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BRIEF REPORT

Preview benefit in speaking occurs regardless of preview timing

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Abstract Speakers access information from objects they will name but have not looked at yet, indexed by *preview benefit*—faster processing of the target when a *preview* object previously occupying its location was related rather than unrelated to the target. This suggests that speakers distribute attention over multiple objects, but it does not reveal the time course of the processing of a current and a to-be-named object. Is the preview benefit a consequence of attention shifting to the next-to-be-named object shortly before the eyes move to that location, or does the benefit reflect a more unconstrained deployment of attention to upcoming objects? Using the *multiple-object naming paradigm* with a *gaze-contingent display change* manipulation, we addressed this issue by manipulating the latency of the onset of the preview (SOA) and whether the preview represented the same concept as (but a different visual token of) the target or an unrelated concept. The results revealed that the preview benefit was robust, regardless of the latency of the preview onset or the latency of the saccade to the target (the lag between preview offset and fixation on the target). Together, these data suggest that preview benefit is not restricted to the time during an attention shift preceding an eye movement, and that speakers are able to take advantage of information from nonfoveal objects whenever such objects are visually available.

Keywords Parallel processing · Object naming · Eye movements · Attention

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Part of what makes speaking so efficient is our ability to plan ahead. When speaking about objects in our environment, planning ahead can be measured by a subject's ability to preprocess upcoming, to-be-named objects before looking at them (Meyer & Dobel, 2003; Meyer, Ouellet, & Häcker, 2008; Morgan & Meyer, 2005; Morgan, van Elswijk, & Meyer, 2008; Pollatsek, Rayner, & Collins, 1984; Schotter, Ferreira, & Rayner, 2013; for reviews, see Meyer, 2004; Schotter, 2011). This ability for simultaneous processing raises the issue of how the processing and management of information from multiple objects is achieved. Do speakers process all visible objects whenever available, or is preprocessing of the upcoming object restricted to a brief amount of time, before the speaker has moved his or her eyes to that object but after attention has shifted to its location?

Because a shift in attention generally precedes an eye movement to a particular location (Deubel & Schneider, 1996; Henderson, 1993; Hoffman & Subramaniam, 1995; see Rayner, 1998, 2009, for reviews), it may seem advantageous for speakers describing their environment to restrict preprocessing of an upcoming object to just before the eyes move to it (Henderson, Pollatsek, & Rayner, 1989); otherwise, they may risk prematurely accessing and saying the wrong word. However, such narrow deployment of attention may be difficult, because the order in which speakers inspect their environment is generally unconstrained (in comparison to reading, in which the sequence of fixations is guided by the order of the words in the text; see Rayner, Angele, Schotter, & Bicknell, 2013; Reichle, Liversedge, Pollatsek, & Rayner, 2009; Schotter, Angele, & Rayner, 2012). Therefore, a process whereby speakers fully process one object and then shift attention to preprocess the next object before an eye movement may not be viable. Rather, because speakers explore their visual environment with the task of speaking about it (Griffin & Bock, 2000), it may be that they distribute attention and processing resources over the entire scene. We note that how visual attention is allocated (e.g., sequentially vs. in a more distributed fashion) likely depends on the nature of the task (e.g., reading, visual search, or scene perception). Therefore, the focus of this article and the interpretation of our data reflect only how multiple objects are processed during a task in which subjects name several in succession.

In the present study, we investigated how speakers distribute attention over multiple objects using the *multiple-object naming paradigm* (Morgan & Meyer, 2005) with a *gaze-contingent display change* manipulation (Pollatsek et al., 1984; Rayner, 1975). In this paradigm, speakers see three objects on the screen and name them in a prescribed order. During the trial, the *target* (the object in the second to-be-named location) is replaced with a *preview* (a different object) while the speaker looks at and names the first object. When the speaker makes an eye movement to the target location, the preview is replaced by the target. *Preview benefit*—faster processing of (i.e., shorter gaze durations on[1]) the target when the preview is related to it, as compared to when it is unrelated—suggests that speakers have processed the preview and used that information to facilitate processing of the target. The preview benefit in object naming has been demonstrated for visually similar objects (Henderson & Siefert, 2001; Pollatsek et al., 1984; Schotter et al., 2013), objects that represent the same concept (Meyer & Dobel, 2003; Pollatsek et al., 1984; Pollatsek, Rayner, & Henderson, 1990), and homophones (Meyer et al., 2008; Morgan & Meyer, 2005; Pollatsek et al., 1984; see Schotter, 2011, for a review). In all of these studies, however, the timing of the preview was not manipulated. Therefore, it is unclear *when* the preview benefit arises.

We manipulated the timing of the preview (i.e., its onset relative to the start of fixation on the preceding object) to assess whether the preview benefit diminishes as the preview is presented earlier, relative to the saccade to the target. If so, this would suggest that speakers only process the upcoming object during an attention shift that precedes a saccade to it. Conversely, if the preview benefit remained relatively stable regardless of when the preview was available, it would suggest that allocation of attention to the upcoming object occurs not only during this attention shift. Using a preview that is identical to the target would yield the largest preview benefit (because the preview and target would match on all dimensions: visual, conceptual, and phonological). However, smaller but significant preview benefits are still observed for previews that represent the same concept as the target with a different visual token (Meyer & Dobel, 2003; Pollatsek et al., 1984; Pollatsek et al., 1990). To ensure that any preview benefit we observed would be due to postperceptual processing, we followed Pollatsek et al. (1984; Pollatsek et al., 1990) and Meyer and Dobel (2003) in using previews that represented the same concept as the target, but with a different visual token (see Fig. 1).

[1] As in Schotter et al. (2013; see also Henderson et al., 1989), *gaze duration* (the sum of all fixations on the object before moving to another) was chosen as the dependent measure because it is sensitive to many properties of objects in production studies (visual degradation, word frequency, word length, codability, phonological properties, and preview). Naming latencies are not as diagnostic, because they are more sensitive to idiosyncrasies of the words spoken before the target word, and measurement of onset latency is less precise than measurement of gaze duration.

Method

Subjects

A group of 52 students from the University of California, San Diego (ages 18–24 years), participated in this experiment for course credit or $10. Five of the subjects were excluded because blinking led to excessive track loss. All of the subjects were native speakers of English with normal or corrected-to-normal vision and were naïve concerning the purpose of the experiment.

Apparatus

Eye movements were recorded via an SR Research Ltd. EyeLink 1000 eyetracker in remote setup (no head restraint, but head position was monitored) with a sampling rate of 500 Hz. Viewing was binocular, but only the right eye was monitored. Following calibration, eye position errors were less than 1º. Subjects were seated approximately 60 cm away from a 20-in. Sony Trinitron CRT monitor with 1280 × 1024 pixel resolution and an 85-Hz refresh rate.

Materials and design

A total of 144 line drawings of objects (48 target pictures, 48 pictures for the first location, and 48 pictures for the third location) were selected from the International Picture Naming Project database (IPNP; E. Bates et al., 2003) with selection criteria similar to those used in Schotter et al. (2013; i.e., monosyllabic names, a large proportion of usable responses, high name agreement, and fast response times). Forty-eight other line drawings were taken from Web searches in order to create same-concept previews. For each target, one picture was selected that represented the same concept as the target but with a different visual token of that concept (see Fig. 1). To create the different-concept preview, the same-concept previews were shuffled across targets so that the target and preview were semantically or phonologically unrelated.

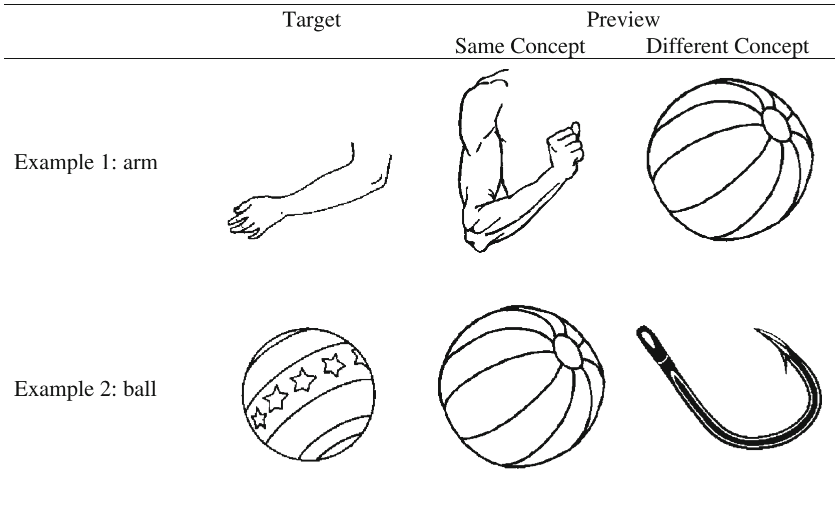

Fig. 1 Example stimuli used in the experiment

Because the same items were used as both the same-concept and different-concept previews, any idiosyncratic effects of those objects were controlled across conditions.

The monitor featured three object locations (Fig. 2), and subjects were instructed to name the image at the top left (the first object), then the image at the top right (the target object), and then the bottom image (the third object). The objects were black line drawings on a white background (on average, they subtended approximately 5º) and were arranged so that the distance between the midpoints of any two objects was 21º. For the experiment, we used a 2 × 2 design with Preview Type (same vs. different concept) and Stimulus Onset Asynchrony (SOA: 50 vs. 250 ms) as crossed within-subjects and -items factors. We chose these timings to ensure that the preview would likely be fully presented by the time that the subject moved his or her eyes to the target (in order to avoid data loss due to the exclusion of trials in which the display change to the target started before the offset of the preview).[2]

Procedure

To ensure that subjects used the correct names, the experiment began with a training session in which all of the line drawings, including the preview objects, were presented individually at the center of the monitor. Subjects were instructed to name each object as it appeared, and naming errors were corrected (all of the intended object names were monosyllabic and common terms for the objects). The objects were displayed until the correct response was made or until the experimenter corrected the subject.

After training, the subject put on a headset microphone, and a target sticker was placed on his or her forehead to monitor head movements. To record movements of the eyes in both the x- and y-axes, the tracker was calibrated using a nine-point calibration. At the start of each trial, the subject saw a fixation point in the center of the monitor. If the tracker was calibrated accurately, the experimenter pressed a button, causing the fixation point to disappear and a black box to appear in the top left quadrant of the monitor (the location of the first object to ensure that the subject was looking in that location when the trial started). Once a fixation was detected in this region, images appeared in all of the locations, with objects appearing in the first and third locations and a gray box appeared in the second (target) location.

Depending on the SOA condition, the preview appeared in the second location either 50 or 250 ms after trial onset (fixation on the black box that triggered the objects to appear). In all conditions, the preview was displayed for 200 ms before reverting to a gray box. When the subject's eyes crossed an invisible boundary located to the right of the first object, the target appeared in place of the gray box. This occurred regardless of whether the display changes of the preview objects were complete. If the display change to the target occurred before the preview offset (<1 % of the time), the trial was excluded. The display change (which took, on average, 15 ms) occurred during a saccade (when vision is suppressed) that took approximately 50–60 ms to complete. The three objects remained in view until the subject named them all. The experimenter then pressed a button to end the trial and to code the naming accuracy of the first and second objects. Subjects were not informed of the display changes in the instructions. However, at the end of the experiment, they were asked whether they had been aware of the display changes and to report the percentage of the time that they could identify what the preview object was. The experiment lasted 30 min.

[2] We chose these fixed timings rather than tailoring the SOAs to each subject because that procedure would lead to a lack of equivalency across subjects, and because subjects will tend to speed up or slow down across the experiment.

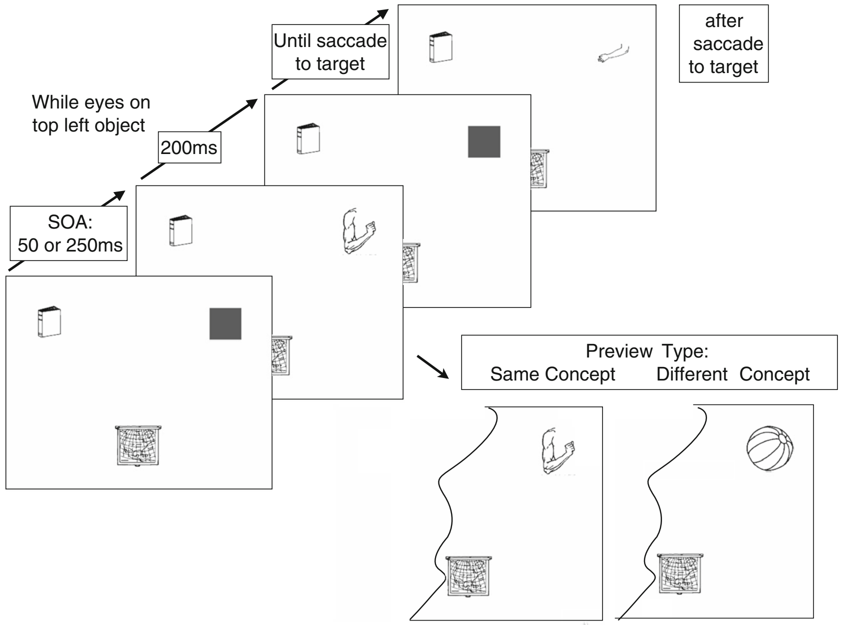

Fig. 2 Display during a trial in the experiment. Subjects were to name the top left object, then the top right object, and then the bottom object. On a correct trial, a subject here would say "book, arm, map." During fixation on the first object (the book), the second object location would appear as a gray box. After a stimulus onset asynchrony (SOA) of either 50 or 250 ms, the preview would appear in the second location for 200 ms, and then be replaced by the gray box. The preview was either the same concept as the target (with a different visual token) or a different concept. As the subject made a saccade to the second object location, the target would appear there

Results and discussion

Data were excluded if (a) subjects misnamed or disfluently named the first or target object (i.e., the first word in the utterance was not the target name; 2 % of the data); (b) the track was lost on the first or the target object (15 % of the data); (c) the target object was not fixated (<1 % of the data); or (d) the display causing the target to appear was triggered before the offset of the preview (<1 % of the data). In all, 7,436 observations remained after these exclusions (82 % of the original data).

We report inferential statistics based on generalized linear mixed-effects models (LMMs). In the LMMs, preview type (same vs. different concept) and SOA (50 vs. 250 ms) were centered and entered as fixed effects, and subjects and items were entered as crossed random effects (Baayen, Davidson, & Bates, 2008) with the maximal random-effects structure (Barr, Levy, Scheepers, & Tily, 2013). To fit the LMMs, the lmer function from the lme4 package (D. Bates, Maechler, & Bolker, 2011) was used within the R environment for statistical computing (R Development Core Team, 2012). We report regression coefficients (b) that estimate the effect size (in milliseconds) of the reported comparison, standard errors, and the t value of the effect coefficient (for which a value greater than or equal to 1.96 indicated an effect that was significant at approximately the .05 alpha level).

Gaze duration on the first object

Gaze duration on the first (pretarget) object was unaffected by preview type ($t < 0.49$) because, at this time, the subject did not know whether the preview was related or unrelated to the target (which had not yet appeared). A significant effect of SOA emerged ($b = 22.96$, $SE = 8.33$, $t = 2.75$), with longer gaze durations on the pretarget picture when the preview appeared at the 250 ms SOA ($M_{\text{same}} = 864$ ms, $M_{\text{diff}} =$ 866 ms) than when it appeared at the 50 ms SOA ($M_{\text{same}} =$ 867 ms, $M_{\text{diff}} = 871$ ms). We found no interaction between preview type and SOA ($t < 0.09$).

Gaze duration on the target object

A significant effect of preview type was evident ($b = 20.37$, $SE = 5.29$, $t = 3.86$), with shorter gaze durations on the target when the preview was the same concept as the target than when it was unrelated. We also found a significant effect of SOA ($b =$ 12.13, $SE = 6.12$, $t = 1.98$), with longer gaze durations on the target when the preview appeared at the later SOA.[3] No interaction emerged between preview type and SOA ($t < 0.31$),

[3] This is may have been due to the psychological refractory period effect (Pashler, 1994; Welford, 1952). Later previews appeared closer in time to the onset of target fixation. If a refractory period did emerge due to processing of the preview, this would be more likely to extend into the period of the target gaze duration for later than for earlier previews.

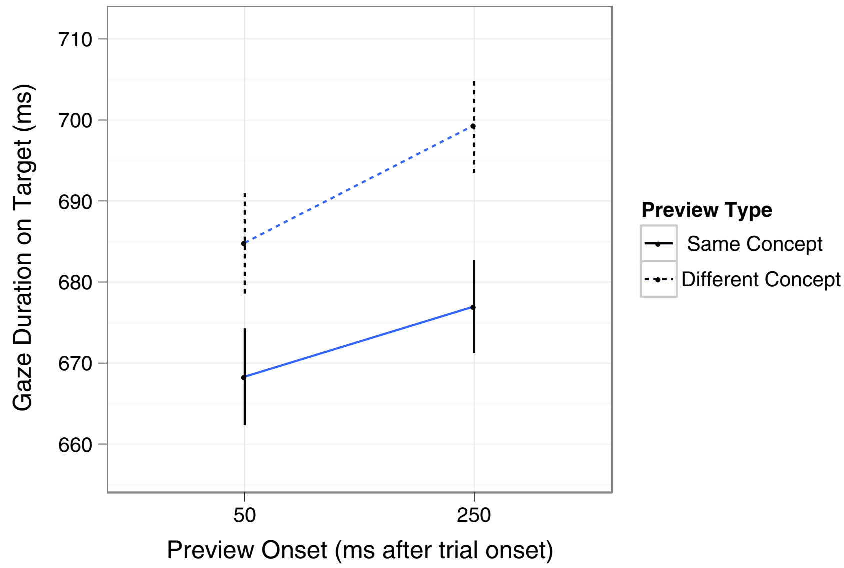

Fig. 3 Gaze duration on the target object as a function of preview type (same vs. different concept) and SOA (50 vs. 250 ms after trial onset)

suggesting that the magnitude of the preview benefit was unaffected by when, relative to trial onset, the preview appeared (Fig. 3).

The effect of saccade latency on preview benefit

If preview benefit only accompanies an attention shift preceding an eye movement, one would expect that it would be larger when the preview appeared shortly before the subject moved his or her eyes to the target. If so, we would expect to see an interaction between preview type and preview offset-to-saccade latency, such that the preview benefit would be larger at shorter latencies (when the preview would coincide with an attention shift to that location). If an interaction were not observed, it would suggest that preview benefit during multiple-object naming does not only occur during an attention shift preceding a saccade. To test this, we ran an additional model on all of the data in which, instead of SOA, the continuous variable of latency from preview offset to the saccade to the target (binned in 100-ms intervals)[4] was centered and entered as a predictor (both in the fixed effects and random effects). In this model, the effect of preview was significant (b = 18.08, SE = 5.38, t = 3.36), as was the effect of latency (b = .05, SE = .02, t = 2.50). Again, we found no interaction between preview type and preview offset-to-saccade latency (t < 0.77), suggesting that the magnitude of the preview benefit was the same, regardless of saccade latency.

Together, these data suggest that preview benefit during multiple-object naming is fairly stable and does not depend on the timing of the preview relative to the saccade to the target. This indicates that speakers do not restrict preprocessing of the upcoming object to an attention shift before the saccade. Neither the experimental manipulation of preview SOA nor the latency between preview offset and the saccade to the target modulated the magnitude of the preview benefit in our task (preview benefits were fairly stable, regardless of these variables; see Fig. 4).

The effect of preview awareness on preview benefit

It is also possible that, rather than preprocessing the upcoming object continuously, subjects processed the preview because the sudden visual onset attracted their attention (although, in a previous study with display changes during fixations [Schotter et al., 2013], preview benefit was not obtained from objects that subjects were told to ignore, suggesting that display changes during fixation per se are not sufficient to cause preview benefit). If this were the case, we would expect to see that subjects who were more aware of the display changes (i.e., those who reported identifying the preview a large proportion of the time) would exhibit larger preview benefits than would subjects who were unaware or less aware. Thus, we categorized subjects into three groups: unaware (reported identifying less than 2 % of the previews: 11 subjects), less aware (reported identifying 2 %–65 % of the previews: 25 subjects), and more aware (reported identifying more than 65 % of the previews: 10 subjects). We entered this factor into the analyses (both as a fixed and as a random effect for items with interactions with the other factors). A main effect of preview emerged (b = 30.12, SE = 12.18, t = 2.47), but neither the effect of SOA (t = 1.31) nor awareness group, nor any of the interactions, was significant (all ts < 1; see Fig. 5). Although self-reported postexperimental awareness

[4] The pattern of data and significance tests showed the same pattern when the data were not binned and raw latency values were used instead.

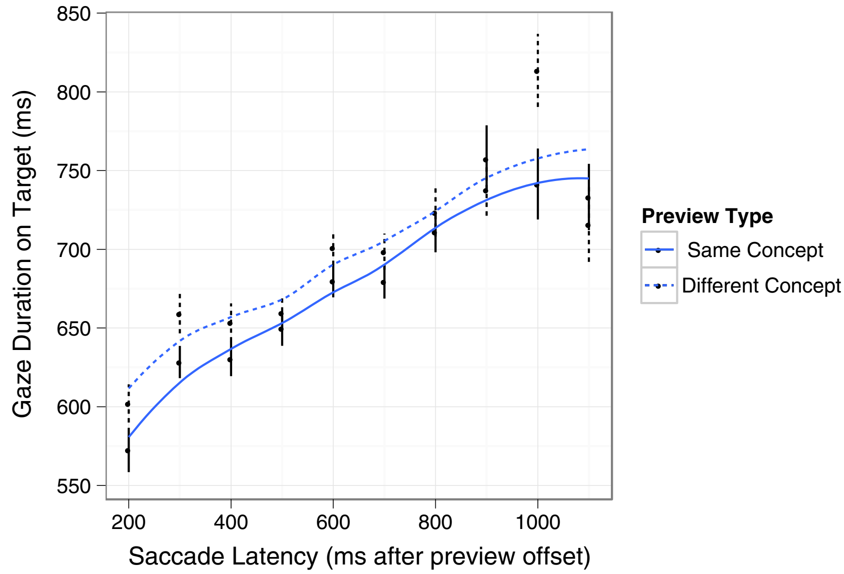

Fig. 4 Gaze duration on the target as a function of preview type and preview offset-to-saccade latency (binned in 100 ms intervals). Only saccade latencies between 200 and 1,200 ms are included in the figure for clarity, because data at more extreme latencies were much noisier (note the greater variability of the data points above 800 ms in the figure). All data points were used in the statistical model

may not be the most accurate measure of awareness during an experiment, this analysis suggests that the preview benefit is, at least, independent of remembered awareness of the preview.

Conclusion

The data reported here add to a growing body of research suggesting that speakers access information from to-be-named objects concurrently as they fixate preceding objects (see also Henderson et al., 1989; Meyer & Dobel, 2003; Meyer et al., 2008; Morgan & Meyer, 2005; Pollatsek et al., 1984; Pollatsek et al., 1990; Schotter et al., 2013; for a review, see Schotter, 2011). Crucially, though, the present study provides evidence that preview benefit occurs regardless of the latency of the preview relative to the onset of processing the prior object (our manipulation of SOA) or the latency of the saccade to the target location. Under the assumption that preprocessing only occurs during an attention shift preceding an eye movement (Henderson et al., 1989), the preview benefit should show a negative relationship with saccade latency, but this was not observed. This finding suggests that speakers access information from objects that they intend to name whenever the information is available. This may be a natural part of the

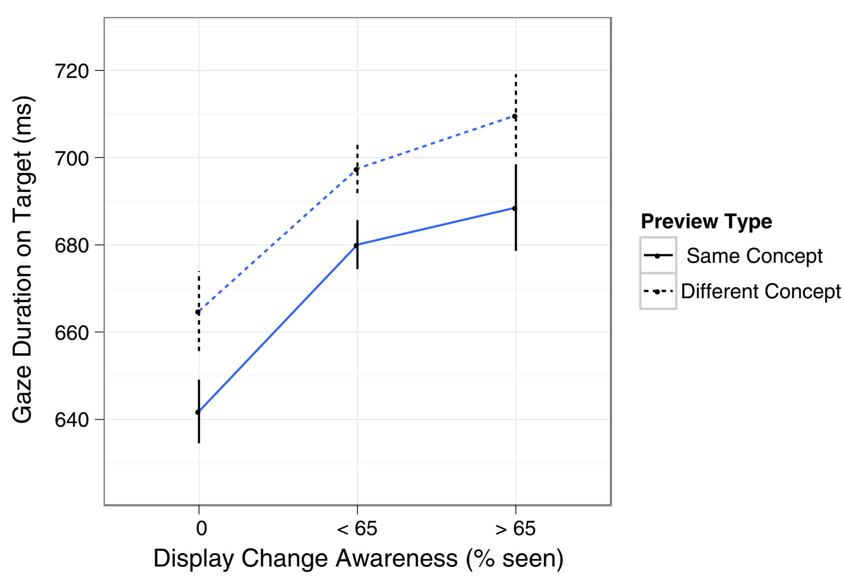

Fig. 5 Gaze duration on the target as a function of preview type and the subjects' awareness of the display changes

speaking process; in general, speakers combine speaking about their environment with visual inspection of it (Griffin & Bock, 2000). For this reason, it may be advantageous for speakers to distribute attention broadly, in order to allow apprehension of the scene.

One consequence of the fact that speakers promiscuously process multiple objects simultaneously is that the linguistic processing system requires a way to regulate the potentially overwhelming amount of incoming information. Other research of ours (Schotter et al., 2013) revealed that speakers restrict this processing to only those objects that they *intend* to process (name), such that only to-be-named objects provide preview benefit, and objects that are to be ignored do not affect processing. This work suggests that the results of the present study were not purely driven by the display changes capturing attention, because a sudden onset is not sufficient to cause preview benefit; in that study, no preview benefit was observed when the subjects were told to ignore the object in that location (despite the sudden onset of the preview during fixation). This suggests that one way that speakers avoid potentially accessing and naming the wrong object is by restricting the set of processed objects only to those that are intended.

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