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Insight into analogies: Evidence from eye movements

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Eye movements were recorded while participants solved picture analogies in which they had to identify the object in one picture that "went with" an object in another, simultaneously presented picture. The pattern of saccades between objects, but not the time spent looking at objects, was a very sensitive measure of the time course of both relational and object-matching processes. The results show that processing of relations between objects precedes processing of matches between objects for young adults solving simple analogies.

Analogies are viewed as a major source of intellectual creativity, particularly in finding solutions to problems in novel domains where an individual lacks relevant previous experience (Gentner, 1983; Holyoak & Thagard, 1995). Empirical evidence about how people solve analogies has consisted primarily of the solutions that people give when asked to find correspondences between a source problem and a target problem. Researchers examine how these solutions are influenced by the structure of the problem, the capacities of the subjects solving the problem, and the imposition of different types of concurrent tasks; evidence of this type has been used to support and contest a number of detailed theories of analogical processing (e.g., Falkenhainer, Forbus, & Gentner, 1989; Gentner, 1983; Hummel & Holyoak, 1997, 2003). While theoretical accounts of analogy have many differences, two important processes are included in all major theories: *Relational* processes, which establish correspondences based on similar relations among the objects in the two problems, and *object-matching* processes, which establish correspondences based on the similarity of an object in the target problem to one in the source problem. Here, we attempt to increase understanding of these

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processes by recording participants' eye movements as they solve scene analogies presented in line drawings.

The first goal of this research is exploratory; it is to determine the ways in which characteristics of eye movements are informative about how scene analogies are solved, and particularly how they reflect object-matching and relational processes. Eye movements have been employed for many purposes in the study of cognitive and perceptual processes (Rayner, 1998), with studies in two areas, scene perception and problem solving, being most relevant to the current work. Most studies of scene perception have focused on fixation density, a set of measures that includes probability of fixation on objects, the frequency of different types of fixations, and the time spent looking at objects; this research has shown that fixation density increases with both the visual and semantic informativeness of regions of a scene (e.g., Antes, 1974; Henderson, Weeks, & Hollingworth, 1999; Loftus & Mackworth, 1978). Measures of scan patterns have enjoyed more limited success in providing information about how scenes are processed, with efforts focused on scan patterns as a measure of memory for scenes and with recognition of the need for improved tools for characterizing scan patterns (for discussions see Henderson, 2003; Josephson & Holmes, 2002). Most studies of problem solving have examined looking time on critical objects, finding that it (and other measures of fixation density) provides the most informative measures of underlying cognitive processes. In problem-solving studies, information about saccadic transitions (or scan patterns more generally) has provided only very general information (Epelboim & Suppes, 2001; Hegarty & Just, 1993; Hodgson, Bajwa, Owen, & Kennard, 2000; Knoblich, Ohlsson, & Raney, 2001). One study, by Salvucci and Anderson (2001a), did find very systematic patterns of saccadic transitions in a study of analogical problem solving, but these patterns were linked to the physical arrangement of the text on the screen rather than to the content of the problems to be solved. The scene analogies used here place less constraint on patterns of eye movements than do written analogies, which increases the possibility that critical mental processes would be observable in the pattern of saccadic transitions. Further, the use of a well-specified task with scenes containing objects with clearly defined semantic interrelations provides an opportunity to increase understanding of how eye movement patterns are affected by task goals, a question that has primarily been studied by comparison between eye movements during memory tasks and visual search tasks (e.g., Henderson et al., 1999), but which has been recognized as a topic in scene perception that would benefit from greater study (Henderson & Hollingworth, 1999).

The second goal of this research is to determine the relative order of object-matching and relational processes in adults as they solve analogies. Gentner and Rattermann (1991; Rattermann & Gentner, 1998) have demonstrated that during development children undergo a *relational shift* in solving analogies, in that younger children tend to choose object matches as solutions, whereas older children and adults choose relational matches as solutions even when object matches are present in the problem. In countering arguments by Goswami and Brown (1989; Goswami, 1992) that relational processes are always primary but that the presence of object matches induces performance errors in younger children, Rattermann and Gentner (1998, p. 471) cite evidence that even for adults object matches are essential to comparisons, "… with object matches generally computed before relational matches". This hypothesis can be tested by tracking eye movements, which can provide information about mental processes as they occur.

Our study uses a set of simple scene analogies developed by Richland, Morrison, and Holyoak (2006), which are similar to stimuli developed by Markman and Gentner (1993) and used in a variety of studies (Tohill & Holyoak, 2000; Waltz, Lau, Grewal, & Holyoak, 2000). The stimuli consist of a set of pairs of line drawings, in which the top picture serves as the source analogue and the bottom picture serves as the target. The pictures depict actions that can be described by motion verbs (e.g., *chase*, *feed*, or *kiss*) that create relations among pairs of objects. Participants must find an object in the target picture that corresponds to a specified object in the source picture.

Following Richland et al. (2006), two factors were manipulated in the stimulus set. The first factor was relational complexity. For the one-relation condition (left panel of Figure 1), one single action was strongly conveyed within each picture (e.g., the cat chases the mouse in the top picture and the

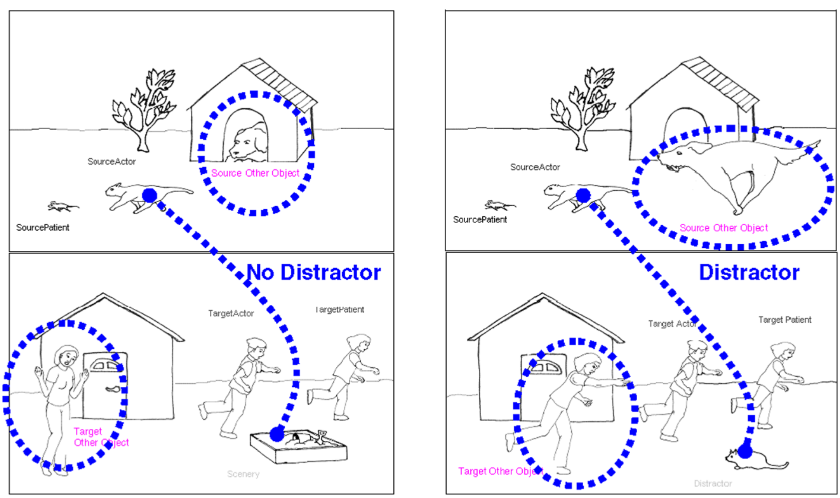

Figure 1. Two sample stimuli, the first in the one-relation, no-distractor condition, and the second in the two-relation, distractor condition.

boy chases the girl in the bottom picture). For the two relation-condition (right panel of Figure 1), two instances of the single relation were strongly conveyed within each picture. Using these stimuli Richland et al. found that across three age groups (3–4, 6–7, and 13–14 years old) the proportion of correct relational selections (e.g., cat mapped onto boy) was higher in the one-relation condition than in the two-relation condition. The second factor was the presence of a distractor object, i.e., the presence of an object in the target picture that matches a critical object in the source picture. For the distractor (matching-object) condition, the object from the source picture that was to be matched was also depicted in the target picture (e.g., the cat in the target picture in the right panel of Figure 1). For the no-distractor (control-object) condition, an unrelated object (e.g., a sandbox) was substituted for the matching object as shown in the target picture in the left panel of Figure 1. Using these stimuli, Richland et al. found that the likelihood of selecting the distractor object (when it was present) declined with the age of the participant from 46% (3–4 year olds) to 26% (6–7 year olds) to 6.5% (13–14 year olds).

The rationale for the present experiment was that relational complexity should affect characteristics of eye movements that indicate relational processing, whereas the presence of a distractor should influence object-matching processes. The two goals of the experiment—determining which characteristics of eye movements reflect relational and object-matching processes, and the relative timing of relational and object-matching processes—can be addressed by measuring the nature and timing of effects of relational complexity and presence of a distractor.

METHOD

Participants

Thirty-two undergraduates at the University of North Carolina at Chapel Hill participated in the experiment as a way of satisfying a course requirement.

Materials

Eight stimuli were taken from the scene analogy problems developed by Richland et al. (2006), which describes the spatial configuration of the objects and the methods used for norming critical features of the stimuli. The eight stimuli were used in four conditions created by manipulating relational-complexity and presence of an object match. Each participant saw two problems in each of the four conditions; across subjects each picture occurred equally often in each condition.

Procedure

Participants performed the task while wearing an SMI Eyelink that recorded eye movements throughout the experiment. On each trial the tracker was calibrated while the subject fixated on a central fixation point. Next, a pair of pictures, like those in Figure 1, was shown for a 10 s study phase. During a subsequent test phase, an arrow indicating the object from the source picture to be matched (the cat in Figure 1) was added to the display. The test phase was terminated when the subject indicated to the experimenter which object in the target picture "went with" the indicated object in the source picture.

RESULTS AND DISCUSSION

Object selections

Table 1 shows the proportions of different response types that subjects made. Overall, 88% of responses were relational selections (e.g., the boy is a relational match to the cat in Figure 1). The proportion of relational matches was higher in the control-object condition than in the matching-object condition, $F(1, 31) = 5.13$, $p < .05$. There were a trend toward more relational selections in the one-relation condition than in the two-relation condition, $F(1, 31) = 3.83$, $p = .059$. The interaction between the two factors was not significant. This pattern of response choices indicates that

TABLE 1
Percentage of types of responses for each condition of analogy problem

	Participant Response		
Type of Analogy Problem	*Relational Selection*	*Object Match Control Match Selection*	*Other*
Matching Object/ One-Relation	89	4.7	6.3
Control Object/ One-Relation	93.8	0	6.2
Matching Object/ Two-Relation	79.7	7.8	12.5
Control Object/ Two-Relation	89	1.6	9.4

our college-age subjects were affected by high relational complexity and presence of a distractor object but to a smaller extent than young children (Richland et al., 2006).

Eye movement analysis

This analysis focused on the study phase, as it was clear that subjects routinely derived their solution during the study phase due to the simple nature of the problems. In addition, data from all trials were included in the analyses regardless of which object the subject chose as an answer to the analogy problem. Preliminary analyses showed that data were similar for relational and nonrelational object selections, and including all data preserved the balanced analysis design. Eye tracks were manually corrected for drift (Feng, 2003). Closely-fitting rectangular coordinates were determined for each object in a display so that fixations could be assigned to objects. Analyses focused on seven critical objects in each stimulus. These consisted of the three objects in each picture (source and target) that participated in the critical relations leading to a relational selection. We call these relational objects the actor, the patient, and the extra object (they correspond to the cat, the mouse and the dog in the top pictures of Figure 1 and the boy the girl and the woman in the bottom pictures of Figure 1). The final object was only present in the target picture and consisted of the distractor object or its control (these correspond to the cat and the sandbox in the bottom pictures of Figure 1). These seven objects account for 88.3% of fixations during the study period, with fixations on other objects (e.g., the tree, dog kennel, and house in Figure 1) accounting for 9.0% of fixations, and with unattributed fixations (blank space or uncoded visual detail such as the horizon line) accounting for 2.7% of fixations. The analyses presented below focus on eye movements involving the seven critical objects. Data are analysed first using measures of fixation density and then by looking at the frequency of saccades between different objects.

Fixation density

Figure 2 provides three measures of the fixation density on each of the seven critical objects. *Total time* is the sum of the duration of all of the fixations on an object. *All fixations* refers to the number of times that a given object is fixated. *Entry fixations* refers to the number of times that an object is fixated given that the immediately preceding fixation was not on that object; it is equal to the number of fixations minus the number of immediate refixations, and provides a measure of the number of times that the eyes were directed toward the object from elsewhere in the scene. ANOVAs on these measures

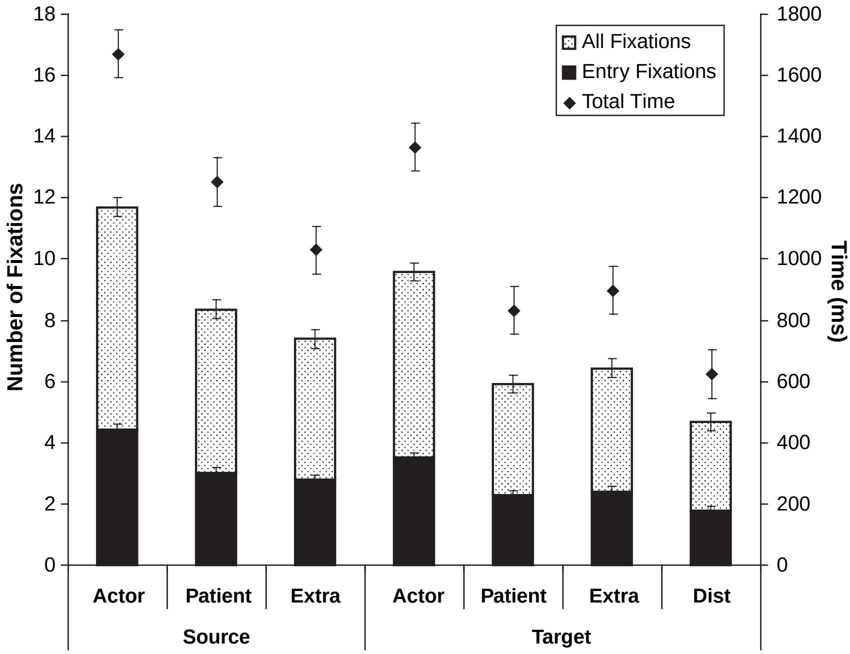

Figure 2. Three measures of fixation density for the seven critical objects in a scene analogy stimulus. The error bars are 95% confidence intervals (Loftus & Masson, 1994).

assessed generality by subjects (F_1) and by items (F_2). All three measures showed significant effects of type of critical object: Total time, $F_1(6, 186) = 70.07$, $p < .001$, $F_2(6, 42) = 7.56$, $p < .001$, number of fixations, $F_1(6, 186) = 106.58$, $p < .001$, $F_2(6, 42) = 8.46$, $p < .001$, and number of entry fixations, $F_1(6, 186) = 138.00$, $p < .001$, $F_2(6, 42) = 17.86$, $p < .001$.

As seen in Figure 2, variation in the three measures across the objects shows substantial congruence, with three features of the pattern being most notable: (1) There is greater fixation density in the source picture than in the target picture, (2) there is greater fixation density for the actors than for the patients and extra objects, and (3) the relational objects show greater fixation density than the distractor/control objects.[1] Research by a number

[1] Two additional ways of measuring fixation density were examined. The average fixation duration was 233 ms overall and it did not vary significantly over the seven critical objects shown in Figure 2, $F_1(6, 186) = 0.67$, $p > .25$; $F_2(6, 42) = 0.70$, $p > .25$. The average first-pass gaze duration (the sum of the durations of the first fixation on an object and any immediate refixations on the object) was 328 ms, it varied significantly by subjects, $F_1(6, 186) = 3.66$, $p < .05$, but not by items, $F_2(6, 42) = 0.93$, $p > .25$. Henderson et al. (1999) found that semantic informativeness did not impact average fixation duration but did impact first-pass gaze duration.

of investigators (e.g., Antes, 1974; Henderson et al., 1999; Loftus & Mackworth, 1978) has shown that fixation density across a scene is strongly influenced by both the visual informativeness and the semantic informativeness of objects or regions within the scene. When considered in conjunction with the structure of the analogy problem, the differences in fixation density seen in Figure 2 are consistent with the idea that subjects found the most critical objects (the actors in the source and target) highly informative. However, the design of the stimuli does not allow a firm conclusion about the source, or sources, of that informativeness. It could be due to the inherent visual or inherent semantic characteristics of the objects, or to the role that the objects play in the analogy.

Evidence about the role of looks to an object in solving an analogy was sought by examining how fixation density was influenced by the experimental factors (number of relations and presence of a distractor). The effect of the experimental conditions was assessed with ANOVAs testing effects of relational complexity and presence of a distractor for each fixation-density measure on each object. For the six relational objects (actor, patient, and extra object in the source and in the target) there were no significant effects (α of .05) of either the number of relations or the distractor manipulation. Thus, while the patterns of fixation density shown in Figure 2 may reflect important aspects of relational processing, they do not provide evidence for the influence of factors (relational complexity and presence of a distractor) that other studies have shown to influence performance with these stimuli (Richland et al., 2006).

In contrast to the pattern for relational objects, fixation density for the distractor/control object was sensitive to the experimental manipulations, as shown in Table 2. The distractor showed greater density (or trends toward greater density) as compared to the control object on total time, $F_1(1, 31) = 5.75, p < .05$; $F_2(1, 7) = 3.52, p = .10$, number of fixations, $F_1(1, 31) = 13.22, p < .001$; $F_2(1, 7) = 3.72, p < .10$, and number of entries, $F_1(1, 31) = 9.75, p < .01$; $F_2(1, 7) = 3.73, p < .10$. This pattern of fixation density suggests that the distractor object had greater informativeness than the control object,

TABLE 2
Measures of fixation density, time, and frequency of different types of fixations for the distractor/control object as a function of experimental condition

	Total time (ms)	*All fixations*	*Entry fixations*
1-Rel No Dist	643	2.98	1.77
1-Rel Dist	741	3.64	2.05
2-Rel No Dist	488	2.29	1.51
2-Rel Dist	626	2.72	1.74

consistent with the operation of object-matching processes during the processing of the analogy. Further, fixation density on the distractor and control object was consistently greater in the one-relation condition than in the two-relation condition on all three measures: Total time, $F_1(1, 31) = 4.44, p < .05$; $F_2(1, 7) = 12.16, p < .05$, number of fixations, $F_1(1, 31) = 9.14, p < .01$; $F_2(1, 7) = 50.58, p < .001$, and number of entries, $F_1(1, 31) = 4.49, p < .05$; $F_2(1, 7) = 12.46, p < .001$. This effect of relational complexity on time spent looking at the distractor/control object is consistent with the idea that relational processes can cause subjects to devote their attention to objects other than the distractor/control object.

Scan patterns

Characterizing the fixation sequences that make up scan patterns is a challenging problem in sequential pattern analysis. Though techniques based on string editing have recently shown some promise in this regard (Josephson & Holmes, 2002; Myers & Schoelles, 2005; Salvucci & Anderson, 2001b), we begin our analysis by considering fixation locations as a Markov series. Doing so allows identification of the range over which there is a general dependence between fixations. This range of dependence can then be combined with the analogical structure of the scenes to test hypotheses about how specific scan patterns are influenced by the relational complexity and distractor manipulations.

Previous analyses of scan patterns using Markov statistics in problem-solving research (Epelboim & Suppes, 2001) and in other domains (Pieters, Rosbergen, & Wedel, 1999; see Josephson & Holmes, 2002, for a discussion) have found that the sequence of fixated objects was most consistently described as a first-order Markov process, that is, the probability of fixating an object was influenced significantly by the identity of the object on the immediately preceding fixation, but was not significantly influenced by the identity of objects on fixations that were further back in the scan pattern. To address this issue in our data, we evaluated the Markov order separately for each picture using the independent scan patterns provided by each of the 32 subjects. Zero-order, first-order, and second-order Markov models were examined using the Bayesian Information Criterion (BIC), a measure that adjusts a model's fit by the number of free parameters it has (Berchtold, 2001). For each of the eight problems, the first-order model gave the lowest BIC, indicating that it was the best model. This finding is consistent with previous Markov analyses of scan patterns (Epelboim & Suppes, 2001; Josephson & Holmes, 2002; Pieters et al., 1999); it indicates that analyses of the scan patterns should focus initially on patterns of fixations on successive objects or (in other words) on saccadic eye movements. For our analyses, we treated a saccade between objects as equivalent regardless of which object was the starting location and which was the ending location. This aggregation cuts in half the number of saccade types that need to be considered, and is supported by a previous analysis showing that the first-order Markov model for scan patterns is reversible (Pieters et al., 1999).

Saccades involving uncoded visual locations constituted 4.9% of the total number of saccades, and refixations on the same object (a measure of fixation density) constituted 35.2%; the remaining 59.9% of saccades were between different objects. The two pictures in a problem contained 10 coded objects, so there were 45 possible saccade types (excluding order of fixated objects) per trial. We focus our analyses on eight of these saccade types which, as discussed below, were defined on the basis of the structure of the analogical problems as relational saccades or as object-matching saccades. These eight saccade types account for 52.3% of the total number of between-object saccades.

Saccades and relational processing

Relational saccades were defined as occurring between the three critical objects (the actor, patient and extra object) within the source or within the target picture. Figure 3 shows the number of each type of relational saccade over the 10 s study interval divided into four equal epochs. For the source problem, actor–patient saccades were the most frequent, followed by actor–extra object saccades, which were more frequent than patient–extra object saccades. The frequency of each of these types of saccades declined with epoch: Actor–patient saccades, $F_1(3, 93) = 24.06$, $p < .001$; $F_2(3, 21) = 10.12$, $p < .001$, actor–extra object saccades, $F_1(3, 93) = 12.87$, $p < .001$; $F_2(3, 21) = 9.14$, $p < .001$, and patient–extra object saccades, $F_1(3, 93) = 7.93$, $p < .001$; $F_2(3, 21) = 6.15$, $p < .005$. This pattern shows that subjects spent more time studying relations in the source problem at the beginning of the study interval than at the end. The relation factor did not significantly affect actor–patient saccades, nor did it affect patient–extra object saccades, Fs < 1. However, actor–extra object saccades were much more frequent in the two-relation condition than in the one-relation condition, $F_1(1, 31) = 16.9$, $p < .001$; $F_2(1, 7) = 33.36$, $p < .001$. This pattern shows that the presence of a relation between the actor and extra object selectively causes a substantial increase in the incidence of saccades between the two objects. The distractor factor did not significantly influence the frequency of any of these three types of saccades.

For the target picture, the number of saccades was also affected significantly by epoch for actor–patient saccades, $F_1(3, 93) = 6.38$, $p < .001$; $F_2(3, 21) = 6.01$, $p < .005$, for actor–extra object saccades, $F_1(3, 93) = 5.28$,

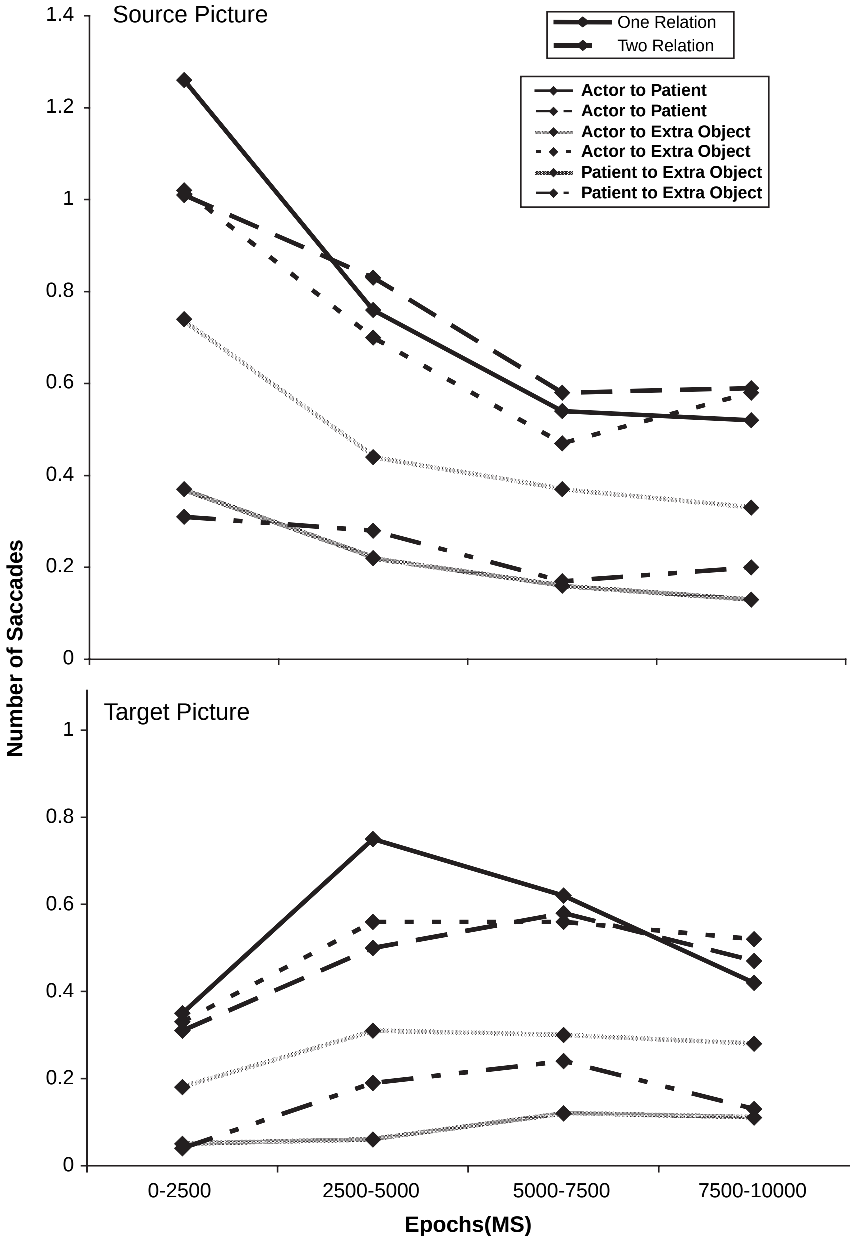

Figure 3. Relational saccades within the source and target pictures.

$p < .005$; $F_2(3, 21) = 10.02$, $p < .001$, and for patient–extra object saccades, $F_1(3, 93) = 5.74$, $p < .001$; $F_2(3, 21) = 4.96$, $p < .01$. However, in contrast to the pattern for the source problem, the frequency of relational saccades in the target problem started low and then increased for the middle of the study phase, after which they either stayed constant or declined.

For the target problem, the relation factor did not significantly affect actor–patient saccades, $F_1(1, 31) = 1.95$, $p > .15$; $F_2(1, 7) = 2.39$, $p > .15$. However, actor–extra object saccades were much more frequent in the two-relation condition than in the one-relation condition, $F_1(1, 31) = 28.88$, $p < .001$; $F_2(1, 7) = 30.61$, $p < .001$, as were patient-extra object saccades, $F_1(1, 31) = 6.20$, $p < .02$; $F_2(1, 7) = 5.82$, $p < .05$. This finding shows that the presence of a relation between the actor and extra objects increases the incidence of saccades between the extra object and the other relational objects. As with the source picture, none of the relational saccades in the target picture was significantly influenced by the distractor manipulation.

Saccades and processing object matches

Two types of saccade involving the distractor object (or the control object in the no-distractor condition) were identified as possibly reflecting information pickup related to the process of object matching. Those saccades were between the distractor/control object and the source actor, and between the distractor/control object and the target actor. The first of these saccades indicates a direct processing connection between the target and source pictures, which in the distractor condition would suggest that participants are directly establishing a match based on the similarity of the objects. The second of these saccade types is within the target picture and suggests a process of comparing two plausible answers. Figure 4 shows these two types of saccade broken down by distractor condition and epoch.

For source–actor to distractor/control object there were more saccades in the distractor-present condition than in the control-object condition, an effect that was significant by subjects and marginally significant by items, $F_1(1, 31) = 12.32$, $p < .001$; $F_2(1, 7) = 4.39$, $p < .08$. In addition, the effect of the distractor manipulation was stronger during the second half of the study interval than during the first half, an interaction that was again significant by subjects and marginal by items, $F_1(3, 93) = 8.14$, $p < .001$; $F_2(3, 21) = 2.70$, $p < .08$. For target–actor to distractor/control object saccades there was a significant main effect of epoch, $F_1(3, 93) = 8.28$, $p < .001$; $F_2(3, 21) = 8.76$, $p < .001$. There were more saccades from the target–actor to the distractor object than to the control object; this effect of distractor condition was significant by subjects and marginal by items, $F_1(1, 31) = 21.39$, $p < .001$; $F_2(1, 7) = 3.55$, $p = .10$. These patterns of saccades in the

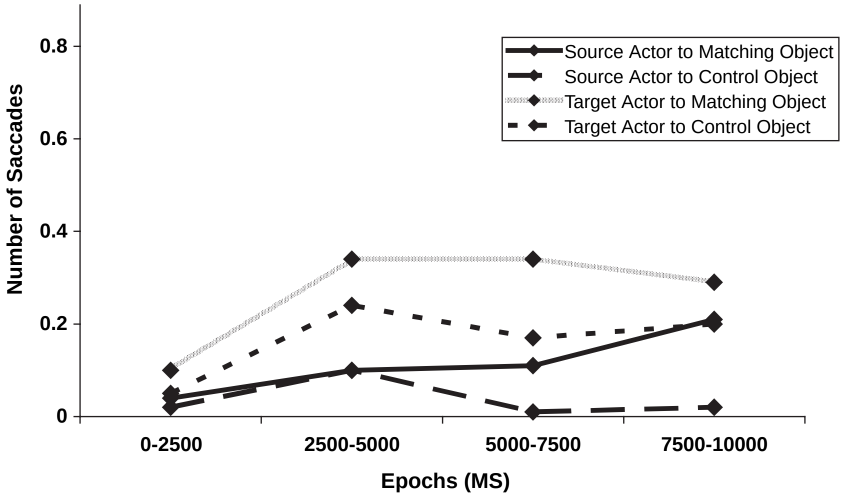

Figure 4. Number of matching object/control transitions over time in the study phase for the matching object and control object conditions.

eye tracks thus provide a signature of the effects of object-matching processes of the sort that have been inferred based on people's analogical solutions. The effects of the distractor manipulation on saccades involving the distractor/control object and the source and target actors were highly significant by subjects but only marginally significant by items. The marginal significance in the item analyses is almost certainly due in part to the small number of items (eight) that were used in the experiment. However, it should be noted that item analyses showed highly significant effects of relational complexity on relational saccades, suggesting that relational complexity was more generally implemented in the stimuli, at least as it is apprehended by the adult mind, than was object similarity. This is consistent with a characterization of adult subjects as focusing on relational, rather than object-matching, processes.

CONCLUSIONS

The patterns of fixation density shown in Figure 2 provide empirical support for the a priori definitions of the relative importance of the different types of objects within the scene analogies. Previous studies have shown that fixation density is highly correlated with independently assessed informativeness of regions of within a scene (Antes, 1974; Henderson et al., 1999; Loftus & Mackworth, 1978), and the current results showed greater fixation density for the objects that were most central to the analogical mapping. However, the design of the stimuli does not permit strong inferences about the sources of this variation in informativeness, which could include inherent visual characteristics of the objects, inherent semantic characteristics of the objects, and/or the importance of the object to understanding the relationship between the two scenes presented in each stimulus. In contrast, the patterns of saccade (shown in Figures 3 and 4) are more informative about how normal adults form simple analogical mappings between scenes. These patterns show that subjects focus initially on relations in the source problem, where they devote processing resources to examining the clear relations between objects (actor–patient in the one-relation condition and additionally actor–extra object in the two-relation condition). Subsequently, processing shifts to the target problem, where processing resources are again devoted to relations between objects (actor–patient in the one-relation condition and additionally actor–extra object and patient–extra object in the two-relation condition). Finally, subjects engage in processes related to object matching, including investigation of the similarity of matching objects in the source and target problems, and comparison of the target–problem distractor with the target–problem relational match. These findings are directly relevant to the two goals outlined at the beginning of this paper.

The first goal of this research was to determine which characteristics of eye movements are informative about the object-matching and relational processes that are thought to form the basis of analogical reasoning. For the scenes used in this study, patterns of saccades were clearly more informative than a range of measures of fixation density which, while consistent with differences between objects in informativeness, were not sensitive to the manipulation of the relational complexity of the analogical problems. In contrast, saccade patterns were very sensitive to the relational complexity of the analogical problems. The most straightforward characterization of why the frequency of saccade types depends on relational complexity is that trying to understand the relationship between two objects increases the likelihood that people will move their eyes from one of the objects to the other. This characterization is probably best seen as an heuristic for interpreting saccadic patterns, which (like the *eye–mind* hypothesis of Just & Carpenter, 1980) is sometimes incorrect but which nonetheless provides a useful first approximation for interpreting eye tracking data. To our knowledge, the current results are the first to measure saccadic transitions in such a way that they could be used to characterize the processes whereby people discover the relationships that exist between entities and then use those relationships to form analogical mappings.

The second goal of this research was to determine the relative order of object-matching and relational processes in adults as they solve analogies. Our finding that relational processes precede object-matching processes does not support Rattermann and Gentner's (1998) hypothesis that adults usually compute object matches before relational matches. It seems likely that the timing of object-matching and relational processes during analogical problem solving is affected by the type of problems to be solved and by an individual's cognitive abilities, as influenced by factors such as development or neurological impairment. Measuring eye movements as subjects solve picture analogies appears to provide a valuable method for exploring the time course of those processes.

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