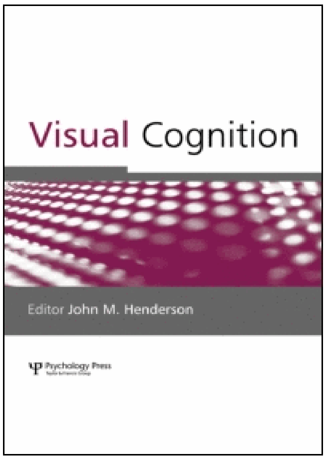

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Detection and Identification of Change in Naturalistic Scenes

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Research using change detection paradigms has demonstrated that only limited scene information remains available for conscious report following initial inspection of a scene. Previous researchers have found higher change identification rates for deletions of parts of objects in line drawings of scenes than additions. Other researchers, however, have found an asymmetry in the opposite direction for addition/deletion of whole objects in line drawings of scenes. Experiment 1 investigated subjects' accuracy in detecting and identifying changes made to successive views of high quality photographs of naturalistic scenes that involved the addition and deletion of objects, colour changes to objects, and changes to the spatial location of objects. Identification accuracy for deletions from scenes was highest, with lower identification rates for object additions and colour changes, and the lowest rates for identification of location changes. Data further suggested that change identification rates for the presence/absence of objects were a function of the number of identical items present in the scene. Experiment 2 examined this possibility further, and also investigated whether the higher identification rates for deletions found in Experiment 1 were found for changes involving whole objects or parts of objects. Results showed higher identification rates for deletions, but only where a unique object was deleted from a scene. The presence of an identical object in the scene abolished this deletion identification advantage. Results further showed that the deletion/addition asymmetry occurs both when the objects are parts of a larger object and when they are entire objects in the scene.

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People fail to detect large changes in successive views of scenes, despite lengthy inspection times, when the changes are effected: During saccades (Ballard, Hayhoe, & Pelz, 1995; Blackmore, Brelstaff, Nelson, & Troscianko, 1995; Grimes, 1996; McConkie & Currie, 1996); or following brief repeated masking fields (Rensink, O'Regan, & Clark, 1995); or where concurrent, but unrelated, transient motion is present (O'Regan, Rensink, & Clark, 1996); or during other occlusion events (Levin & Simons, 1997; Simons, 1996). (See Simons & Levin, 1997, for a review.)

Grimes (1996), for example, showed subjects photographs for 10 sec, ostensibly for recall. During a previously determined saccade, a change occurred to an object's colour, size, location, or orientation, or an object was removed from or added to the scene. The subjects' task was to detect any change. Surprisingly, many subjects failed to detect large changes to the scenes, including, for example: Two men exchanging hats of different colours and styles (100% failure rate), a prominent building in a city skyline becoming 25% larger (100%); two cowboys sitting on a bench exchanging heads (50%).

Simons (1996) presented subjects with arrays of five photographs of common objects in a nine-cell matrix for two sec. One of three changes could occur after an ISI of four sec: An item was replaced by a new one; two items exchanged positions or an item moved to a previously empty matrix cell (Configuration Change). A series of experiments with photographs of real objects, novel shapes, and photographs with a verbal shadowing task, showed that memory for the spatial configuration of objects was high in all conditions, but that memory for object identity was poor, particularly when verbal labelling was suppressed by concurrent articulation. These data suggest that memory for spatial information is "directly visual" and encoded automatically, whereas abstraction of identity information requires more effortful encoding, attention, and verbal labelling.

Agostinelli, Sherman, Fazio, and Hearst (1986) proposed that change recognition involved two stages: An initial awareness of change (detection) followed by a specification of the nature of the change (identification). They argued, following Tversky (1977), that the comparison process begins with features in the subject of the comparison and involves a search for these in the referent. If subjects are told in advance about the detection and identification task, then they are likely to focus extra attention to the specific features of the initial stimulus, which will then serve as the subject of the comparison. Thus, deletions should be easier to detect than additions because the deleted feature is present in the subject of the comparison. Likewise, deletion of a recently attended and encoded feature should be easier to identify than the addition of an unencoded feature present only in the second, referent stimulus. These predictions were confirmed in two experiments in which the stimuli were simple schematic drawings of a common object (or a nonsense figure for which different predictions were made). The change occurred to one discrete feature such as a bumper bar on the car drawing. It is not apparent whether the same processes would be used in the identification of additions and deletions to objects in natural, photographed scenes in which more than one real object is present in a background that contains more features than did the blank field used in Agostinelli et al.'s (1986) experiments.

The addition or removal of whole objects in scenes was studied by Miranda, Jackson, Bentley, Gash, and Nallan (1992) who showed kindergarten (5–6-year-old) and second-grade (7–8-year-old) children line drawings of scenes containing several objects displayed against a simple background. Unlike Agostinelli et al. (1986; Exp. 2), they found a superiority for identification of *additions* in a recognition test. Similarly, with adults, Nallan et al., (1994), using the same methodology, and type of line drawings, also found better identification performance for additions of whole objects than deletions. In a further experiment Nallan et al. (1994), using close-up photographs, again found that identification of (whole object) additions was significantly better than that of deletions. (That experiment, however, differed from those using line drawings, in that subjects were asked to identify six objects added/deleted from a single scene: A dinner place-setting comprising a tabletop and 15 discrete objects.) Thus, there may be an asymmetry in detecting additions and deletions depending on whether a whole object or part of an object is added to or deleted from a scene.

It has been shown that when realistic drawings or photographs of scenes are presented, people rapidly comprehend the gist of the scene using higher order, schematic knowledge (Biederman, Mezzanotte, & Rabinowitz, 1982). However, Johnston and Hawley (1994) argued that schematic, higher order knowledge enhanced immediate comprehension of a scene at a cost of inhibiting the processing of lower order perceptual detail. Thus, the automatic activation of higher order information that allows us immediately to perceive that an object is a car, may inhibit our ability to register the lower order detail required to perform a change detection and identification task.

Support for this argument comes from Pezdek and colleagues (Pezdek, 1987; Pezdek & Chen, 1982; Pezdek et al., 1988), who proposed an *asymmetric confusability effect* in picture recognition. They hypothesized that both complex and simple versions of pictures were schematically encoded such that representations in memory were more likely to match the simple version of a picture. They found that subjects shown a simple version of a line drawing were better at rejecting a complex distractor (that included extra detail, shading, and elaboration to both figure and background of the simple picture) than when shown a complex picture and tested with a simple distractor.

Simons' (1996) research indicated that focused attention and systematic verbal labelling are used to register detail in the first stimulus. This leads to the prediction that changes in easily labelled features should be easier to detect and identify than changes that are difficult to label such as a change in an object's location when that change does not alter the global configuration of the entire scene. Additionally, the research of Agostinelli et al. (1986) suggests that a deleted object (that is part of a larger object) will be easier to detect and identify than an added object (that is part of a larger object), but that the addition of a whole object (Miranda et al.,1992; Nallan et al., 1994) should be easier to detect than the deletion of a whole object. Finally, the suggestions of Johnston and Hawley (1994) lead to the expectation that change to a lower order perceptual feature of an object, such as colour, would be less readily recognized than removal of that entire object when the object's colour was not a defining feature. A change to the colour of a (yellow) lemon, for example, could render it an unripe lemon (green), a rotten lemon (brown), or an unreal or painted lemon (blue), whereas a change in the colour of other types of objects (e.g. a bow) does not alter its meaning to the same degree, and the colour changes made in Experiment 1 were of the latter type, namely colour changes to objects that are found in a variety of colours in the environment.

Thus, Experiment 1 investigated detection and identification rates of the following types of changes in natural scenes across successive views: Addition and deletion of objects, object colour and location changes. These four types of change were made to the same object in each scene, but subjects saw only one of the changed versions. Thus, one subject saw an object change colour, another saw its location change, and so on. Additions and deletions involved the same stimuli shown in different order, and these changes are therefore more directly comparable than are changes in colour or location.

Changes in colour involved a hue already present in the scene, so that the change would not "pop out" as a colour singleton, and the colour was plausible for the object. Location changes preserved the position of the object in depth relative to the camera position so that the retinal image and perceived size of the object were unchanged. Although we cannot be certain that the four types of changes were equivalent in detectability and salience, a subsidiary experiment in which the masking field was removed showed that detection rates for the four types of change did not differ significantly (as is noted in the Results section). The experiment also explored the effects of addition and deletion to scenes containing an identical object. For example, were subjects better at detecting change if a bowl (say) appeared *de novo* in a laundry scene, than if the bowl appeared in the scene where an identical bowl was already present? An earlier pilot experiment had suggested that the addition of a new object to a scene was more easily detected than was the addition of a second instance of an already present object. This appeared also true for deletions, which were more likely to be detected when a unique object was removed than when one of a pair of identical objects disappeared.

EXPERIMENT 1

Method

Subjects. 48 Macquarie undergraduates (15 male, 33 female; mean age = 20.1 years) participated for course credit. All reported normal or corrected-to-normal vision.

Stimuli and Apparatus. Subjects (tested individually or in pairs) viewed 16 unchanged scenes, 16 filler changed scenes, and 16 "critical" changed scenes (A list of the stimuli is given in the Appendix.) The photographs were selected from a large commercially available corpus of stock digital photographs of scenes varying in subject matter (Corel Corporation, 1994), in 8-bit GIF87A file format. The unchanged scenes and fillers varied in visual area, the largest 19.6 × 13.1 cm (subtending a visual angle of 14.6 × 9.9 degrees), the smallest 11.8 × 14.7 cm (subtending 8.9 × 11.1 degrees of arc). Filler changed scenes were included to increase the number and types of scenes and changes, and to distribute the experimental items across trials. Stimuli were presented by means of Microsoft Powerpoint (Microsoft Corporation, 1995) on a Pentium (200 MHz) personal computer with a 17-inch SVGA (1024 × 768) monitor at a distance of approximately 75 cm in a dimly-lit room. The second photograph of a changed pair was produced by digitally altering the first photograph using Corel Photo-Paint (Corel Corporation, 1994) software. An object in the original scene was added, deleted, "moved", or changed in colour (Panels A–D in Figure 1). The critical changed scenes were similar in style and content to the unchanged scenes and fillers, though more uniform in area (the largest 20.3 × 13.5 cm, subtending a visual angle of 15.1 × 10.2 degrees; the smallest 19.3 × 12.8 cm (subtending 14.4 × 9.7 degrees of arc). Critical changed scenes were selected so that all four types of change could be made within the same scene. Changes were not made so that the appearance, disappearance, or movement of an object caused an existing object to be obscured or a new object to be revealed. Scenes contained other single or duplicate objects that were not the subject of change.

The changes were factorially manipulated across stimuli: The set of 16 "critical" changed stimuli were devised so that each "critical" stimulus could be subjected to all four types of change. Thus, four changed forms of each stimulus were constructed. The originals and one changed form were assigned to one of four different lists of the stimuli in such a way that equal numbers of each type of change occurred and an original stimulus (and its changed form) occurred only once in a list. Furthermore, half the addition and deletions in critical changed stimuli involved a unique object, and half involved a pair of identical objects.

Design and Procedure. The stimulus sequence consisted of a yellow field that filled the screen and displayed the stimulus number for four sec, then the

FIG. 1. Examples of stimuli: A vs. B, Duplicate Addition; B vs. A, Duplicate Deletion; A vs. C, Colour Change; A vs. D, Location Change; A vs. E, Unique Deletion; E vs. A, Unique Addition. Panels A, B, C, and D were stimuli in Experiment 1. Panels A, B, and E were stimuli in Experiment 2. Note that in both experiments the stimuli were in colour.

first photograph was displayed for 5 sec, a blue patterned mask followed for 1 sec, and then, either the first photograph or an altered version was shown for a further 5 sec. The yellow field displaying the stimulus number of the next stimulus immediately followed. Subjects responded to each stimulus pair by ticking one of two boxes: "No Change", or "Change" on a numbered response sheet, and described (in no more than a sentence) the form of change if any had occurred.

Subjects were instructed to remember the first photograph, the four types of change were described and illustrated with examples, and they were informed that two-thirds of the test stimuli changed. The sequences were counterbalanced so that, for half the subjects, the order of presentation of each pair was reversed.

Results and Discussion

Mean correct "Same" response to unchanged scenes was 82%. Change detection and change identification data are shown in Table 1, but as both yielded the same pattern of significant effects, only the analyses of change identification performance are reported. A stringent scoring criterion was used for change identification, so that a trial was scored as correct only if the correct change object and the correct type of change was identified by the subject. Change identification scored using this criterion eliminates instances where subjects detect change, but the wrong type of change, or attribute the correct type of change to the wrong object, or attribute the wrong type of change to the wrong object.

Mean filler scene change identification was 38%. Mean percentage change identification for critical changed scenes in each condition is shown in Table 1. As it was possible that the four types of change may have differed in detectability and/or salience, Table 1 also shows the results of a subsidiary control experiment in which 12 subjects were presented the changed scenes without an intervening mask to obscure motion and other transients. Change

TABLE 1
Mean percentage correct change identification and detection rates for critical changed scenes in each condition in Experiment 1 ($n = 48$) and Control Experiment ($n = 12$)

Change	*Addition*	*Deletion*	*Colour*	*Location*
Change identification	51 (29)	66 (25)	43 (30)	31 (28)
Change detection	66 (29)	81 (20)	57 (30)	53 (30)
Control change identification	81 (19)	77 (13)	79 (18)	76 (12)
Control change detection	91 (11)	90 (10)	80 (17)	95 (8)

Standard deviations are shown in parentheses.

identification rates in the control experiment varied between 76% and 81% and did not differ significantly for the four types of change ($F < 1$). Thus the additions, deletions, colour, and location changes were comparable in detectability, and were readily identified with similar levels of accuracy when motion transients and other cues were available. Although this experiment was based on a smaller sample of subjects, the standard deviations were much lower than they were in Experiment 1, further demonstrating the ease with which the changes were identified. We note, however, that, salience may partly be determined by the capacity of a change to trigger the motion detection system, and that all four types of change may not have been equivalent in this respect.

Correct change identification responses in Experiment 1 were subjected to a three-factor ANOVA with stimulus direction (original first/second) and type of change (addition, deletion, colour, location) as within-subjects factors and list (1, 2, 3, 4) as a between-subjects factor. A comparable item analysis with stimuli as the random factor was also performed. The results of the analyses by subjects are reported as F_1, and those by items as F_2. (Effects that are significant by items as well as by subjects are unlikely to be caused by one or two atypical stimuli, and hence effects significant in both analyses are more likely to generalize to other stimuli; Clark, 1973.) These analyses showed a significant main effect of Type of Change: $F_1(3,90) = 15.59$, $MSE = 1.03$, $p < .001$; $F_2(3,78) = 9.61$, $MSE = .46$, $p < .001$, with no other main effects or interactions significant.

Planned comparisons using the Dunn–Bonferroni adjustment for the number of tests yielded a critical mean difference of 9.2%. These comparisons showed that correct change identification was significantly more likely for deletions (where a previously presented object disappeared in a subsequent view) than for additions of an object. Identification of an addition of an object and of a colour change to an object did not differ significantly. Location changes were significantly less likely to be identified than were additions and colour changes. Detection of location changes was much lower in Experiment 1 than Simons (1996) found for configurational changes in spatial arrays (mean approximately 95%, across five experiments). The location changes in this experiment may have been much more difficult to detect, because they occurred against a naturalistic scene background and did not change the overall scene outline, whereas Simons' location changes effected a change in the global configuration of the matrix. Further, if, as Simons (1996) found, subjects were covertly naming items during the first stimulus, and relying on this object "list" at test, verbal encoding of colour should increase change identification because the changed object's colour name will differ. Location is less likely to be verbally encoded in any precise way, and is thus less likely to be identified when changed.

As noted earlier, additions and deletions included instances in which a unique object in the scene was removed or added, and scenes in which one of a pair of identical objects was removed, or a second identical object was added to the scene. Change identification for these two types of additions and deletions was separately examined.

Mean percentage change identification for unique object additions and deletions and duplicate object additions and deletions are shown in Table 2.[1] There was a significant effect of the Type of Change: $F_1(3,40) = 4.21$, $MSE = 0.30$, $p < .01$. A planned comparison showed that additions of a new item were more likely to be detected than a second exemplar of an object already present in the scene: $F_1 = 5.47$, $p < .02$. For deletions, the removal of a single object from a scene was more likely to be detected than was the removal of one of a pair of identical objects, but this difference was not statistically reliable: $F_1 = 3.53$, $p < .07$.

The failure of subjects to detect changes involving the second of two identical items in a scene might be due to repetition blindness, or to a Ranschburg effect (Jahnke, 1969). Repetition blindness (RB) is a phenomenon where subjects fail to detect the second instance of an item in a list serially presented at rates of 6–10 items per second. Kanwisher (1987) proposed that RB arises through limits on a process of token individuation required to establish reportable episodic memories of visual stimuli. If an identical stimulus follows the first, the second item fails to be encoded as a separate instance.

Subjects in Experiment 1 searched for scene information likely to change. If the scene was sampled by subjects at sufficiently high fixation rates, and with small lags between fixations of identical objects, then some degree of RB could have occurred for those identical items. Alternatively, difficulties in identifying deletions and additions of duplicates may reflect a Ranschburg effect (Jahnke, 1969), a difficulty in recalling repeated items, which operates over a

TABLE 2
Mean percentage correct change identification rates for additions and deletions to scenes in Experiment 1

	Number of Identical Objects in Scene (following Addition, or before Deletion)			
	One		*Two*	
	Addition	*Deletion*	*Addition*	*Deletion*
Mean % change identification	56 (22)	69 (23)	35 (31)	54 (23)
Mean % change detection	70 (31)	84 (20)	54 (32)	71 (18)

Standard deviations are shown in parentheses.

[1] Two of the critical changed scenes were removed from the analyses. These were scenes in the unique item change groups in which an object similar to the object of change was present in the background (e.g. in a scene with a man holding the change object, an oar, another oar was present).

longer time course, and is observed in STM list recall. Subjects may have had difficulty in recalling the number of objects of each type in the initial stimulus.

However, the scenes and objects differed for the unique object and duplicate object additions (and the unique object and duplicate object deletions). Consequently, differences between these types of changed scenes might have been due to other differences between the scenes and the objects. Therefore, Experiment 2 was designed to examine the effects of additions and deletions of unique and duplicate objects in the *same scenes* with *the same set of objects*. Thus, there were the following versions of a woman standing in a doorway (Figure 1): In the unique object conditions her dress had one bow (panel A) or no bows (panel E), and in the duplicate condition the dress had two bows (panel B) or one bow (panel A). Additionally, the object added or deleted in Experiment 2 was part of a larger object (bow on a dress, chimney on a building), or was a whole object (a bus, a glass of wine). The inclusion of the part–whole variable was intended to examine whether the asymmetry in identifying additions and deletions extended to entire objects (Miranda et al., 1992; Nallan et al., 1994), or was confined to changes involving features of objects as in Agostinelli et al.'s (1986) study.

EXPERIMENT 2

Method

Subjects. 36 Macquarie undergraduates (8 male, 28 female; mean age = 20.7 years) who had not participated in Experiment 1 participated in exchange for course credit. All reported normal or corrected-to-normal vision.

Stimuli and Apparatus. Subjects were shown 48 picture pairs (see Appendix for a list of stimuli). Subjects saw the same 16 unchanged scenes used in Experiment 1. The 16 filler changed scenes came from Experiment 1 and a pilot experiment. The 16 critical changed stimuli were a modified sub-set of those used in Experiment 1 plus some newly created stimuli.

In Experiment 1, unique and duplicate additions (and unique and duplicate deletions) were made to *different* stimuli. Note that in Experiment 2, unique and duplicate additions (and unique and duplicate deletions) were made to the *same* stimuli (compare panels A, B, and E in Figure 1). In the addition condition, a unique object was added to a scene, or an object was added to a scene already containing an identical object. Deletions were effected by reversing stimulus pair order.

Half the additions/deletions were of objects that formed part of a larger object and half were whole objects. Changes were not made to whole objects that changed the meaning of the scene nor to parts of objects that changed the meaning of the object. Whole objects and part objects that were changed were similar in magnitude: Mean whole object size was 2.60% of the scene (SD 1.93); mean part-object size was 2.73% (SD 2.40) of the scene. Objects and part-objects subject to change were also similarly located within the scene (foreground/background) and on the screen (half appeared in the upper half of the scene and half in the lower half of the scene in both conditions). The same apparatus as that of Experiment 1 was used.

Design and Procedure. The procedure was the same as that of Experiment 1. The design included three within-subjects factors: Type of Object (part, whole), Stimulus Number (one, two), and Type of Change (addition, deletion).

Results and Discussion

The mean percentages of change identification and detection for additions and deletions of unique and duplicate objects, and for whole objects and parts are shown in Table 3. ANOVAs in which subjects and items were the random factors yielded the following significant effects. Changes to whole objects were more frequently identified (61%) than were changes to objects that were part of a larger object (43%): $F_1(1,35) = 18.332$, $MSE = 24383.7$, $p < .0002$; but the difference was not reliable in the by-items analysis, $F_2(1,14) = 3.054$, $MSE = 5419.7$, $p = .10$. Type of Object (part/whole) did not interact with any other variable, $F_1(1,35) = 1.973$, $MSE = 1050.35$, $p > .16$; $F_2 < 1$. Deletions were more likely to be identified (57.6%) than were additions (46.9%): $F_1(1,35) = 7.062$, $MSE = 8342.0$, $p < .02$, $F_2(1,14) = 5.724$, $MSE = 1853.8$, $p < .05$. The interaction between the Type of Change (addition/deletion) and the Number of Objects: 1 or 2 (present after addition, or before deletion) was significant by subjects,

TABLE 3
Mean percentage correct change identification rates for additions and deletions to scenes in Experiment 2

	Number of Identical Objects in Scene (following Addition, or before Deletion)			
	One		*Two*	
	Addition	*Deletion*	*Addition*	*Deletion*
Change identification				
Mean %	43.0 (31.7)	62.5 (30.0)	50.7 (35.1)	52.8 (37.4)
Parts	34.7 (31.2)	58.3 (32.7)	40.3 (35.5)	38.9 (36.1)
Whole Objects	51.4 (30.4)	66.6 (26.7)	61.1 (31.9)	66.6 (33.8)
Change detection				
Mean %	60.4 (33.5)	75.0 (27.8)	63.9 (36.8)	69.4 (36.1)
Parts	48.6 (32.7)	70. 8 (30.2)	56.9 (39.9)	58.3 (38.7)
Whole Objects	72.2 (30.3)	79.2 (25.0)	70.8 (32.5)	80.6 (29.9)

Standard deviations are shown in parentheses.

$F_1(1,35) = 5.978$, $MSE = 5425.3$, $p < .02$; although marginal by items, $F_2(1,14) = 3.788$, $MSE = 1205.9$, $p < .08$. Comparisons of single and double addition/deletions showed the identification advantage for deletions was confined to scenes containing a single instance of the deleted object, $F_1 = 14.999$, $p < .001$; $F_2 = 9.502$, $p < .01$. When a scene contained a pair of identical objects, deletion of one was no more likely to be identified than was the addition of a second instance of an object already present in the scene (F_1, $F_2 < 1$).

These results confirmed the findings of Agostinelli et al. (1986), namely that the deletion of a unique object from a scene is much easier to identify than is the addition of an object not present in the first scene. Our results extend the generality of their findings two ways. First, Experiment 2 showed that the deletion/addition asymmetry applies to real scenes of considerably greater complexity (and ecological validity) than their line-drawn cartoon-like objects. It also demonstrated that the deletion/addition asymmetry occurs both when the objects are parts, or features, of a larger object and when they are entire objects in the scene. This asymmetry is in the opposite direction to the findings of Miranda et al. (1992) and Nallan et al. (1994), who found a whole object addition superiority using line drawings. However, Miranda et al. (1992) and Nallan et al. (1994), used much longer inspection durations (10–30 sec) and test durations (up to 45 sec) compared to our 5-sec and Agostinelli et al.'s (1986) 7-sec inspection and test intervals. It is unclear, however, how such differences could result in a reversal in the direction of the deletion/addition asymmetry.

The results of Experiment 2 did not support our finding in Experiment 1 of an increased difficulty in identifying the addition of an identical object over the addition of a novel object. Experiment 2, however, directly compared these types of changes using a larger set of stimuli and directly contrasted the effects of adding and deleting the same novel and duplicate objects to the same scenes and the results obtained from this factorial manipulation are thus likely to be more reliable.

GENERAL DISCUSSION

Studies of change detection have demonstrated that we retain little information across successive views of scenes. It appears that information unattended or unabstracted from a scene in one view is unlikely to contribute to detection of changes to that information in a second view. It was found, in both Experiments 1 and 2, that identification of object removal was more likely than identification of object addition, suggesting that attention and verbal encoding at presentation assist the survival of information across successive views. Such verbal encoding strategies might produce a differential pattern of results for detection and identification. Verbal encoding should enhance the identification of changes that can be readily labelled or described, but not of changes less straightforward to describe such as the location changes made in Experiments 1 and 2. The results showed a similar pattern for detection and identification, suggesting that verbal encoding strategies were not consistently used by subjects across trials. The role of verbal encoding in the detection and identification of changes may be established through direct manipulation of its use.

The results also supported Agostinelli et al.'s (1986) proposals about the distinction between stimuli that act as the subject and referent in a comparison of similarity. As noted previously, the processes assumed to apply in comparisons of simple schematic stimuli appear to generalize to comparisons of the more complex stimuli seen in natural scenes.

These processes appear to differ when scenes contain more than one instance of an object. The results of Experiment 2, with a larger set of factorially manipulated stimuli, did not demonstrate a generally lower level of performance with scenes having more than one instance of an object as suggested by the results of Experiment 1. However, the identification advantage conveyed by an object deletion is clearly not found when an identical object remains in the changed scene.

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APPENDIX

Experiment 1 Stimuli

Unchanged Scenes

Scene
Army helicopter winching two people from the ground.
Vertical (upward) view of skyscraper.
A country road.
A bear.
Internal view of an Asian temple.
A series of Egyptian statues.
A scuba diver feeding fish.
Several workmen on a construction site.
A lake with children playing in the foreground.
Portrait shot of two African women.
Pool and buildings in a Spanish setting.
A herd of buffalo.
A religious painting.
Pumpkins by a verandah.
Yaks in a mountain scene.
A city skyline by night.

Filler Changed Scenes

Scene	*Change*
A church with a bell-tower.	Part of building appears or disappears.
A public building.	Windows appear or disappear.
A country scene.	A horse appears or disappears.
A woman seated at a desk.	Writing on a postcard appears or disappears.
Portrait shot of two women.	An earring on one woman appears or disappears.
A close-up of notes and coins on a desk.	Coins appear or disappear.
Two horses in a field.	A fence appears or disappears.
A family trimming a Christmas tree.	A chair disappears.
A water polo match.	The goalie's hat changes colour.
A cement mixer delivering cement.	The cement mixer changes colour.
A vintage plane.	Markings on the plane change colour.
A woman sitting by a swimming pool.	Her bathing costume changes colour.
A lighthouse.	A window moves position.
A Cavalier.	His drooping moustache inverts.
South American dancers.	A dancer's arm moves.
A stairwell from above.	A chair at the bottom of the stairs changes position.

Critical Changed Scenes

Scene	*Change Object (each was subject to all four changes)*
A young woman standing in a doorway.	The bow on her dress.
A woman washing clothes in a river.	A large barrel.
A house from the street.	The chimney.
A Roman garden with columns and statues.	A statue.
A helicopter taking off.	An emblem on the side of the helicopter.
An orang-utan.	Its teeth.
A toy snowman.	The broom it is holding.
A city skyline.	A large dome.
A portrait shot of an eagle.	Its tongue.
A mosque.	A central door.
A streetcar.	A man standing on the streetcar.
A poker hand and chips.	A poker chip.
An African woman pouring grain.	Her headdress.
A cowboy and his horse.	The horse's saddle.
A man holding an oar in a camping scene.	The oar.
A vintage car in a courtyard.	A headlamp.

Experiment 2

Critical Changed Scenes

Scene	*Change objects that were part of a larger object*
A young woman standing in a doorway.	The bow on her dress.
A house from the street.	The chimney.
A city skyline.	The large dome of a building.
The steps and doorway to a house.	A doorknob.
The front of a vintage car.	A headlight.

A jet in mid-flight.	A fuel pod on its wing.
A country village.	The roof gables of a house.
A portrait shot of a woman.	Her earring.

Scene	*Change objects that were whole objects*
A collection of horse grooming equipment.	A large comb.
Gambling paraphernalia.	A die.
A drummer on a boat.	His drum.
A city street.	A flag.
A collection of assorted pills.	A pill.
A Roman garden.	A statue.
A restaurant table.	A glass of wine.
City traffic.	A bus.