

DETECTION OF CHANGE: ROLE OF STIMULUS TYPE VERSUS STIMULUS COMPLEXITY

Algis Norvilas

Professor
Department of Psychology
Saint Xavier University
Chicago, IL 60655, USA
E-mail: norvilas@sxu.edu
Tel. (773) 298 34 70

Teresa Mackey

Department of Psychology
Saint Xavier University
Chicago, IL 60655, USA
E-mail: T.Mackey@sxu.edu

This study has investigated the claim that detection of change for spatial configuration is inherently easier than for object identity. Specifically, it looked at whether a difference in complexity, which was much greater in object than in configuration stimuli, might have mediated the difference in performance. In order to assess this possibility, participants were asked to detect change both for object and configuration stimulus pairs at two levels of complexity: simple and complex. The results showed that participants were much better at detecting change for simple stimuli than for complex stimuli, regardless of the type of stimulus involved. These findings, then, do not support a special status for configuration, rather they point to stimulus complexity as playing a determinate role in change detection.

Keywords: change detection, level of complexity, immediate visual memory.

In a series of experiments, Simons (1996) seemed to demonstrate that change detection for spatial configuration is far more accurate than for object identity, suggesting that spatial encoding might be inherently superior to object encoding. After reviewing these findings, O'Regan (2001) also has suggested that "layout (configuration) plays a special role in perception" (p. 293). However, before such a claim can be accepted, Simons' (1996) study needs to be critically evaluated for potential covariation that might have occurred between the two types of stimuli (object identity vs. configuration) and stimulus complexity.

In Simons' (1996) study, subjects were first presented with an array of five different objects (e.g., table, tree, etc.) in a 3×3 matrix. An identity change was created by replacing one of the five objects with a new object, and a configuration change was brought about by moving one of the objects to a new location. Given the nature of these changes, the two stimuli conditions while differing in terms of the aspect involved (representation versus position) might have also differed in terms of complexity. In the case of identity change, the subjects had to keep track of all five objects without knowing which one might change, if any. Clearly, this could have been a

challenging task to accomplish. Configuration change, on the other hand, might have been noticed much more easily. Since each configuration consisted only of five components, the subjects might have perceived them as a uniform pattern, a kind of a Gestalt (Garner, 1963). The displacement of a single component might have disrupted the whole pattern and thus led to quick detection of a change.

Evidence that complexity may exert a significant effect on change detection comes from a number of previous studies. Wright, Green, and Baker (2000), for instance, showed that even arrays of four or fewer simple stimuli could have a negative impact on change detection. They concluded that stimulus complexity has a strong effect on the subject's ability to detect a change. Pollack (1972) found that detection of changes in spatial position in random dot patterns with a

small number of dots was higher than in those with a large number of dots.

This experiment was carried out to see if stimulus complexity might have played a part in bringing about the configuration superiority effect in change detection. Basically, the experiment closely followed Simons' (1996) procedure, but this time it varied stimulus type orthogonally with stimulus complexity (see Fig. 1). In the case of object stimuli, the simple stimulus condition consisted of an array of five objects that were all identical, whereas in the complex stimulus condition, as in Simons' (1996) study, the objects were all different. As for configuration stimuli, the simple stimulus condition was an array of five black dots, while the complex stimulus condition encompassed five arrays of five black dots each.

If it is true that configuration is encoded fas-

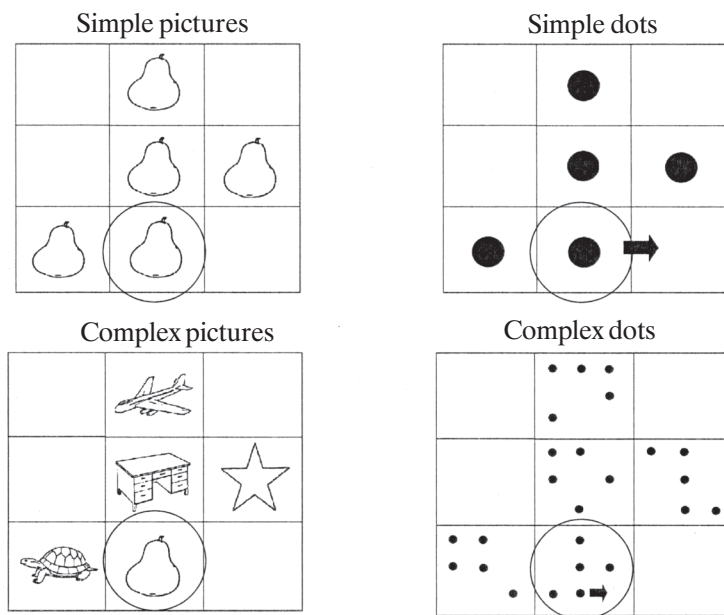


Fig. 1. Examples of the four stimulus conditions. Note that circles around windows indicate location of change, and arrows indicate the direction of dot movement

ter and more effectively than object identity, one would expect detection of configuration change to stay highly accurate relative to object identity, irrespective of the degree of stimulus complexity. On the other hand, if stimulus complexity exerts a determinate influence on detection, then one would expect a correct change detection for simple stimuli to exceed that for complex stimuli, regardless of the type of stimulus involved.

METHOD

Participants

Thirty-eight undergraduate students from the Saint Xavier University participated in the experiment as volunteers.

Design and Materials

The experiment was a 2×2 within-subjects design. The two variables were type of stimulus (objects vs. configurations) and level of complexity (simple vs. complex). The stimulus objects consisted of five sets of six pictures taken from Snodgrass & Vanderwart (1980). To generate the complex object stimuli, five randomly chosen pictures from a set were randomly assigned to five windows of a 3×3 matrix with the restriction that no row or column remained empty. One of the five pictures was then randomly selected for the purpose of being displaced by the remaining sixth picture that would serve as a new object. This procedure was repeated six times, each time producing a new random array, such that every picture served as a to-be-replaced and as a new object at least once. The simple object stimuli basically paralleled the complex object stimuli, except that the to-be-replaced picture appeared in all of the array windows.

The configuration stimuli were presented as dot patterns. The simple configuration stimuli consisted of five dots that replaced the five pictures in each of the arrays. To bring about a change, the dot that stood in the to-be-replaced picture position was moved to a randomly chosen adjacent window, also with the restriction that a row or column did not become empty. For complex configuration stimuli, the pictures were replaced with their corresponding array patterns consisting of five dots. The full stimulus display, then, had five different five-dot patterns in the corresponding picture windows with change occurring in the same window as the displaced picture. Examples of each of the stimulus conditions can be seen in Figure 1.

All possible combinations of stimulus materials yielded 240 pairs of displays: 30 arrays taken over four stimulus conditions, half of which were presented as identical pairs (120) and half as changed pairs (120). To avoid fatigue, the pairs of displays were divided into two mirror-image sets of 120 pairs each, 60 identical and 60 changed, with 15 pairs per each of the four conditions.

Procedure

The participants were tested individually, half of them were randomly assigned to one set of stimulus pairs and half to the other. The stimulus materials were presented in random order on an 18-in. computer monitor. Each stimulus display consisted of a 3×3 matrix – that was 168 mm \times 186 mm in size. The longest distance measure of picture objects varied between 40 to 55 mm. The diameter of simple stimulus dots was 21 mm, the displacement distance of the critical dot 65 mm, and complex stimulus dots being 6 mm and the displacement distance 20 mm. The

presentation of stimulus pairs was controlled by Cedrus “Super Lab” computer software. On each trial, a stimulus display appeared for 2 s, followed by a 4.3-s interstimulus interval (ISI) and then by a second display. The second display remained on the monitor until the subjects selected either “same” or “different” on the response box in front of them.

RESULTS

The percentage of correct change detection and percentage of errors (guesses) in judging identical stimuli are presented in Figure 2. Interestingly, if looked at selectively, the results replicate Simons’ (1996) finding of a significantly higher correct detection for simple configuration sti-

muli (95%) in relation to complex object stimuli (68%), $t(37) = -9.91, p < .01$. However, a comprehensive view of the results reveals a different picture. As one can see in Figure 2, change detection was highly accurate and comparable for simple objects (94%) and simple configurations (95%) conditions, $t(37) = -.45, p > .05$. The accuracy declined for the complex stimuli, but more so for objects (69%) than for configurations (82%), with the two differing from each other, $t(37) = -5.61, p < .01$. On the other hand, identity judgment errors were uncommon, but also similar for simple objects (6%) and simple configurations (5%), $t(37) = -.75, p > .05$. However, they increased dramatically for the complex stimuli, with errors for complex configurations (31%) far exceeding those for complex objects (18%), $t(37) = 5.25, p < .01$. Figure 3 shows change detection scores that have been corrected for error (guessing) in both the simple and complex conditions (see Mantyla & Sandstrom, 2004). Notice that once the change detection scores were transformed for each subject relative to his or her identity judgment errors, the differen-

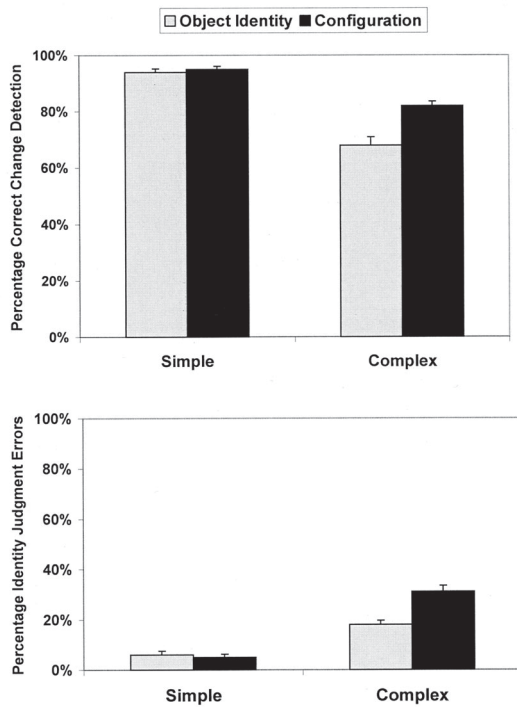


Fig. 2. Percentage of correct change detection (top panel) and percentage of identity judgment errors (lower panel) as a function of stimulus type and stimulus complexity. Error bars represent 1 SE

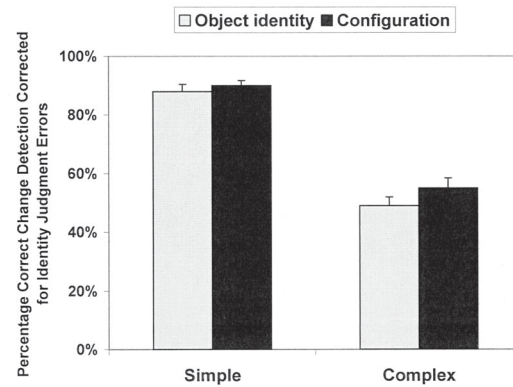


Fig. 3. Percentage of correct change detection corrected for identity judgment errors as a function of stimulus type and stimulus complexity. Error bars represent 1 SE

ce in change detection between object and configuration conditions virtually disappeared: for simple stimuli the difference, respectively, was 88% vs. 90%, $t(37) = -.76, p > .05$, and for complex stimuli it was 49% vs. 55%, $t(37) = -1.13, p > .05$.

DISCUSSION

The results of the experiment failed to support the claim that change detection for spatial configuration is superior to that for object identity. In fact, when complexity is taken into account, the difference in change detection for the two types of stimuli is eliminated. What the results did show was that detection of change was closely associated with the degree of stimulus complexity. For simple stimuli be they simple patterns or single objects, change detection was easy; for complex stimuli such as complex patterns or multiple objects, detection of change was difficult. These findings suggest that the presumed spatial configuration superiority effect in Simons' (1996) study was brought about not by something inherently advantageous about configuration, but by the contrasting detrimental effect that multiple object stimuli had on change detection.

However, one note of caution pertaining to these results should be mentioned. The size of dots did change in scale, and one might wonder if that could have biased the results. Since both dot sizes (21 mm and 6 mm) were large enough to easily enable detection of changes in spatial position, a biasing influence was unlikely. A pat-

tern change in the five-dot configuration brought about by the displacement of a large dot is assumed to have been commensurate with that produced by the displacement of a smaller dot. Nevertheless, one can still ask if the discrepancy in displacement distance (65 mm for large dots and 20 mm for smaller dots) could have had an independent biasing effect. On this issue Pollack's (1972) research has shown that even with random dot patterns the performance associated with dot displacement of 20 mm is already operating at the ceiling level. Moreover, his findings indicate that for displays of eight dots or less, performance differences in detection show little change in relation to display area.

Finally, one might ask why changes for simple stimuli, whatever the type of stimulus, are much easier to detect than for complex stimuli. A possible explanation may be found in Simons and Levin's (1998) view that change detection "requires effortful encoding of precisely those features or properties that will distinguish the original from the changed object" (p. 648). They refer to these encodings as abstract expectations about a stimulus that permit the subject to anticipate the change that is about to occur. Obviously, in the simple stimulus condition this abstract expectation would most likely relate to the stimulus at hand, and, therefore, any stimulus alteration would be quickly detected. In the complex stimulus condition the abstract expectation could easily pertain to a feature or aspect not slated for a change, and thus would have no bearing on the feature change that does take place.

REFERENCES

- Garner W. R., Clement D. E. Goodness of pattern and pattern uncertainty // *Journal of Verbal Learning and Verbal Behavior*. 1963, vol. 2, p. 446–452.
- O'Regan J. K. Thoughts on change blindness // M. Jenkins & L. Harris (Eds.). *Vision and attention*. New York: Springer-Verlag, 2001. P. 281–301.
- Mantyla T., Sundstrom A. Changing scenes: Memory for naturalistic events following change blindness // *Memory*. 2004, vol. 12, p. 696–706.
- Pollack I. Detection of changes in spatial position: III. Dot number or dot density? // *Perception & Psychophysics*. 1972, vol. 12, p. 487–491.
- Simons D. J. In sight, out of mind: When object representations fail // *Psychological Science*. 1996, vol. 7, p. 301–305.
- Simons D. J., Levin D. T. Failure to detect changes to people during real-world interaction // *Psychonomic Bulletin & Review*. 1998, vol. 5, p. 644–649.
- Snodgrass J. G., Vanderwart M. A standard set of 200 pictures: Norms for name agreement, image agreement, familiarity, and visual complexity // *Journal of Experimental Psychology: Human Learning and Memory*. 1980, vol. 2, p. 174–215.
- Wright M., Green A., Baker S. Limitations for change detection in multiple Garbor Targets // *Visual Cognition*. 2000, vol. 7, p. 237–252.

POKYČIO PASTEBĖJIMAS: PATEIKIAMO DALYKO SAVYBĖS IR DALYKO SUDĖTINGUMO VAIDMUO

Algis Norvilas, Teresa Mackey

Santrauka

Simons (1996) manė aptikęs, kad pateikto pavidalo pokytis yra daug greičiau pastebimas negu pateikto daikto pokytis. Tačiau kritiškiau pažvelgus į šį atradimą darosi neaišku, kiek šis skirtumas yra susijęs su pateiktais dalykais: pavidalu ir daiktu, kiek su pateikto dalyko sudėtingumu, kuris daiktų atžvilgiu buvo gero-kai didesnis negu pavidalo atžvilgiu. Mat daiktų vaizdą sudarė penki skirtingi daiktų paveikslai, o pavidalo vaizdą sudarė penkių išdėstytų daiktų vientisa forma.

Šio tyrimo tikslas buvo patikrinti, ar sudėtingumas kartais nebus suvaidinęs svarbaus vaidmens pastebint pateiktų dalykų pokyčius. Tam buvo paruošti keturių pobūdžių pateikiamieji dalykai, susidedantys, kaip ir Simons tyrime, iš penkių vienetų, kurie buvo atsitiktinai išdėstyti 3 × 3 lentelės langeliuose. Paprastą daiktų pateikimą sudarė penki to paties daikto paveikslai (pvz., kriaušė), sudėtingą daiktų pateikimą sudarė penki skirtingi daiktų paveikslai (pvz., kriaušė, vėžlys, rašomasis stalas, žvaigždė, lėktuvas). Paprasto pavidalo pateikimą sudarė penkių taškų rinkinys, sudėtingo pavidalo pateikimą sudarė penkių taškų grupių, kurių kiekviena buvo sudaryta iš penkių taškų, rinkinys. Tiriamesiems iš viso buvo pateikta 120 dalykų porų,

kurių pusė nesikeisdavo ir pusė pasikeisdavo. Pakeitimas daiktų poroje buvo daromas pakeičiant vieną daiktą visai nauju daiktu, o pavidalą pateikiančioje poroje – perkeltiant vieną kurį tašką į šalimais stovintį langelį.

Tiriamieji buvo tikrinami atskirai. Jiems visos atsitiktinai išdėstytos 120 daiktų poros buvo pateiktos 18 colių kompiuterio ekrane. Porų pateikimą valdė Cedrus „Super Lab“ kompiuterio programa. Pirmasis poros vaizdas pasirodydavo 2 s, tada buvo daromas 4,3 s tarpelis, po kurio pasirodydavo tapatus ar pakeistas antrosios poros vaizdas. Dalyvio užduotis buvo nuspręsti, ar pateikti poros vaizdai yra „tokie patys“, ar „skirtingi“, paspaudžiant atitinkamą mygtuką ant priešais stovinčios dėžutės.

Įvertinus tyrimo duomenis, nepasitvirtino tariamai didesnis pavidalo imlumas pokyčio pastebėjimui, nes skirtumo tarp pateiktų daiktų porų ir pavidalų porų pokyčio pastebėjimo atžvilgiu nebūta. Tačiau aptikta, kad pateiktų daiktų sudėtingumas turi ypač didelį poveikį pokyčio pastebėjimui: paprastų dalykų porose pokytis buvo kur kas lengviau pastebimas negu sudėtingų dalykų porose.

Pagrindiniai žodžiai: pokyčio pastebėjimas, sudėtingumo lygis, netarpiškoji regimoji atmintis.

Įteikta 2005 09 20