Reynolds, 2009; Zwaan, Langston, & Graesser, 1995; Zwaan & Radvansky, 1998). Most adults segment continuous activity into events and sub-events by tracking these situational features and perceiving event boundaries when they change (Kurby & Zacks, 2012; Speer, Zacks, & Reynolds, 2007; Speer & Zacks, 2005; Zacks, Speer, et al., 2009; Zacks, Speer, Swallow, & Maley, 2010; Zwaan et al., 1995; Zwaan, 1996). For example, Zacks, Speer, et al. (2009) had participants watch and segment the movie *The Red Balloon* (Lamorisse, 1956) by pressing a button during viewing. They found that participants were more likely to segment at both a coarse (i.e., large units) and fine (i.e., small units) grain when there were changes in characters, character–character interactions, goals, causes, spatial location, and object interactions. Studies of narrative comprehension report evidence for working memory updating and changes in reading behavior at these situational changes (Rinck & Weber, 2003; Zwaan & Radvansky, 1998; Zwaan, 1996). Research has also shown that viewers perceive event boundaries when there are changes in visual motion (Hard, Tversky, & Lang, 2006; Schubotz, Korb, Schiffer, Stadler, & von Cramon, 2012; Zacks, Kumar, Abrams, & Mehta, 2009; Zacks, Swallow, Vettel, & McAvoy, 2006).

This collection of results are consistent with theories of narrative and event processing which state that viewers construct structured representations organized by events (Gernsbacher, 1997; Kurby & Zacks, 2008; Zacks et al., 2007; Zwaan & Radvansky, 1998). The event-indexing model (Zwaan & Radvansky, 1998) specifically proposes that readers track a set of situational features, such as goals and causes, and update their representations when those features change. The structure-building framework (Gernsbacher, 1997) and event segmentation theory (EST: Zacks et al., 2007) argue that perceivers build mental models of events by attending to relevant situational, and perceptual, information and building a new representation when that information is no longer relevant to understanding the incoming perceptual stream. Individuals perceive an event boundary as a consequence of the working memory updating processes that are engaged to build a new event model (Zacks et al., 2007).

The effective segmentation of events likely involves a complex coordination of attentional control, working memory maintenance and updating, and access to long-term knowledge stores (Kurby & Zacks, 2008; Zacks & Sargent, 2010; Zacks et al., 2007). Generally, cognitive aging is associated with a reduction in functioning on a number of these perceptual and cognitive abilities that likely play a role in the understanding of events and event structure (Zacks & Sargent, 2010), as well as a reduction in brain regions important for supporting such functioning (e.g., medial temporal lobes, frontal cortex, etc.; see Raz, 2005 for a review). This would suggest a general age-related decline in event perception.

However, there is conflicting evidence regarding whether such a decline exists. Recent work in event perception for *continuous naturalistic activity* (e.g., a movie of someone washing a car) suggests that older adults may have difficulty understanding continuous events and how they are structured (Kurby & Zacks, 2011; Zacks, Speer, Vettel, & Jacoby, 2006). However, this work is somewhat at odds with work on aging in a related, but different field: the comprehension of *written narrative events*. Research by Radvansky and colleagues (see Radvansky & Dijkstra, 2007 for a review), for example, has shown that older adults are equally able to construct, update, and remember events described in narrative text.

Together, these findings suggest that older adults have both a deficit in event perception for continuous naturalistic activity and have intact event processing for written narrative events. The goal of the current study was to test for possible age differences at the intersection of these two: the segmentation of narrative film. One possibility is that older adults have a reduced ability to perceive event structure for activity if it is presented in a visually continuous manner (e.g., movies, videos, etc.). Another is that narrative structure supports the comprehension of events, perhaps even when those events are presented in a visually continuous manner.

EVENT SEGMENTATION AND AGING

Recent research has shown that older adults segment naturalistic activity less well than younger adults (Kurby & Zacks, 2011; Zacks, Speer, et al., 2006). For example, in Zacks, Speer, et al. (2006), younger and older adults watched movies of actors doing everyday activities, such as someone planting a flower box or someone washing a car. While they watched the movies, participants pressed a button to mark boundaries between events in the activity. Older adults tended to place event boundaries in less normative places than younger adults, compared to group segmentation norms. Segmentation was further reduced for those with very mild dementia. Kurby and Zacks (2012) found that older adults also segmented events less hierarchically than younger adults; their fine (i.e., smaller timescale) segmentation of events was less aligned with their coarse (i.e., larger timescale) segmentation. Adaptive segmentation of naturalistic activity is important for memory encoding; older adults who segmented more normatively tended to also have better memory for the activity, controlling for a number of general cognitive factors such as dementia status, working memory functioning, episodic memory functioning, and executive control (Kurby & Zacks, 2011; Zacks, Speer, et al., 2006) as well as when controlling for medial temporal lobe volume (Bailey et al., 2013).

Together with the large body of research showing age-related decline in general cognitive functioning (for review, see Salthouse, 2010), this research suggests that older adults are less able to perceive event structure in continuous naturalistic activity. However, no study to date has investigated age differences in event perception for narrative film. There is reason to believe, in fact, that there may be little to no age-related differences in such an experience.

NARRATIVE COMPREHENSION AND AGING

Narrative comprehension requires an ability to build event representations effectively (Zwaan & Radvansky, 1998). Filmic and textual narratives make use of event structure to convey a story. Episodes in stories are constructed of characters interacting with one another and objects, entering and exiting spatial locations, pursuing goals, and so on. Understanding of narratives proceeds, in part, through the construction of mental models of the described events, called *situation models*. Research shows that younger and older adults are equally able to construct and update event representations during narrative comprehension. When reading a narrative text, comprehenders will tend to slow down their reading rate when there is a change on one, or more, situational dimensions, such as a change of time, space, goals, etc. (Rinck & Weber, 2003). This effect has been interpreted as evidence for additional updating processes that occur at situational changes; some of which involved incorporating that new information into their situation model. Both younger adults and older adults show this effect, at statistically equal magnitudes (Radvansky, Zwaan, Curiel, & Copeland, 2001), suggesting that there are no age differences in the quality of situation model updating. Other studies assessing working memory updating during narrative comprehension have shown that older adults can effectively update object representations (Radvansky, Copeland, Berish, & Dijkstra, 2003), integrate functional spatial information (Radvansky, Copeland, & Zwaan, 2003), update goal representations (Radvansky & Curiel, 1998), update spatial and temporal representations (Radvansky, Copeland, Berish, et al., 2003), and activate mental simulations (Dijkstra, Yaxley, Madden, & Zwaan, 2004; Madden & Dijkstra, 2010). (It should be noted, however, that there is some research showing that older adults have difficulty tracking multiple characters during comprehension (Noh & Stine-Morrow, 2009).) Studies investigating post-reading memory have found that older adults have preserved memory for the situation – what the story was about (Radvansky et al., 2001). But, memory for surface details may be reduced (for a review see Johnson, 2003).

These studies suggest that narrative structure may support event comprehension for older adults. Thus, one might expect relatively little age-difference in effective event segmentation of narratives. Indeed, a recent study supports this possibility (Magliano, Kopp, McNerney, Radvansky, & Zacks, 2012). Magliano et al. (2012) had older and younger adults segment a set of visual narratives in the form of picture stories and textual narrative into events. The authors coded the unit-to-unit situational changes in both the picture and textual stories. For example, from one panel to the next, a picture story may shift characters, goals, space, time, etc. The changes were used to predict segmentation locations for each individual. The authors found that situation changes predicted the segmentation of the stories equally well for both younger and older adults, with minimal differences between story modality (text vs. picture). Older and younger adults also agreed with group segmentation norms equally well, in contrast with studies on age differences in the segmentation of continuous naturalistic activity. This suggests that older adults were equally able as younger adults to track situational features during comprehension, and used them as effectively as younger adults to structure their event representations. No studies to date, however, have investigated age differences in the segmentation of *narrative* film.

In the current study, we investigated whether there were age differences in the segmentation of narrative film by assessing the relationship between segmentation behavior and moment-by-moment situational change in the film. Younger and older adults watched *The Red Balloon* (Lamorisse, 1956) and segmented it into coarse and fine events. If, on the one hand, older adults have difficulty perceiving event structure in continuous activity then, even when embedded in narrative, then their segmentation will be less systematically related to situational change than younger adults, and their segmentation will be less normative. On the other hand, narrative structure may support older adults' event perception for visually presented continuous activity. If so, then there will be no age differences in segmentation quality, and in the relationship between situational change and segmentation behavior.

METHODS

Participants

Forty older adults ranging 31 years of age ($M = 77$, min = 63, max = 94) and 40 younger adults ranging 9 years of age ($M = 19$, min = 17, max = 26) were recruited to participate in this study. Older adults were community dwelling adults living independently or on-site at local independent-living retirement communities. Older adults were paid $15. Younger adults received credit for partial fulfillment of a course requirement.

Materials and segmentation task

Film

This study used a film called *The Red Balloon* (Lamorisse, 1956), which has been used in previous event segmentation studies (Zacks, Speer, et al., 2009; Zacks et al., 2010). *The Red Balloon* contains many situation changes, has very little dialog, and the movie is cut in a mostly sequential fashion. The film is a 32.97-minute children's story about a little boy who discovers a balloon, which takes on a life of its own.

Scoring

We used the same situation change coding as used by Zacks, Speer, et al. (2009), which was freely available from those authors. The situation-change coding is a frame-by-frame analysis of the movie regarding whether each frame presents a change of spatial location, character–object interaction, character change, character–character interaction, goals, and causes. The location of cuts was also recorded. See Table 1 for a description of the change types and coding rules.

Mini-Mental State Examination

The Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) was used to assess the state of basic cognitive capacities of each participant. The administration of the test took about 10 minutes in total. The number of items correct served as the MMSE score.

Measures of processing speed

Two measures of processing speed developed by Salthouse and Babcock (1991) were administered. These tests have commonly been used in studies of processing speed and aging (Salthouse, 2000). The *letter comparison task* presents 42 pairs of letter sequences (e.g., YCX – YMX) and participants were given 20 seconds to indicate whether or not each pair is different. The *pattern comparison task* was similar to the letter comparison task, except that the sequences of items were 60 pairs of abstract line drawings. The total of items correct, separately for letter and pattern comparison, served as the processing speed scores. For analyses that use processing as a predictor, we z-scored the two scores and then summed them.

TABLE 1. Dimensions coded to predict situation change

Dimension	Description
Cause	Activity caused by something not present in previous frame.
Character	Focus shift to a new character.
Character/character interaction	Character interaction with another character.
Character/object interaction	Character interaction with an object.
Goal	Character performed action associated with a new goal.
Space	When a character changed spatial location or direction.
Cut	Two sequences of continuous film that are edited together.

Segmentation task

For this task, participants were instructed to press the spacebar when, in their judgment, one meaningful unit of activity ended and another began (Kurby & Zacks, 2011; Newtson & Engquist, 1976; Zacks, Speer, et al., 2006). Participants performed this task twice, once segmenting the film at a coarse grain and once at a fine grain. For coarse segmentation, they were instructed to mark off the activity into the largest meaningful units and for fine segmentation they were instructed to mark off the smallest meaningful units of activity. The order of segmentation grain was counterbalanced across participants.

Procedure

Participants first practiced the segmentation task with a short film that depicted a man building a boat out of colored building blocks (247 s). We set a target number of units for participants to identify, based on the grain size they were practicing: three for coarse segmentation practice, and six for fine. When participants finished practice, they segmented *The Red Balloon* in the same grain size as just practiced. The audio was adjusted for each participant to a comfortable listening level. The movie was broken into 4 sections, each about 9 minutes long, and participants were given the opportunity to break between sections. After segmenting the entire movie at one grain size, participants practiced the segmentation task for the other grain, and then moved on to segment *The Red Balloon* at the new grain. For example, if participants segmented the movie at a coarse grain first, they would then segment a second time at a fine grain.

Finally, finishing the second viewing of the movie, the participants were given the MMSE, the letter comparison task, the pattern comparison task, and older adults were given an education questionnaire.

RESULTS AND DISCUSSION

In the following analyses, we assessed age differences in (1) the quality of segmentation and (2) the likelihood of segmentation and its relation to situational change. For all analyses that assessed age effects, we used age as a continuous predictor (Preacher, Rucker, MacCallum, & Nicewander, 2005). This same approach was used in Kurby and Zacks (2011). This method is recommended to increase power in statistical analyses in extreme groups designs (Preacher et al., 2005), which should increase the likelihood of detecting interactions with age. In some cases, these analyses were followed up with analyses within age group, and for descriptive purposes we present means, and coefficients, separately by age group. Because of their lack of theoretical importance, significant effects involving the movie clip factor will be described in footnotes.

TABLE 2. Mean processing speed and MMSE scores (*SD* in parentheses)

Age group	Letter comparison	Pattern comparison	MMSE
Younger	15.35 (4.19)	28.79 (5.32)	27.55 (2.41)
Older	11.33 (2.97)	19.97 (3.87)	28.46 (1.45)

Mean MMSE, and processing speed scores by age group are presented in Table 2. MMSE scores were not significantly correlated with age, $r(78) = .18$, $p = .10$, $d = 0.37$,[1] but scores on letter completion and pattern completion were negatively correlated with age (Letter: $r(78) = -.51$, $p < .001$, $d = 1.19$; Pattern: $r(78) = -.73$, $p < .001$, $d = 2.14$). This indicates that there were no age differences in basic cognitive functioning but there were age differences in processing speed. As such, a summed *z*-score *processing speed score* was used as a covariate in all models that assessed age differences in segmentation.[2]

Quality of segmentation

We computed two measures to assess potential age differences in the quality of segmentation: (1) *segmentation agreement* and (2) *hierarchical alignment*. Segmentation agreement is a measure of how well each individual's segmentation agrees with that of the entire group. To compute this measure, we followed procedures described in Zacks, Speer, et al. (2006) and Kurby and Zacks (2011). Briefly, for each grain and clip, we created 5-second time bins and computed the proportion of participants that segmented within each bin, to form a segmentation norm. Then, for each participant we recorded whether or not that person segmented within each bin. We computed a point-biserial correlation between each individual's segmentation pattern and the norm, scaled by the number of event boundaries each participant indicated (Kurby & Zacks, 2011). The agreement score ranges from 0 to 1, with higher values indicating better agreement. Hierarchical alignment measures how well one's fine segmentation is nested within one's coarse segmentation. For this measure, we counted the number of 5-second bins that contained both a fine and coarse boundary, and subtracted the number of overlaps expected by chance (Zacks et al., 2009). Mean agreement and alignment scores are presented in Table 3.

[1] Four younger adults had particular difficulty answering correctly for the MMSE item that asks for the participant to count backwards by sevens from 100. Removing those participants from the analyses did not change the results. The younger adult MMSE mean with those participants removed was 28.08. Within the older adult group, age was negatively correlated with MMSE, $r(38) = -.37$, $p = .019$, $d = 0.80$.

[2] Removing processing speed as a covariate produced the same pattern of results.

Table 3. Mean segmentation agreement and hierarchical alignment scores (*SD* in parentheses)

Age group	Fine agreement	Coarse agreement	Hierarchical alignment
Younger	0.77 (0.07)	0.66 (0.09)	2.19 (2.17)
Older	0.75 (0.09)	0.68 (0.09)	2.33 (2.40)

Segmentation agreement

A 2 (Grain: Fine vs. Coarse) × 4 (Clip) × Age (mean-centered) ANOVA with processing speed as a covariate revealed a main effect of grain, $F(1, 78) = 86.53$, $MSE = 0.01$, $p < .001$, $\eta_p^2 = .53$, with coarse segmentation producing lower agreement than fine (coarse: $M = 0.67$, $SD = 0.09$; fine: $M = 0.76$, $SD = 0.08$). There were no significant effects involving age (Largest F: Grain × Age interaction, $F(1, 78) = 2.98$, $MSE = 0.01$, $p = .088$, $\eta_p^2 = .04$).[3]

Hierarchical alignment

A 4 (Clip) × Age (mean-centered) ANOVA with processing speed as a covariate revealed no significant effects (Largest F: Main effect of clip, $F(3, 234) = 2.05$, $MSE = 3.38$, $p = .108$, $\eta_p^2 = .03$). One-sample t-tests showed that alignment scores were greater than zero for both age groups (Younger: t(39) = 8.70, $p < .001$, $d = 1.38$; Older: $t(39) = 8.74$, $p < .001$, $d = 1.38$). This shows that both groups perceived hierarchical structure in events.

These analyses show that there were no age differences in segmentation quality.

Sensitivity to situational change

We assessed potential age differences in sensitivity to situational change in segmentation behavior in two ways: (1) we examined the relationship between segmentation frequency and amount of situational change and (2) we examined the relationship between change on each of the six individual dimensions (and cuts), and the probability of segmentation.

Frequency of segmentation and amount of change

For these analyses, we fit two logistic mixed effect models to assess the relation between amount of situational change and segmentation behavior, and potential interactions with age (Jaeger, 2008). We created a predictor

[3] There was a significant main effect of movie clip, $F(3, 234) = 5.43$, $MSE = 228$, $p = .004$, $\eta_p^2 = .05$, such that agreement was highest for clip one.

TABLE 4. Odds ratios, and 95% confidence intervals, of the predictors from the logistic mixed effects models for the amount of change analyses

Model	Predictor	Odds ratio	95% CI	z(31836)	p	d
Fine	TotalChanges	1.446	1.424–1.468	47.29	<.001***	10.57
	Age	1.009	0.998–1.020	1.61	.107	0.37
	Speed	1.083	0.769–1.525	0.46	.647	0.10
	TotalChanges × age	1.000	0.999–1.000	−1.28	.200	−0.29
Coarse	TotalChanges	1.313	1.288–1.339	27.77	<.001***	6.21
	Age	1.010	1.003–1.017	2.74	.006**	0.61
	Speed	1.134	0.912–1.410	1.13	.259	0.25
	TotalChanges × age	1.000	0.999–1.000	−1.26	.208	−0.28

Note: ***$p < .001$; **$p < .01$.

variable that coded each 5-second time bin reflecting the total number of situation changes that occurred within it, ranging from zero to five-or-more total situation changes per bin. (There were 121 bins with zero changes, 76 with one change, 85 with two, 56 with three, 42 with four, and 18 with five or more changes.) One model predicted fine segmentation locations from the total changes predictor, age, and their interaction. The second predicted coarse segmentation locations from the same predictors. Both models also included total processing speed score as a fixed effect covariate, and predictors coding for the random effect of subject and clip number. Table 4 presents the results from these analyses.

Fine segmentation

For fine segmentation, increasing number of changes was associated with an increase in the likelihood of segmenting. Age was unrelated to segmentation likelihood for fine segmentation, and did not interact with total number of changes.

Coarse segmentation

For coarse segmentation, an increase in the number of situation changes was associated with a significant increase in the likelihood of segmentation. Increasing age was associated with a significant increase in likelihood of segmentation showing that older adults segmented more often during coarse segmentation. This effect, however, was small. Age did not interact with total number of changes.

These results indicate that there were no age differences in sensitivity to overall situational change. The likelihood of segmentation for both groups, for both grains, increased with an increasing number of changes at a statistically equivalent rate. This is generally consistent with Magliano et al. (2012).

Older adults segmented more often for coarse segmentation, which also is consistent with Magliano et al. (2012), but is inconsistent with Kurby and Zacks (2011) and Zacks, Speer, et al. (2006).

Segmentation and changes of individual situational dimensions

We conducted additional analyses to assess whether there were age differences in the relation between change in each of the individual situational dimensions and segmentation behavior. Separately for coarse and fine segmentation, we fit a logistic mixed effect model predicting segmentation behavior across the 5-second bins from change in characters, character-character interaction, character–object interaction, spatial location, goals, and causation. Cuts were also included as a predictor. Additionally, we included age as a predictor, and the two-way interactions between age and each situational dimension, and cuts. As above, processing speed scores were included as a covariate, and random effects for subject and clip were included.

The results from these analyses are presented in Table 5. As can be seen in the table, there were minimal age differences in segmentation behavior.

Fine segmentation

As presented in Table 5, for fine segmentation, all six of the situational dimensions significantly predicted segmentation; a change on any one dimension increased the odds of segmentation. Age did not interact with any of the situational variables. Cuts were negatively associated with segmentation – the presence of a cut was associated with a decrease in the odds of segmenting (an odds ratio less than 1). Cuts interacted with age; cuts were negatively related to segmentation for younger adults, odds ratio = 0.89, 95% CI [0.82, 0.95], but unrelated to segmentation for older adults, odds ratio = 1.01, 95% CI [0.94, 1.08].[4]

Coarse segmentation

As presented in Table 5, for coarse segmentation, segmentation behavior was significantly predicted by character change, character–object interactions, spatial change, goal change, and causal change. A change on each of those dimensions was associated with an increase in the odds of segmenting. Cuts were negatively associated with segmentation. Consistent with the analyses of total number of changes presented above, older adults segmented more often for coarse segmentation; increasing age was associated with an increased odds of segmenting. Age significantly interacted with character–character interactions. Changes in character–character interaction were unrelated to the odds of segmenting for younger adults, odds ratio =

[4] These odds ratios were computed from within-age-group mixed effect models including the same predictors as those in the main analysis, except for age.

TABLE 5. Odds ratios, and 95% confidence intervals, of the predictors from the logistic mixed effects models for the individual dimension change analyses

Model	Predictor	Odds ratio	95% CI	$z(31824)$	p	d
Fine	Character	1.330	1.283–1.380	15.30	<.001***	3.42
	CharChar	1.317	1.242–1.396	9.20	<.001***	2.06
	CharObj	1.491	1.409–1.579	13.75	<.001***	3.07
	Space	1.171	1.130–1.214	8.57	<.001***	1.92
	Cause	1.281	1.203–1.364	7.73	<.001***	1.73
	Goal	1.201	1.129–1.277	5.81	<.001***	1.30
	Cuts	0.946	0.899–0.995	−2.16	.031*	−0.48
	Age	1.007	0.997–1.018	1.37	.170	0.31
	Speed	1.082	0.774–1.512	0.46	.645	0.10
	Character × Age	1.000	0.999–1.001	−0.28	.781	−0.06
	CharChar × Age	0.999	0.997–1.001	−1.21	.227	−0.27
	CharObj × Age	0.998	0.997–1000	−1.59	.113	−0.35
	Space × Age	1.000	0.999–1.001	0.11	.909	0.03
	Cause × Age	1.000	0.998–1.003	0.35	.725	0.08
	Goal × Age	1.000	0.998–1.002	−0.11	.909	−0.03
	Cuts × Age	1.002	1.000–1.004	2.39	.017*	0.53
Coarse	Character	1.323	1.265–1.383	12.24	<.001***	2.74
	CharChar	1.071	0.995–1.153	1.82	.069†	0.41
	CharObj	1.297	1.212–1.389	7.50	<.001***	1.68
	Space	1.105	1.056–1.155	4.33	<.001***	0.97
	Cause	1.116	1.035–1.203	2.84	.004**	0.64
	Goal	1.106	1.024–1.195	2.58	.010*	0.58
	Cuts	0.797	0.745–0.852	−6.63	<.001***	−1.48
	Age	1.009	1.002–1.016	2.50	.012*	0.56
	Speed	1.133	0.912–1.406	1.13	.260	0.25
	Character × Age	1.000	0.998–1.001	−0.09	.929	−0.02
	CharChar × Age	1.003	1.001−1.006	2.55	.011*	0.57
	CharObj × Age	0.998	0.996–1.000	−1.69	.092	−0.38
	Space × Age	0.999	0.998–1.001	−0.96	.339	−0.21
	Cause × Age	0.998	0.995–1.000	−1.66	.097	−0.37
	Goal × Age	0.999	0.997−1.002	−0.43	.670	−0.10
	Cuts × Age	1.001	0.999–1.003	1.02	.307	0.23

Note: $^{***}p < .001$, $^{**}p < .01$, $^{*}p < .05$.

0.97, 95% CI [0.87, 1.09], whereas for older adults changes in character–character interaction were associated with increased odds of segmentation, odds ratio = 1.18, 95% CI [1.07, 1.30].[5]

These results show that situational change predicts segmentation behavior similarly across age. For fine segmentation, all situational dimensions predicted segmentation for both groups, suggesting that older adults did not have difficulty tracking this information during viewing and using it to segment their event fine representations. (There was an interaction with age

[5] These odds ratios were computed from within-age-group mixed effect models including the same predictors as those in the main analysis, except for age.

regarding the effect of cuts on segmentation.) For coarse segmentation, there were minimal age differences. There was only one significant interaction with age, which suggested that older adults segment their coarse event representations, at least partially, by character–character interactions whereas younger adults showed no evidence of such.

GENERAL DISCUSSION

When comprehending narrative or naturalistic activity, viewers create mental models that reflect the event structure of the experience. They do so, in part, by tracking a set of situational features, such as characters, space, goals, causes, etc., and segmenting their representations when they change. Previous studies on aging and event cognition suggest conflicting hypotheses about whether cognitive aging is associated with decreased event segmentation for continuous visual narrative experience. On the one hand, research has shown that older adults segment continuous naturalistic experience less well than younger adults (Kurby & Zacks, 2011; Zacks, Speer, et al., 2006). This suggests that older adults might have a general deficit to perceive event structure in continuous activity. On the other, studies of narrative text comprehension have generally shown relative age-preservation of event understanding (e.g., Magliano et al., 2012; Radvansky & Dijkstra, 2007). In this study, we investigated potential age differences in event segmentation at the intersection of these two genres: narrative film. We found little difference between younger and older adults in segmentation behavior; supporting the possibility that narrative structure supports event perception in older adults for continuous activity. Younger and older adults agreed equally well with group segmentation norms. Total amount of situational change predicted younger and older adults' segmentation behavior equally well. The analyses of individual situational change and segmentation showed that segmentation of both age groups was sensitive to a majority of the same situational features. To our knowledge, this is the first study to investigate event perception of narrative film in older adults.

It is unlikely that the overall lack of age-differences in our study is due to a lack of power. First, our study had more participants than previous studies on age-differences in segmentation (Bailey et al., 2013; Kurby & Zacks, 2011; Zacks, Speer, et al., 2006). Those studies, which report age-differences in segmentation, all had less than 40 participants per group. Second, our use of mixed-effect models maximized the potential to detect significant effects because they are more powerful than standard univariate approaches (Baayen, Davidson, & Bates, 2008; Jaeger, 2008), and the use of age as a continuous factor also increases power over its categorical counterpart (Preacher et al., 2005). In regard to the participants (unrelated to power), we do not have reason to believe that the older adults in this study were different than those in previous studies on event segmentation. The older adults in this study were similar in basic demographics to those in the previous studies; their overall cognitive functioning was preserved, but had slower processing speed (Zacks, Speer, et al., 2006).

Our findings are consistent with studies showing age-preservation of event processing for narratives. And, most closely so with results from Magliano et al. (2012), which found no age differences in the relation between segmentation behavior and situation change in textual narratives and picture stories. (That study did find that older adults' segmentation was less related to changes of character emotion than younger adults.) There were no age differences in our study regarding fine segmentation and situational change. For coarse segmentation, we found only one interaction showing that younger adult segmentation was *unrelated* to character–character interactions whereas older adult segmentation was related to such changes.

The interaction between age and character–character interactions suggests that older adults tend to monitor social interaction in film and may, in part, use that information to structure their event representations. Previous work suggests that older adults may pay more attention to social interaction than younger adults (Charles & Carstensen, 2010). According to Socioemotional Selectivity Theory (SES) theory, as people age they become more focused on social meaning and emotion because the life-goals one can pursue become necessarily constrained by time, shifting focus towards valuing the present and immediate future. Our finding here may reflect one perceptual consequence of such a shift in socio-emotional processing; older adult event models more robustly code for character interactions than younger adults'. Additionally, older adults may be more attuned to social events than younger adults because of age-related increases in social expertise (Leclerc & Hess, 2007); older adults are more adept at using diagnostic trait information when making social inferences (Hess, 2005). This increased ability to infer social information may allow for richer event models of social events, which may improve one's ability to predict the incoming perceptual stream. Perceptual predictions have been proposed to be a main causal mechanism in event segmentation (Zacks et al., 2007).

We did find that older adults segmented more often at a coarse grain than younger adults. Magliano et al. (2012) found a similar effect, though they did not manipulate segmentation grain size. It is unclear how to interpret this effect. Kurby and Zacks (2011) found the opposite effect; older adults tended to segment less often than younger adults. A possibility is simply that this is a task-specific effect with older and younger adults interpreting the instruction to segment into large units slightly differently. Another is that older adults may be demonstrating more difficulty with attending to higher levels of the event hierarchy, compared to younger adults. Future studies on the replicability of this effect are needed to determine its importance.

Why might there be relatively preserved event processing for older adults in narrative contexts? There have been suggestions made in the previous literature that, in part, it has to do with characteristics of older adults themselves and how they deploy attention during narrative comprehension (Radvansky & Dijkstra, 2007). Older adults have been argued to be experts in comprehending narratives given their typically larger amounts of semantic knowledge (Verhaeghen, 2003), preserved event schematic knowledge (Rosen, Caplan, Sheesley, Rodriguez, & Grafman, 2003), and more frequent episodic experiences with narratives (Radvansky & Dijkstra, 2007). In addition to this possibility, older adults may expend more effort on the construction of situation-level representations, perhaps by differentially deploying attention, to the detriment of processing lower-level textual information (Radvansky et al., 2001; Stine-Morrow, Gagne, Morrow, & DeWall, 2004). (It should be noted, however, that increased event knowledge in older adults runs counter to their reduction in event segmentation ability for naturalistic stimuli.)

In addition to these possibilities, features of the narrative genre itself may contribute to age-preservation in the comprehension of events embedded in narratives. In general, narratives are easier to process than non-narratives (Graesser, Golding, & Long, 1991). This is likely the case for a number of reasons. First, typical narrative structure organizes event information into connected episodes, or event sequences (Graesser et al., 1991). Such organization affords the reader the ability to generate explanatory inferences, causal connections, and activate appropriate event knowledge (Graesser, Singer, & Trabasso, 1994). In contrast, these connections are not made for the viewer of naturalistic activity, but rather need to be constructed by the viewer as the activity unfolds. Second, the comprehension of narrative events is supported by story grammars, which are typical regularities in text that are accepted organizations of story information (Haberlandt, Berian, & Sandson, 1980; Mandler, 1987; Mandler & Johnson, 1977). For example, story grammars state that stories progress from beginning, middle, end, and are connected by a plot with conflict, attempts to resolve conflict, and resolution (Haberlandt et al., 1980). Such regularities allow readers to use a conceptual framework with which to organize event information appropriately. This supports the construction of coherent situation models (Graesser et al., 1994; Mandler, 1987). Third, narratives typically present situations that allow readers to use schematic knowledge to interpret events and actions, and provides opportunity to integrate their knowledge into representations of the events (Graesser et al., 1991). Difficulty with such integration should lead to difficulty in comprehension. Indeed, Hannon and Daneman (2009) have shown that individual differences in knowledge integration ability correlate with memory for text in older adults. Fourth, authors present narratives in ways that effectively guide attention to appropriate situational and perceptual features, sometimes referred to as foregrounding. In text, authors use linguistic markers that set up new times, places, etc. (e.g., "The next day . . . "). In film, directors design shots to guide visual attention to regions of interest (Hasson et al., 2008), largely through the use of framing and basic visual composition (Altman, 2008; Bordwell, 1985). Framing is defined by the angle, zoom, and focus of the camera that foregrounds some of the objects in the scene and backgrounds others. Some have argued that framing may be a fundamental difference between narrative experiences and naturalistic experience because of its unique ability to highlight specific perspectives and visual organization of action (Altman, 2008). Indeed, studies of event perception in cinematic film have shown remarkable control over viewers' perceptual processing of content; there is very good inter-individual agreement of eye-movement patterns, and very good inter-individual agreement of brain activity in large portions of posterior cortex (e.g., occipital and parietal cortex), and some frontal regions (Hasson et al., 2008; Hasson, Nir, Levy, Fuhrmann, & Malach, 2004). Thus, visual composition can have a strong effect on event processing. It is possible that with a careful use of cinematic devices such as framing and other visual composition techniques that age-differences may be reduced for the segmentation of naturalistic observation. Lastly, it may be possible that viewers' level of interest is higher for narrative film than naturalistic activity.

Although we used a single film as our experimental stimulus, there is good reason to think that *The Red Balloon* is an effective entry point to investigating potential age differences in the perception of event structure in narrative film. We chose to use this film for a number of reasons. The first is that *The Red Balloon* provides a clear narrative structure. It has very few temporal jumps, is cut using conventional editing techniques (Magliano & Zacks, 2011; Zacks, Speer, et al., 2009), and has a reliably identifiable episodic composition (Baggett, 1979). Second, *The Red Balloon* has been previously well-characterized regarding its organization on the six dimensions of situation model construction as proposed by the event-indexing model, and how that organization is related to segmentation behavior (Zacks, Speer, et al., 2009; Zacks et al., 2010). As such, there is good documentation on how event structure in the film is related to the perception of that structure during viewing. Third, *The Red Balloon* has very little dialog, which removes potential complications regarding the study of age differences in event perception of continuous activity. Research and theory suggests that individuals likely monitor the same situational dimensions during event comprehension across most narrative experiences (Magliano, Radvansky, & Copeland, 2007; Zwaan & Radvansky, 1998). Given this, it is reasonable to assume that the cognitive processes engaged during event comprehension are similar from viewing to viewing, providing some confidence in generalization across films. However, given the variety of film styles in cinema, future work should investigate to what extent the current findings generalize to other stimuli.

Indeed, films can vary considerably regarding their complexity. Would narrative films of more complexity than *The Red Balloon* still improve event processing for older adults? Given the well-described complexity by age effect – that age differences in task performance tend to increase with increasing task complexity (Salthouse, 1992) – it is possible that with increasing narrative complexity one would observe a reduction in benefit. Our study cannot rule out this possibility. Some of the scenes in the movie presented a large number of situational changes, which should increase working memory demands on the viewer. Increasing demands on working memory have been used an explanation for the complexity by age effect (Salthouse, 1992). Further work is needed to test this possibility more thoroughly.

CONCLUSION

Perceiving the event structure of activity is important to constructing appropriate mental models of the activity (Kurby & Zacks, 2008; Zacks et al., 2007). Viewers of narrative film, and visual continuous activity in general, tend to segment their experiences into discrete events when there are changes on one, or more, of a number of situational dimensions. In contrast to previous research on aging and event segmentation of naturalistic activity, the current study found little age-difference in segmentation of narrative film. This suggests that older adults do not have a general deficit to perceive events when presented in visual continuous activity (e.g., video, film, etc.), but rather can use narrative structure to support their perception of event structure during such experiences.

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