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A Comparative Study on the Set-size Effects in Polygon and Words in Visual Search Task

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Abstract: Collection size has a very important effect on visual working memory. In this paper, we use an interview and repeated measure design to empirically investigate the relationship between larger ensemble sizes (more than four distractors) and reaction times for participant responses. We set up a scene for daily observation of polygons and words. Participants were required to identify a correctly written Chinese character and the target item, and the pentagon in the hexagon (distractor). The study found that there was no significant difference in the impact trend of large and small groups on people, and there was a high degree of consistency. At the same time, this experiment also found that the effect of ensemble size may be different for males and females. And the reaction time has a great relationship with the location of the target and the reading habits of the subjects. This requires further exploration.

Keywords: Set-size effect, Visual working memory, Polygon, Words

1. Introduction

A well-recognized property of visual working memory (VWM) is that the precision of encoded items decreases with the number of items encoded [1]. A common way of explaining this set size effect is to assume that a fixed number of resources are available for encoding: the more items there are, the fewer resources there are for each item and, therefore, the lower the precision of each item. This is also in line with McGuire's theory of cognitive miser, which states that the brain is extremely stingy in allocating and using cognitive resources when thinking about problems. The set-size effect, on the other hand, is one of the manipulation variables and impression factors. The set-size effect is still a point of discussion and is relevant to our daily lives. There are also hypotheses and tests on how different materials, sizes, and polygonal set-size effects affect human reaction speed [2]. The relationship between the set-size effect and visual working memory has also been elaborated [3]. In addition to this, a study has been conducted on the set-size effect and the formation of personality impressions [4]. It has been shown that the speed of response in the set-size effect is closely related to personality impressions. The main point of interest in this experiment, based on previous research, is the effect of the set-size effect on reaction speed in large sets of positive polygons. In the previous literature, it was stated that shapes with more than 4 sets were large sets and that there was a significant difference in reaction time compared to small sets. (However, large sets of more than 5 have not been studied in this literature, so this experiment focuses on the effect of large sets of more than 5 on reaction times. To explore how the fluctuations in reaction times differ from those of small collections as they grow, whether they increase exponentially, or whether they slow down gradually

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as the collection size increases. Meanwhile, encoding accuracy in visual working memory decreases with the number of encoded items. Brain minimization is based on a weighted sum of the behavioral and neural encoding costs of errors. The model developed by this theory predicts the effect of the set-size effect [5]. This further suggests a link between the set-size effect and visual working memory. Based on the above literature and surveys, the set-size effect still has many points that deserve further study.

2. Literature Review

A sound principled theoretical explanation for VWM was provided in previous experiments where the expected task performance was weighed against the cost of spending neural resources on coding and the fact that the VWM limit was driven by a mechanism to minimize costs rather than by a fixed constraint on available coding resources [6]. The effect of set size on shape attention is because the selection and conceptualization of objects derive from the feature of spatial working memory it limits the number of items that may be simultaneously located, counted, or quantified and used perceptually as bounded shapes. Discriminations and comparisons of large sets are imprecise, while small set quantification is precise [7]. The effect of stimulus selection on set size effects is a fundamental question in visual search. For simple search stimuli such as luminance increments or more complex stimuli such as letters, one can measure the search for many eye fixations as well as for one eye fixation. This suggests that their reaction times may be influenced by something other than a set size. The set-size effect has a greater impact on complex tasks such as distinguishing between different materials and multidimensional polygons. However, it has a similar effect on all simple tasks, such as distinguishing between different shapes or text. For simple task stimuli, there is a pure attentional effect that is specific to the stimulus [8]. At the same time, the Set-size effect in Visual working memory has been investigated in previous experiments to illustrate the use of procedure memory in this context [9]. In summary, the set-size effect, in either case, has an impact on the reaction time of people's decisions but not to the same extent. In general, however, the response time increases with increasing set size. So, it is said that in another experiment it was shown that, it is essentially the set-size effect that affects people's decisions and judgments. Decision-making processes are crucial for organisms living in dynamic environments, which require more than simple stimuli and each individual has a certain selection preference for their choices and responses. If based on a framework for understanding choice set effects between organisms at the neural level, this may explain many previously irrelevant observations about set-size effects [10]. The simultaneous learning paradigm has long been used to understand the mechanisms of knowledge generalization. The impact of the set-size effect can be mitigated by learning. In this study, it was tested whether conditions that facilitate the formation of new concepts have an impact in terms of the number of examples per category (set size) and their relative similarity to the category mean (set coherence). Experiments show that in categorization, high set coherence leads to faster learning and better generalization, while set size has almost no effect [11]. The results of an experiment in another paper imply that the effect of set size on working memory accuracy does not come from working memory storage processes, such as slot averaging, nor is it due to perceptual constraints, but rather to other limitations [12].

In previous experiments with words, for individual words, immediate continuous recall of both high and low-frequency words decreased as the set increased, with low-frequency words being particularly evident [13]. Similarly, similarities to known representations appear to affect the speed of word learning, such as syllabic similarity, semantic similarity, and lexical similarity. However, lexical similarity can speed up learning, whereas semantic similarity slows it down [14]. In summary, the effects on words are mostly pronunciation and meaning, and in this experiment, we chose the words "己" and "己" as targets, both of which have the same syllable "i ", because of the high degree of similarity. Meanwhile, most of the comparison experiments compare text learning with face recognition and car recognition. Smaller object set size effects can be found for faces and words than for cars, as face search accuracy measures correlate with the accuracy of the Cambridge Face Memory Test and word search time measures correlate with single word reading time, but car search is independent of semantic car knowledge [15]. In the present experiment, however, word learning was compared with polygons against each other, as polygon search time measures were related to sensitivity to images, such as associations between specific occupations. However, in the present experiment, students were selected as specific subjects to avoid this phenomenon.

3. Methods and Expected Results

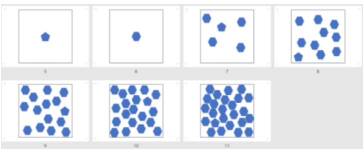
3.1. Questions and Hypothesis

Based on the above review of documents and information, the inquiry question for this experiment was "How large set-size effect influence youth groups' ability to distinguish between different polygons?" in this experiment. In this experiment, the operational variables were pentagons (target) and hexagons (distraction), in which participants were asked to identify the location of the pentagon or determine whether it was present on the slide in the shortest possible time. Therefore, in this experiment, an equal number of males and females were selected as the subjects for comparative analysis, in an attempt to find out whether gender has any influence on the judgment of the large set-size effect. It has been shown in several previous experiments that an increase in set size leads to participants consuming more cognitive resources to find the corresponding target so that attention is dispersed and cognitive resources are less available. As a result, the time to respond and judge cognition increases exponentially. It is therefore hypothesized that as the set size increases, participants will need more time to judge whether a pentagon exists or not. And it is predicted in this experiment that as the set size increases, the reaction time required by participants increases to a certain point before the growth rate slows down and eventually stays at a certain fixed peak. A similar trend has been observed in previous experiments [16].

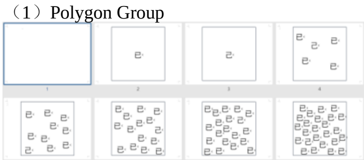
3.2. Designs and Expected Results

The experimental design tool used in this experiment was an online interview. All subjects were required to work online via Tencent meetings throughout the experiment, and all data from the experiments were recorded. The experimental language was Chinese.

The subjects in this experiment were selected from the young adult group aged 16-20 years old, both male and female. The number of subjects is 10 or more males and females.



（1）Polygon Group



（2）Words group

Figure 1: Two control groups for the experiment (1) polygon group; (2) words group

The entire experiment was a repeated measures design in which all subjects had to receive all 7 traits individually. Figure 1 shows the set-size settings (5, 10, 15, 20, 25) and position sizes for the polygon and text groups in this experimental group. The first two sheets of each group formed the pre-test section, the purpose of which was to obtain the subject's basal reaction time and to determine

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the subject's ability to participate in this experiment. The last five sheets are the actual measurement part of this experiment.

At the start of the experiment, each participant must be pre-tested to confirm that the participant has a normal ability to distinguish between pentagons & "己" (target) and hexagons & "已" (distractor). In a pretest, they were asked to distinguish whether the polygons shown on the slides were pentagons or hexagons, respectively. This step brought independent base reaction times for each participant, which helped the experimenter better analyze each individual's real-world response data.

After the pre-test, the subjects were selected to participate in the formal experiment. They were asked to focus on the center of the slide. After 1 second, pentagons and hexagons randomly appear in an 8*8 square in different arrangements on the slide. This operation is edited in advance, no more changes are made in the experiment, and it is randomly arranged. Participants were asked to dictate 'yes' and 'no' to distinguish whether the pentagon & 'self' were present. "Yes" means the target exists, and "No" means it does not exist. Each participant independently participated in the experiments for all seven characteristics.

The data collected in this experiment are interval-level variables because the differences between all time points are equal, but there are no 'true zero' values at the time. Therefore, it was necessary to use Wilcoxon signed ranks to do the statistical analysis. To be able to better predict the likely outcome of the experiment, five sets of experiments were conducted in this experiment, and although the sample size is relatively small to support statistical analysis, it is still possible to already see a little trend in the outcome of the experiment from its results.

To measure the response times of participants more accurately and to make the results more reliable. For this experiment, the following formula was used.

Base reaction time – formal reaction time = personal time difference

In this experiment, one hexagonal and one pentagonal slider were the control group for this experiment. (This is because in my experiment the basic reaction time was different for each individual, being the reaction time for only 1 hexagon or 1 pentagon). The reaction times will also be different at the time of formal entry into the experiment. Therefore, the final analysis of this experiment measured the difference between each person's reaction time and their basic reaction time in the formal experiment.

3.3. Descriptive Data Analysis

Table 1: Standard deviation and average of polygon and words groups at different set-size sizes

Polygon					
Set-size	5	10	15	20	25
Standard deviation	1.445069	1.536	2.528772	1.859883	2.507581
Average	4.345	4.012	5.271	5.264	6.014
Words					
Set-size	5	10	15	20	25
Standard deviation	1.542734	1.429351	1.646277	2.223966	3.836207
Average	4.017	4.265	4.779	6.016	8.056

Descriptive data include mean and standard deviation, as shown in Table.1. The mean is calculated to find the most typical characteristic of two sets of data, and because it references all the data in that set, it is a good indicator for research to see the overall estimate for each set. As the data shows, as the number of disturbances increases (set size increases), the average estimate increases gradually in both the polygon group and words group. Comparing the averages of the polygon and word groups,

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we can see that the polygon group has a smooth upward trend as each set-size increases. The words group, however, has a dramatic increase in mean from 4.779 to 6.016 when the set size reaches 15. Reaching a set size of 25 interfering items, the mean reaches 8.056, much larger than the value for the polygon group at the same set size (6.014). Overall, it can be seen from this that the increased number of interference items in the polygon gives subjects less impact than that caused by the text. At the same time, it took longer to respond to a text than to simple graphics, even though people were more familiar with the text.

Among other things, the standard deviation helps to identify the distribution of data within each group which shows the dispersion of the data. All the standard deviations in the polygon group and the words group are above 1, which means that the variance in the groups is larger. But in contrast, the standard deviation in a polygon is smaller, so it has higher consistency.

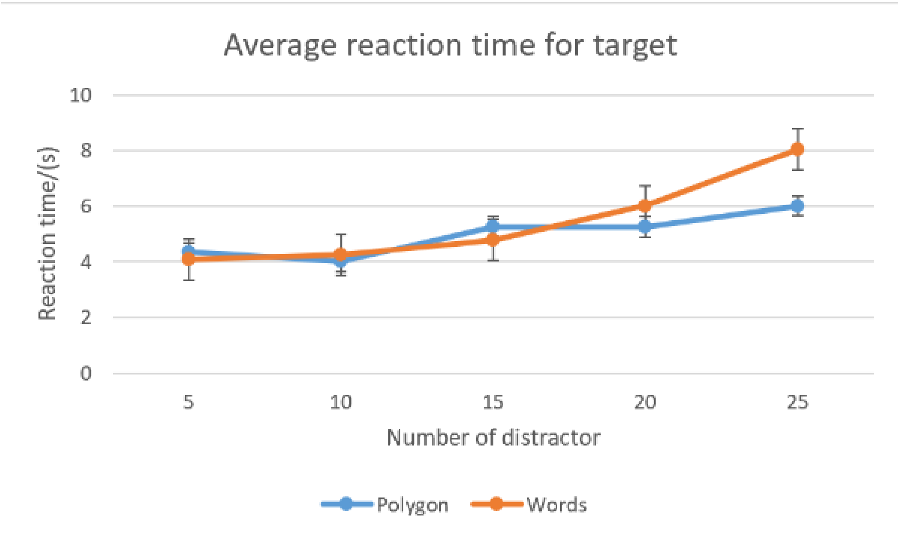

Figure 2: Comparison of mean reaction times between the polygon and words groups

The line graph (Figure 2) shows the differences based on the individual mean time and its error bars. Both the polygon group and the words group shown in the chart show a mild upward trend, especially the words group has a larger increase. This graph shows that before the set size was less than 15, the reaction times of the subjects were similar and stable in both the polygon and word groups. Above this value, however, the reaction time of the words group increased rapidly and greatly surpassed that of the polygon group. Therefore, it can be guessed that the increase in the size of the set of words is more likely to distract the subject's attention than the polygon. Together, these two groups validate the hypothesis that response time increases as the number of set sizes increases. However, it does not match the prediction that the response time will continue to increase as the set size increases and will not reach a point of stagnation. The reaction time for words is supposed to be faster than for graphics because people are more familiar with "己" and "巳" than with pentagons and hexagons, but the results of the experiment are the opposite.

4. Discussions and conclusion

According to this study, the presence of the Set-size effect in the polygon visual search task results in a distraction of attention, i.e. a slower response to the same item with more distractor items. Adults and children both tended to focus on the shape of small sets of items and the material and quantity of large sets of three or more items(Cantrell & Smith, 2013). As their search time is unlimited, personalized elements take more time and energy to perceive. Therefore, the large set will have to expend time and cognitive resources to find the target. Similarly, this experiment shows that young adults' reaction time increases with the size of the set, indicating that shape is not the most significant factor, as has been previously suggested. At the same time, the present experiment shows that the subjects' reaction times to words and images differed significantly when the set had more than 15 distractors, i.e. reaction times to words were much higher than those to polygons. This suggests that subjects may be more sensitive to images, even though they may be more familiar with words. However, this may be related to the subjects that students study and the things they are exposed to on a daily basis. In my previous questionnaire, most of the subjects who participated in this experiment were mostly studying art and only two were studying arts or science projects. Thus those studying arts would be more sensitive to images than subjects studying arts. Even though all the subjects' mother tongue was Mandarin. So this suggests that their left and right brain development may not be consistent, but this needs to be further investigated.

In conclusion, when large sets are presented to adults and children, they are less likely to conceptualize the items as individuals, as the elements of personalization are blurred and attention is instead drawn to the whole, such as color, material, and quantity. There are still some problems with this experiment, firstly the limitations of sample selection, in previous experiments the sample was not limited enough or there was only one, whereas in this experiment there were only 10 subjects and the results could be highly biased due to various external factors, thus affecting the reliability of this experiment. At the same time, all subjects were voluntarily enrolled in this experiment, so there may be consistency in the subjects' work or study, which cannot cover the vast majority of situations, and thus would lead to failure to generalize. secondly, in previous experiments, the effect of order effects was less because most were independent measurement designs, but in this experiment, to reduce the need for the number of subjects, A repeated measures design was used, resulting in the order effect is greatly increased. If subjects became frustrated and were unable to determine the presence or absence of the target item from the 25 distractors in a short period, they would lose interest in subsequent experiments or experience visual fatigue and be unable to concentrate on subsequent experiments. At the same time, all subjects in this experiment were given a text test immediately after taking the graphical test. There may be a greater influence between the two, interfering with each other. Since there were no separate repetitions of the experiment for each subject, there is no guarantee that there was no interference between the two. Therefore the results of the experiment need to be evaluated again.

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