Bachelor Thesis

Visual Working memory for Sizes and Orientations

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Abstract

Visual working memory (VWM) has become a widely discussed topic with research focusing on its capacity and units of information. Two theories have been proposed. The discrete-capacity model suggests that VWM can hold a fixed number of items (~ 4) which can be manipulated and stored, regardless of the features included in the items. Contrarily, the limited-resource model supposes that VWM capacity is determined by a certain amount of resources which can be allocated flexibly to stimuli or specific features of stimuli. Past research examined mostly the representations of colors in VWM. Instead, this study focuses on rarely investigated features, namely the size and the orientation of stimuli. A delayed-estimation task was employed in which participants were asked to remember the sizes and orientations of red squares. To gain a greater understanding of VWM, recall precision was examined in relation to attentional instructions, number of stimuli, and the type of feature to-be-memorized. Furthermore, an individualized stimuli set was created for each participant, to account for perceptual differences. The results show that VWM performance is influenced by the number of stimuli, as well as the attentional instructions. Additionally, recall precision was higher for sizes than for orientations, and there was an interaction effect between number of stimuli and type of feature. These findings support the limited-resource theory and the notion of multiple resource pools for different types of features. Moreover, the results suggest that VWM is interrelated with attentional process which seem to determine the allocation of resources to specific stimuli.

Keywords: Visual working memory, Attention, Size, Orientation, Limited-resource, Discrete-capacity

Visual Working Memory for Sizes and Orientations

The ability of humans to temporarily store and manipulate information can be conceptualized as working memory (e.g., Bocincova & Johnson, 2019; Yatziv & Kessler, 2018). The visual component of this concept is called visual working memory (VWM) and it has become a widespread topic of research. The majority of studies about VWM focused on how colors are stored and represented in memory (van der Lubbe, Borsci, & Miežytė, 2020; Bocincova & Johnson, 2019; Mayer et al., 2007; Oberauer & Lin, 2017). However, there seem to be differences in VWM performance depending on the type of feature being memorized. This suggests that there might be multiple resource pools for different types of features (Shin & Ma, 2017). To investigate this notion further, this study will focus on the assessment of VWM related to the features size and orientation. In the past, these features were rarely investigated in relation to VWM. However, assuming that proposed theories about the mechanisms of VWM are valid, they should be applicable to other features than colors as well.

There are mainly two conflicting approaches, the discrete-capacity theory and the limited-resource theory. Early accounts conceptualized VWM as an object-based discrete capacity. This means that VWM can hold a fixed number of items in so-called slots. One of the initial notions around this topic was the “magical number seven, plus or minus two” (Miller, 1956, p. 81) which refers to working memory as being able to store about seven chunks of information. More recently, Cowan (2000) described this model as merely a vague estimate of the capacity of working memory with the precise limit being about four (three to five) chunks. In general, these discrete-capacity accounts suggest that VWM stores integrated objects rather than individual features (Luck & Vogel, 1997). This means that either all of the features of an object are stored, or the object is not remembered entirely.

The current findings in the field of VWM, however, contradict the discrete-capacity theory. To begin with, Park, Sy, Hong and Tong (2017) showed that by remembering additional features of objects, greater demands are placed on maintenance processes which affect the temporary stability of information in the VWM. Further, they found that recall precision of objects with multiple features deteriorates faster and starts within a few seconds after encoding. Supposing that objects which are asked to be memorized are stored in their entirety in slots, these behavioral consequences cannot be explained. The addition of features to these objects should not be more demanding, nor should the recall precision of multifeatured objects deteriorate faster than objects with fewer features.

Contrary to the discrete-capacity account, the limited-resource theory is able to explain these behavioral phenomena. This approach suggests VWM being continuous rather than discrete. Accordingly, the limit of VWM is determined by flexible resources which can be allocated to specific items or features of items (Yatziv & Kessler, 2018). The limited-resource theory is mainly based on two assumptions. First, it suggests that internal representations of stimuli are inherently noisy, being affected by random and unpredictable fluctuations. The more resources are allocated to internal representations, the less noisy they become. Secondly, this noise grows with an increasing number of features/objects stored in working memory (Ma, Husain, & Bays, 2014).

In line with these assumptions, several studies indicate that the limit of VWM is not determined by the quantity of information but rather the quality or preciseness with which this information is stored (Ma et al., 2014; Park et al., 2017; Wilken & Ma, 2004). More specifically, it is suggested that VWM performance is limited by internal noise which, in turn, is determined by the amount of information to be recalled. Accordingly, information about objects is not encoded in a binary way, but rather on a continuous scale ranging from low to high precision. The “four-item limit” suggested by Cowan (2000) might be merely a function of growing internal noise, eventually leading to the deterioration of performance and hence, constituting a limit of VWM.

The behavioral consequences of this limited-resource theory include fallibility of VWM before the previously suggested object-based limit since the probability to make errors increases as the amount of information to-be-memorized increases (Lilburn, Smith, & Sewell, 2019; Shin & Ma, 2017). Neural correlates of VWM also support this view. Persistent neural activity in certain brain regions, especially in the frontal and parietal lobes, is associated with VWM. Higher neuronal activity in these regions correlates with increasing information stored in working memory. At some point, however, this can reach a plateau which can be described as the limit of the store’s capacity (Ma et al., 2014; Slana Ozimič & Repovš, 2020).

The role of visual attention

Closely related to VWM is the concept of visual attention. It can be defined as the selection of visual input which is currently relevant to the individual (Jonikaitis & Moore, 2019). Initially, VWM and visual attention were both viewed as independent from each other and therefore, were mostly studied separately (O’Craven, Downing, & Kanwisher, 1999; Wilken & Ma, 2004). More recently, however, it turned out that these two concepts are interdependent on behavioral as well as neural levels. Therefore, they are often studied in relation to each other (Chun, 2011; Jonikaitis & Moore, 2019; Van Der Lubbe, Bundt, &

Abrahamse, 2014). Visual attention is crucial to VWM since it is necessary for the encoding of stimuli as well as the maintenance of object information (Hitch, Allen, & Baddeley, 2020).

Recent research in this domain focused mainly on the mechanisms and ways of functioning of visual attention. Similarly, this debate includes questions about the units of information involved in attentional processes and again, whether all features of objects are processed collectively or individually. Previous studies were in line with discrete-capacity models, characterizing integrated objects as the unit of information (Luck & Vogel, 1997; O'Craven, Downing, & Kanwisher, 1999). This approach would suggest that attentional instructions do not play a major role in the processing and the recall ability of multifeatured objects since all features are encoded collectively anyways. However, contemporary findings show that this is not entirely true. Although most studies suggest that encoding does take place for not task-relevant features of objects, the precision with which these features are encoded is substantially lower than for task-relevant features (Bocincova & Johnson, 2019; Shin & Ma, 2016). Thus, it is not clear yet what specifically are the units of information regarding visual attention.

Nevertheless, attentional instructions seem to affect recall precision in VWM tasks as past research indicates. In particular, perceptual attention is often described as a gatekeeper to VWM as it plays a major role in the encoding of stimuli in the first place (Chun, 2011; Hitch et al., 2020). This suggests a biased-competition model, where instructions lead to a top-down bias resulting in improved processing of certain dimensions or features (O'Craven et al., 1999). Consequently, instructing individuals performing a VWM task to focus their attention on a specific feature rather than divide it on multiple features should lead to enhanced performance.

Aim of this study

This study aims to investigate VWM capacity and its units of information. Therefore, individuals are tested regarding their recall precision of stimuli which differ in two feature dimensions, namely their size and orientation. Attentional instructions are taken into account as well as the type of feature to-be-memorized. Participants are asked to either focus their attention on one feature (size or orientation) or divide their attention on both features (size and orientation). Furthermore, the effect of the set size is examined as they are presented with one, two, or four stimuli at a time. The discrete-capacity theory and the limited resource theory make different predictions in this experimental approach. The discrete-capacity theory predicts no effect of attentional instructions, or the type of feature to-be-memorized, and merely a minor if any effect of set size. In contrast, the limited-resource theory supposes that all three variables will have an effect on the recall precision of participants.

Design of this study

Usually, VWM performance is assessed with either a change-detection task or a delayed-estimation task. Most research has focused on change-detection tasks in which participants have to indicate whether a certain stimulus or feature of a stimulus has changed over time (see i.e. Fougnie, Asplund, & Marois, 2010; Shin & Ma, 2017; Wilken & Ma, 2004). However, this research design received some criticism lately, as it appears to not capture VWM performance precisely, but is affected heavily by guessing behavior of participants (Schurgin, Wixted, & Brady, 2018). Contrarily, delayed-estimation tasks seem to be better suited for the assessment of VWM performance. Here, participants are asked to remember specific features or entire objects, in order to identify these on a continuous scale later on. By conducting this task, responses can be measured on a continuous scale as well. This provides more information as merely a score of correct or incorrect. Indeed, this way VWM precision can be operationalized unambiguously (Bae, Olkkonen, Allred, Wilson, & Flombaum, 2014; Zhang & Luck, 2011).

This research is a conceptual replication of the study of Van der Lubbe and colleagues (2020) and implements a similar design. Accordingly, a delayed-estimation task will be used in which VWM performance is measured, for the features size and orientation. Although differences in size and orientations of stimuli can be conceptualized on a continuous scale, there are substantial differences in the perception of visual stimuli by participants (Grzeczkowski, Clarke, Francis, Mast, & Herzog, 2017). To control for these individual differences, the pre-experimental phase will include a sensitivity test for size and orientation differences respectively. Based on this sensitivity test, individual stimuli sets will be created for each participant. These will be determined by the just noticeable differences of participants, thus ensuring comparable conditions.

Methods

Participants

Twelve participants, mainly students, took part in the study (M_{age}= 24.5, range: 20-54 yrs; 3 females; 2 left-handed, 10 right-handed). The data of one participant had to be replaced due to an insufficient score on the visual acuity test which was carried out using Landolt C stimuli (Bach, 2007). Otherwise, all participants had normal or corrected to normal visual acuity and none reported neurological disorders. The participants were recruited using convenience sampling and every participant was provided with a written informed consent which had to be signed before the start of the experiment. Furthermore, this research was approved by the Faculty of Behavioural, Management, and Social Sciences ethics committee of the University of Twente.

Materials

The participants were first presented with a written information sheet about the general purpose and procedure of the experiment (see Appendix A). The experimental task itself was programmed for Python 3.7 and displayed using PyCharm CE 2019.3.3. It was implemented on a MacBook pro (13.3 inches) with a 1680 by 1050 pixel resolution. The participants viewed the stimuli on a white background with a viewing distance of about 60-70 cm.

The stimuli used in this experiment consisted of red squares, differing in size and orientation, respectively (see Fig.1). There were 40 different sized stimuli, with dimensions ranging from 300x300 to 105x105. Furthermore, the orientation of the red squares differed from 19° to 79° as they rotated clockwise.

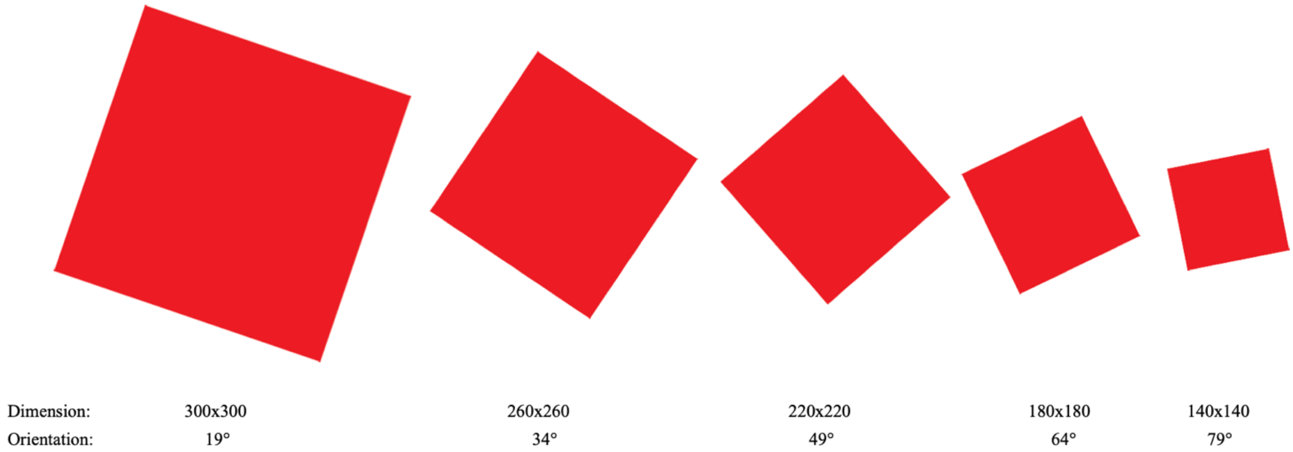

Figure 1. Examples of the stimuli used during the experiment including extreme and incremental values.

Design

In this experiment, a within-subject design was employed. Three independent variables were implemented. These were set size (one, two, or four), attentional instructions (focused or divided), and feature (size or orientation). The dependent variable was task performance, measured as mean error distance (ED).

Procedure

At the beginning of the experiment, the participants received written instructions and signed the informed consent form. Then, they were asked to complete a preliminary visual acuity test (Bach, 2007), and a questionnaire about their age, gender, whether they have any neurological disorders and a brief handedness test (Annett, 1970). After this, the participants carried out a sensitivity test, determining a set of the five most similar stimuli they can just distinguish for sizes and orientations, respectively.

To determine a set of just distinguishable sizes, a fixation cross appeared in the middle of the screen and first, one stimulus appeared on the left side for 1000 msec followed by another stimulus on the right side of the screen for 1000 msec. At first, the stimuli differed in the smallest size difference (e.g., 200x200 to 195x195). The participants were asked whether they could perceive differences between these two stimuli. When they answered it correctly, the same stimuli were presented until four answers were correct. Then, these stimuli were added to the individual stimuli sets. If the participants answered wrong, the size difference was increased by 5x5 each time. This was repeated until five stimuli were added to the individual sets and the same procedure was used in the orientation sensitivity test.

These stimuli sets were then used in the experimental task. It consisted of three blocks, each instructing the participants to attend to different features of the stimuli (size, orientation, and size and orientation). The order of these instructions was counterbalanced for all participants as it was based on the chronological order of participation. At the beginning of each block, five practice trials were presented so that the participants were able to familiarize themselves with the task. Each block, in turn, included three subblocks, randomly administered, which were characterized by the presentation of either one, two, or four stimuli at the same time. In total, the participants completed 540 trials, as each subblock consisted of 60 trials and each block of 180 trials. After each block, they had a five minute break.

During the experimental task, each trial was constructed as follows. First, a fixation cross appeared in the middle of the screen for 1000 msec. Then, either one, two, or four stimuli, randomly drawn from the individual stimuli set were shown for 2000 msec, followed again by a fixation cross for 1000 msec. After this phase, the place at which the to be recalled stimulus appeared was shaded with grey, and the participant was presented with five response options on the bottom of the screen. Here, they had to indicate the size or orientation they thought to remember. After each trial, the participant was provided with the information whether their choice was correct or incorrect and they had to press the spacebar to continue with the next trial.

The entire experiment had a duration of 75-90 minutes and afterwards, the participants were thanked for their participation.

Data Analysis

The collected data were analyzed using IBM® SPSS v.25. The data were tested for normality, homoscedasticity, and sphericity and no violations of these assumptions were found. Descriptive statistics were used to display individual differences in the perception of sizes and orientations. Further, the data acquired in the experimental phase were analyzed in two ways. First, a one sample *t*-test was carried out in order to check for random guessing. Here, the mean ED was tested against the average distance value. Secondly, in order to check for the effects on task performance, repeated measures ANOVA was used with set size, attentional instructions, and feature as independent variables. The effect sizes of this ANOVA were interpreted according to Cohen's (1988) definition of small, medium, and large effect sizes. Consequently, effect sizes were interpreted as small ($\eta_p^2 < 0.1$), medium ($0.1 < \eta_p^2 < 0.4$), or large ($\eta_p^2 > 0.4$).

Results

Individual differences in subjective ability to discriminate size and orientation

As displayed in Figure 2, there are considerable individual differences between the lowest and highest values selected for the VWM task for each participant. The values were measured on a physical scale (size in length and orientation in °). The mean of the size differences was 18.33 (*SD* = 5.68, Range: 12-31), whereas the mean of the orientation differences was 24.17 (*SD* = 10.66, Range: 9-49). Ultimately, these results indicate that participants greatly differed in their ability to discriminate stimuli on the basis of their size and orientation.

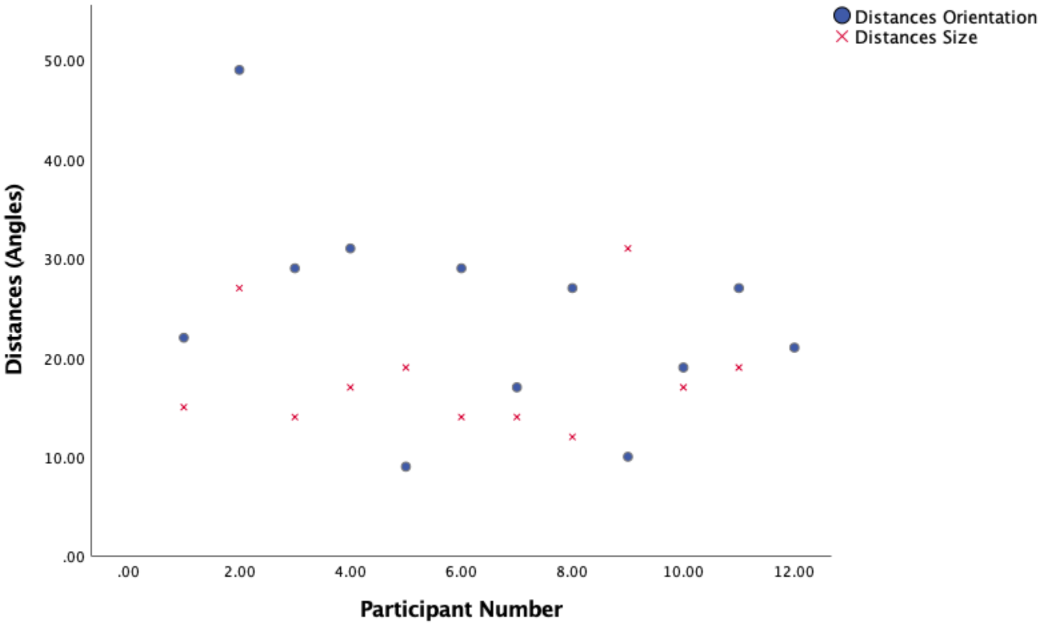

Figure 2. The pre-experimental phase included a sensitivity test determining just distinguishable stimuli sets for each individual. This figure shows the total distances in angles between the first and last feature of each individual stimuli set for orientations and sizes.

Random guessing

The results of the *t*-test showed that the mean EDs regarding all twelve conditions differed from chance. All means EDs were significantly lower than the values which would have been observed with random guessing, 1.6; $t(11) > 4.4$, $p < 0.001$. The smallest deviation from chance was found to be in the divided attention condition attending to four stimuli with orientation being the sought after feature, $M_{\text{diff}} = -0.34$, $t(11) = -4.72$, $p < 0.001$ (95% confidence interval [-0.49, -0.18]). Contrarily, the largest difference was observed in the focused attention condition attending to one stimulus with size being the questioned feature, $M_{\text{diff}} = -1.26$, $t(11) = -18.3$, $p < 0.001$ [-1.41, -1.1].

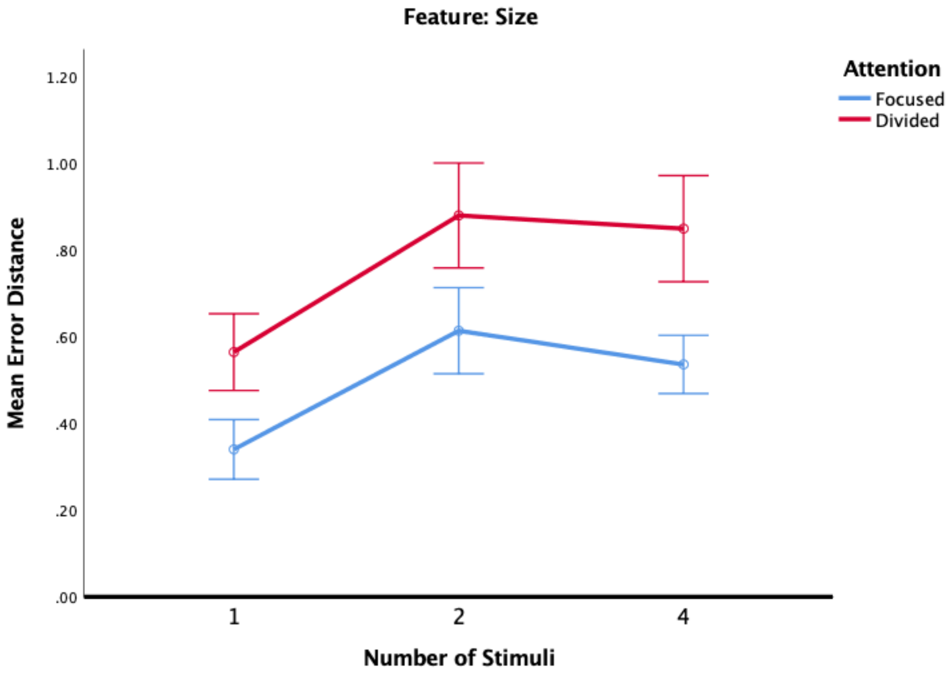

Figure 3. The mean Error Distances (0-4) for the feature size as a function of attentional instructions and number of stimuli. Error bars denote ± SEM.

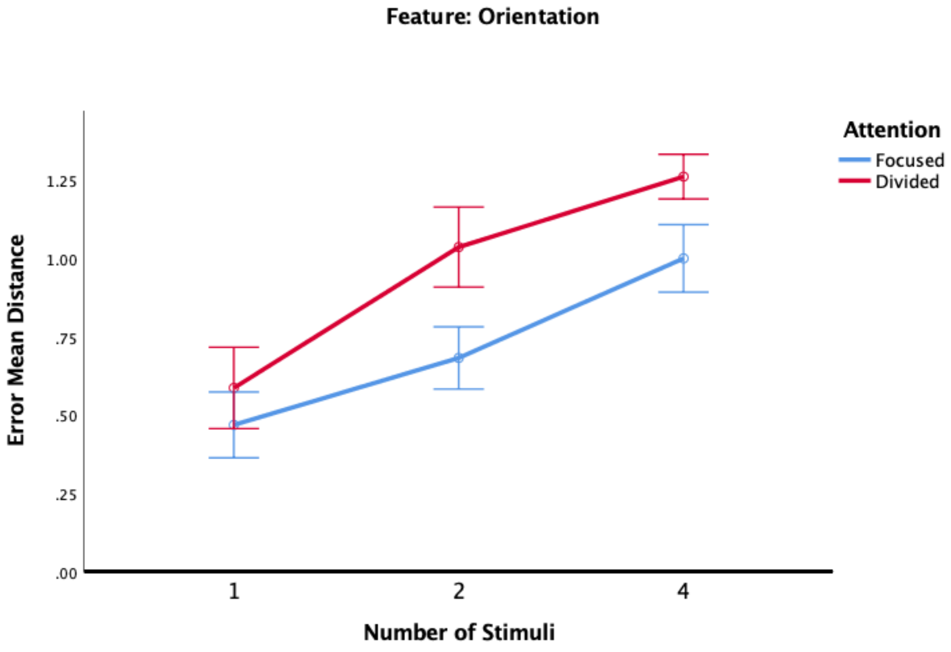

Figure 4. The mean Error Distances (0-4) for the feature orientation as a function of attentional instructions and number of stimuli. Error bars denote ± SEM.

VWM Task

The main effects of the three independent variables were all significant in the 3x2x2 repeated measures ANOVA design (see Fig 3 & Fig 4). To begin with, there was a main effect of attention condition on mean EDs, $F(1,11) = 25.32$, $p < 0.001$, $\eta_p^2 = 0.7$. More specifically, EDs were smaller when participants were instructed to focus their attention on one feature (0.61; CI:[0.44, 0.78]), instead of dividing their attention on two features (0.86; CI:[0.7, 1.02]). Secondly, the main effect of feature on mean EDs was significant as well, $F(1,11) = 6.1$, $p < 0.031$, $\eta_p^2 = 0.36$. EDs were smaller when size was reported (0.63; CI:[0.46, 0.8]) than when orientation had to be reported (0.84; CI:[0.64, 1.04]). Finally, there was also a main effect of set size on mean EDs, $F(2,11) = 26.38$, $p < 0.001$, $\eta_p^2 = 0.71$. In particular, EDs were smallest when one stimulus was attended to (0.49; CI: [0.32, 0.67]), moderate for two stimuli (0.8; CI:[0.62, 0.99]), and highest for four attended stimuli (0.91; CI:[0.75, 1.07]). However, contrast analyses showed that merely the EDs between 1&2 stimuli and between 1&4 stimuli were significantly different from each other ($p < 0.002$), whereas the difference between 2&4 stimuli was not significant ($p = 0.11$).

Furthermore, a significant interaction effect was found between feature and set size, $F(2,11) = 20.44$, $p < 0.001$, $\eta_p^2 = 0.65$ (see Fig 3 & Fig 4). Here, contrast analyses showed that for both features, the initial increase from 1 to 2 stimuli is greater than the second increase from two to four stimuli. These increases were greater for orientation (1: 0.53 [0.39, 0.77]; 2: 0.96 [0.71, 1.21]; 4: 1.06 [0.87,1.25]) than for size (1: 0.45 [0.24,0.57]; 2: 0.65 [0.45, 0.85]; 4: 0.77 [0.61, 0.93]). Besides this, no other interaction effects were observed.

To confirm whether the main effects of attention condition and feature are present for all set sizes, separate analyses for each set size were performed. With regards to the set size of one stimulus, the main effect of attention condition was significant, $F(1,11) = 23.22$, $p < 0.001$, $\eta_p^2 = 0.68$, whereas the main effect of feature was not significant, $p = 0.498$. In the case of two stimuli, the results were similar as the main effect of attention condition was significant, $F(1,11) = 7$, $p = 0.023$, $\eta_p^2 = 0.39$, and the effect of feature was not significant, $p = 0.201$. Finally, with a set size of four stimuli, both the effect of attention condition, $F(1,11) = 19.06$, $p < 0.001$, $\eta_p^2 = 0.63$, and feature, $F(1,11) = 28.26$, $p < 0.001$, $\eta_p^2 = 0.72$ were significant. Here, feature had a slightly greater effect size than attention.

Discussion

This study aimed to investigate VWM with regards to rarely examined types of features, here sizes and orientations. Early research was in line with the discrete-capacity model, whereas more recent findings correspond to the limited-resource model. Assuming that the limited-resource theory is accurate, then it should be applicable to novel features as well. This was examined by taking multiple factors into account besides the type of feature to-be-memorized, including the number of stimuli, and attentional instructions. The results showed that VWM performance deteriorates when the number of stimuli increases. Further, recall precision was significantly lower when participants divided their attention on both features, and for sizes, the recall precision was higher than for orientations. Additionally, an interaction effect between the type of feature and the number of stimuli was found. Separate analyses suggest that the effect of the type of feature to-be-memorized on VWM performance is only significant when four stimuli are shown. Moreover, all but two significant effects were large effect sizes according to Cohen (1988), with the remaining two being in the high medium range as well. This demonstrates the relevance of these effects.

Implications

These results disagree substantially with the discrete-capacity model and favor the limited-resource model. To begin with, the effect of the number of stimuli presented at the same time contradicts the notion that VWM can hold a fixed number of items after which the performance declines. As shown in this experiment, recall precision is already imperfect in situations in which the suggested limit of about four chunks is far from exceeded. As a matter of fact, recent studies share similar results in that VWM performance deteriorates before the above-mentioned limit (Park et al., 2017; Shin & Ma, 2017).

Furthermore, the main effect of attentional instructions is not in accordance with the discrete-capacity model as well. The results of this study indicate that attentional instructions clearly affect VWM performance. In particular, performance decreased when attention is divided rather than when it is focused on a certain feature. According to the discrete-capacity theory, all features of an object are processed since integrated objects are thought to be the units of VWM. Therefore, if an object is attended to and processed, the individual should be able to recall all of its features, regardless of instructions. However, the effect of attentional instructions in this experiment suggest that individual features of objects seem to be the units of VWM.

In line with the limited-resource model, these findings indicate that VWM can be conceptualized as a flexible resource allocated to specific features or items. Accordingly, directing resources, or in other words attention, to specific features of objects leads to a less noisy representation of the feature(s) in the individual's VWM. Consequently, recall precision improves. Nevertheless, since these resources are limited and the internal noise is growing with an increased number of features, recall precision deteriorates with higher numbers of stimuli and divided attention. Additionally, consistent with the biased-competition model of O'Craven and colleagues (1999), instructions to direct attention towards specific features results in top-down bias, ultimately improving processing and therefore VWM performance.

Finally, the results of this study indicate a main effect of type of feature on VWM as well as an interaction effect between the type of feature and number of stimuli. These observed effects might be due to VWM being feature-based and that different dimensions of objects are stored in independent, or at least partially independent, resources. More recent studies which focused on multiple features of stimuli in working memory tasks found similar results (Markov, Tiurina, & Utochkin, 2019; Shin & Ma, 2017). Furthermore, it is interesting to note that the type of feature affects VWM performance significantly solely when four stimuli are shown (see Fig 3 & Fig 4). This might be caused by the spatial arrangement of the stimuli in the experimental procedure. In fact, early accounts described attention as a space-based property, suggesting that merely a limited area of visual space receives complete perceptual analysis (Duncan, 1984). In line with this, Markov and colleagues (2019) came more recently to a similar conclusion as they showed that it is more difficult to remember features which are separated between different objects. That is because attention has to be allocated to a greater number of locations.

However, the fact that VWM performance significantly decreased when participants had to divide their attention, remembering the size and orientation of objects, contradicts the notion of entirely independent resources on a feature-based distinction. Supposing that would not be the case and VWM does consist of independent resources, the recall precision would not decline when individuals focus on multiple features of the same object. Therefore, the proposed explanation of Markov and colleagues (2019) seems to be insufficient to explain the entirety of the results.

Nevertheless, the findings of this study have shown to contradict the discrete-capacity model and are in line with the limited-resource theory. Accordingly, assumptions of the limited-resource theory hold true for novel types of features as well. Furthermore, the interdependence of visual attention and VWM has also been demonstrated.

Limitations and Future Directions

One factor which might have affected the outcomes of this study is the duration of the experimental task. This was also indicated by some participants which noted that they experienced difficulties to concentrate the longer the task was going on. Particularly, the last block of the experimental trial may be influenced by this, resulting in a decrease in VWM performance. However, since the order of the blocks was counterbalanced depending on the participant number, this effect should be accounted for and not affect results accordingly. Nevertheless, incorporating the effect of individuals ability to concentrate, in other words their attentiveness, might be useful in determining the nature of VWM, because these two concepts have shown to influence each other (Chun, 2011; Jonikaitis & Moore, 2019). This can be achieved by either shortening the duration of experimental tasks to ensure high levels of attentiveness or measuring individuals' levels of attentiveness throughout the trials and incorporating this data into analyses.

Another confounding factor of VWM performance of individuals is their age. According to several studies, working memory capacity declines with age in most cases (Sung, Yoo, Lee, & Eom, 2017; Waters & Caplan, 2001). The sample used in this study essentially consisted of students in their twenties. Therefore, the results have to be interpreted with caution, especially when generalizing these to other age groups. Furthermore, incorporating the age of participants as a confounding factor might give insights into the way working memory, and VWM particularly is changing over the course of people's life. Although the general consensus in the literature is that it deteriorates and that this decline can be attributed to limited processing resources, how this change takes place specifically is not yet thoroughly investigated.

Furthermore, it is essential to adopt an interdisciplinary approach when studying VWM which might include investigations of multiple different levels of analysis. More specifically, examining the neurophysiological level of VWM with regards to the representation of different types of features seems promising. Investigating the activity patterns of brain regions during VWM tasks might for example give indications about whether VWM consists of separate resources for different dimensions and whether these are independent of each other.

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Appendices

Appendix A

Instructions

This study aims to assess the mechanisms of visual working memory functioning. Therefore, you will be asked to memorize stimuli (red squares) which differ in their size and their orientation. Before the start of the experiment there will be a sensitivity test to determine which size and orientation differences you are able to distinguish reliably. The experiment consists of three blocks, each including different instructions whether to focus on the size, the orientation, or both features of the stimuli. During these blocks, you will be presented with one, two, or four stimuli for a timespan of two seconds. After this, you will be asked to recall the feature in question from five options which are shown at the bottom of the screen. This procedure is repeated a number of times. After the first and second block, there will be a five-minute break each during which a timer will be presented on the screen. Additionally, there will be more specific instructions before and during the trials. If you have any questions, don't hesitate to ask.

Thank you for your participation!