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Concurrent memory load can make RSVP search more efficient

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The detrimental effect of increased memory load on selective attention has been demonstrated in many situations. However, in search tasks over time using RSVP methods, it is not clear how memory load affects attentional processes; no effects as well as beneficial and detrimental effects of memory load have been found in these types of tasks. The main objective of the present work is to provide more evidence about the involvement of working memory in visual search over time. Using an RSVP search task, we manipulated set size (experiment 1) and congruency in a Stroop-like task (experiment 2), finding that high memory load conditions sometimes increase the efficiency of search over time. Our data also support important similarities between attention in space and time showing that there might be a general system for allocating attentional resources independent of stimulus dimension. However, there are also important differences, thus theoretical implications of present results are discussed.

Attention and working memory are two main components of cognition that contribute to everyday activities. In the laboratory, these processes usually have been studied separately, but in the recent years researchers have realized the importance of studying them together in order to understand better how we simultaneously select, maintain, and process information. Much recent research has been directed towards understanding the effects of memory load on attentional processes in dual-task environments (e.g., Gil-Gómez de Liaño & Botella, 2010; Hester & Garavan, 2005; Lavie, Hirst, Fockert, & Viding, 2004).

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Tasks typically used in the context of endogenous selective attention (such as Stroop-like tasks, the flanker task, or negative priming tasks) have usually found a clear relationship between memory and attention. As memory load increases, attentional resources are diminished and selective attention to relevant material is impaired (De Fockert, Rees, Frith & Lavie, 2001; Gil-Gómez de Liaño & Botella, 2010; Hester & Garavan, 2005; Lavie et al., 2004; Rissman, Gazzaley & D'Esposito, 2009). To the extent that attention and working memory share cognitive resources, increasing the load of either process could impair functioning of the other (Cowan, 1995; Lavie et al., 2004). Even though most studies have shown that memory load impairs attention, a few have found a reduction of the distraction in attentional paradigms under memory load conditions (Gil-Gómez de Liaño, Umiltà, Stablum, Tebaldi & Cantagallo, in press; Kim, Kim & Chun, 2005; SanMiguel, Corral & Escera, 2008).

On the other hand, recent studies have shown a relationship between visual working memory and attention in visual search (Lavie & De Fockert, 2006; O´Shea, Muggleton, Cowey & Walsh, 2006), supporting the idea that working memory plays an important role in search. However, a few experiments have failed to find clear effects of memory load (Logan, 1978; Woodman, Vogel & Luck, 2001). Moreover, Smilek et al. (2006) found that visual search was completed more efficiently when performed with a concurrent memory task than when performed alone. These results are consistent with the idea that improved efficiency can result when reliance on slow executive control processes is replaced with reliance on more rapid automatic processes for directing attention during search.

The effect of a concurrent short-term memory load in an RSVP task has also been used to study the effects of load on the time course of attention (Akyürek & Hommel, 2005, 2006; Akyürek, Hommel & Jolicœur, 2007). Although overall performance in RSVP tasks was impaired by a concurrent memory task, the attentional effect was more or less immune to those manipulations. However, memory loads of increasing size were shown to have a detrimental effect on attentional performance in an atentional blink (AB) task (Akyürek & Hommel, 2007). On the other hand, Colzato, Spapé, Pannebakker, & Hommel (2007) have found that working memory operation span was negatively correlated with AB magnitude. Moreover, Olivers & Nieuwenhuis (2006) reported benefits of a concurrent memory task on a 2-target RSVP task.

Like in visual search, it is not clear how memory load affects attentional processes in RSVP tasks. The main goal of the present research is to provide additional evidence about the involvement of working memory in the time course of attention. We consider that the RSVP procedure may be an analog to visual search, but with distractors distributed over time rather than space[1]. In both situations, the participant has to give a quick response to the item defined by a given feature (i.e. the letter in red, the word in capital letter, the vertical line...) and the difference between tasks settles on the distribution of target and distractors (in different positions over space - visual search- or in the same position but at different rates – RSVP or visual search over time). In Experiment 1 we manipulated the set size (number of items in the RSVP stream), as in standard visual search, as well as the amount of memory load in a dual task paradigm. There is some support for the idea that there might be a general system for allocating attentional resources independent of stimulus presentation in time or space (Correa et al., 2006; Coull & Nobre, 1998), so regardless of some possible differences, we may find similar general results as for visual search in space.

On the other hand, in order to look for other variables that have shown differential effects with increases in memory load, we introduced a Stroop-like task in Experiment 2. Although simplifying the task by making the set size constant, we manipulated the relationship between information in working memory and distractors and target in the RSVP task in order to look for possible beneficial load effects, as shown before by Kim et al. (2005).

EXPERIMENT 1

METHOD

Participants. The participants were 18 student volunteers from the Autónoma University of Madrid. There were 13 women and 5 male with a mean age of 20.55 (range 17-49). All of them reported normal or normal-corrected vision.

Stimuli and Materials. Six different words were used in the RSVP stream: yellow, blue, white, black, red and pink. All words were randomly located and written in black and lower-case, except for the target, which was capitalized. The maximum size of the words was 0.57º x 3.90º.

[1] The authors want to emphasize on the idea that we want to compare the *procedures* of the RSVP and visual search in space. We are not saying anything about the attentional mechanisms immersed in both types of task. Items presented over time and space may underlie similar or different attentional mechanisms. We are only emphasizing the similarities between the procedures in the methods by saying that the main difference is the distribution of items over time or space.

Each RSVP stream had 5, 10 or 15 words, and the target could be in the three central positions of the RSVP: for the 15 items condition, the target could be in lag 7, 8 or 9; for the 10 items condition the target occupied position 4, 5 or 6, while for the 5 items condition, it could be in lag 2, 3 or 4.

Memory load was manipulated by the difficulty of a simultaneous working memory task. In the low load condition the participants had to remember one digit during a trial, whereas in the high load condition they had to recall six digits.

Procedure. The participant's task was to respond, as rapidly and accurately as possible, to the only word in capital letters embedded in the RSVP stream. This was done by typing[2] the corresponding digit, from the set 1, 2, 3, 8, 9, and 0 on the keyboard, with each number identified with a different word. (A training phase, based in a previous pilot, was used initially to insure fast and accurate typing of the appropriate number for each word). Before the attentional task, either one or six digits (depending on the memory load condition) appeared in the center of the screen and remained for 500 ms in the one digit condition and 2000 ms in the six digit condition. These were to be remembered during each trial and reported at the end. We acknowledge that giving different times of exposure may affect the preparedness of participants in the two conditions: the later the target appears (the six digit condition) the more prepared the participant is likely to be (Correa, Lupiáñez, & Tudela, 2005; Rolke & Hofmann, 2007). The different times of exposure could also affect the type of processing in the two conditions. However, if the exposure time was 500 ms in both conditions, there would not be enough time to process the items in the six digit condition and, therefore, to retain them during the trial. On the other hand, if the exposure time was 2000 ms in both conditions, there might be enough time to retain one item (one digit condition) in a more durable form (by encoding and consolidating the one digit to some extent) rather than retaining that one item within working memory (Hitch, Wooding & Baker, 1989). Therefore, as different strategies for processing seemed likely if one and six digits were presented at the same rate, we opted to present the one and six digit loads at different rates. Moreover, as the target was always in

[2] We used manual responses because vocal responses gave us problems measuring RTs. In many trials participants emitted sounds before the response like "eh...", and the vocal key detected it as the response. Because of that and knowing that there is no evidence that vocal and manual responses differ in the demands they place on attention in a visual search task (Logan, 1978) we decided to finally ask for manual responses, although the task become a little bit more difficult.

the center positions of the RSVP stream regardless of the number of items shown in the attentional task (5, 10 or 15), we may be sure that participants had enough time to prepare in order to look for the target.

After the presentation of one or six digits to be remembered, the words in the RSVP stream appeared with a SOA of 83 ms (ISI = 0 ms). The response of the participant was measured from onset of the target item within the stream. After the response, they were asked for the one or six digit items in a non-speeded response, as shown in Figure 1; then, the next trial appeared.

The experiment was composed of six blocks with 52 trials in each block. The three different conditions (number of items 5, 10 & 15) were randomized within blocks and counterbalanced for memory load conditions (ABABAB/BABABA). There was the same number of trials of each condition within each block.

RESULTS

In the memory task, performance was significantly better in the low load condition (94% correct recall) than in the high load condition (78%), as expected $t(17) = 6.25$, $p < .001$, showing that it was more difficult to remember six digits than one during the task. In the six digit condition, the participants had to remember the six digits in order of appearance; otherwise it was considered a mistake. Finally, all analyses in the attentional task used only those trials in which recall was correct in the memory task.

In the attentional task, accuracy results showed a main effect for the set size, $F(2,34) = 12.07$, $MSE = 0.002$, $p < .001$, but not for memory load, $F < 1$, nor for the interaction, $F(2,34) = 2.67$, $MSE = 0.003$, $p = .08$. The set size effect is due to differences in word identification accuracy in the low memory load condition between the 5 and 10 items conditions ($p = .003$), and between the 5 and 15 items conditions ($p = .004$). No differences between identification accuracy across set size were found for the high memory load condition (although there was no interaction).

Results for correct target identification RTs are very similar to accuracy results. There is a main effect of set size, $F(1.24, 21) = 4.91$; $MSE = 9434.4$, $p = .031$, no effect for memory load, $F(1,17) = 2.06$, $p = .169$ nor an interaction, $F(2,34) = 2.43$; $p = .103$. Again, the set size effect is due to differences in the low memory load condition (between the 5 items and 10 items conditions; $p = .004$), but no differences were found for the high memory load condition, although there is no interaction. Means and standard deviations are shown in Table 1, both for proportion of hits and correct target identification RTs.

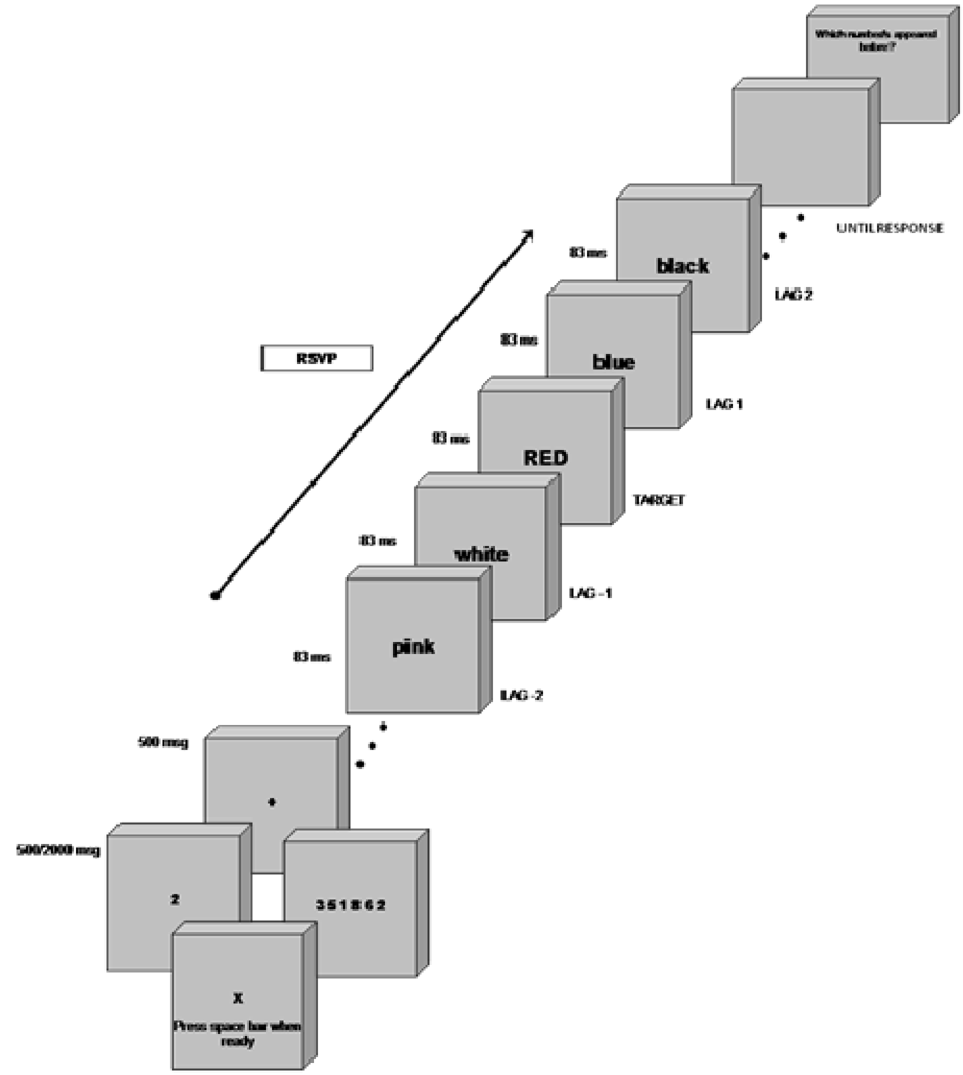

Figure 1. Example of the procedure in experiment 1.

Because of low statistical power of the analyses and since both RT and accuracy show the same effects, we considered interesting to analyze the inefficiency scores that combine RT and errors in a single measure of inefficiency. That consists in dividing mean correct RT for each participant in each condition by mean accuracy (Townsend & Ashby, 1983). In other words, this is a measure that corrects speed of response by its appropriate level of accuracy: If accuracy is perfect in a condition, the inefficiency score will be identical to mean RT; as accuracy decreases the inefficiency score increases in proportion to the level of errors being made.

Results of the inefficiency scores show again a main effect of set size $F(2, 34) = 24.18$; $MSE = 180674$, $p < .001$ and no main effect of memory load $F < 1$. However, there is a significant interaction that did not appear before $F(1.5, 25.57) = 4.11$; $MSE = 52917$, $p = .025$. For the low memory load condition there are no differences between 15 and 10 items conditions ($p >.99$) and they appear between the 5 items condition with the others ($p =.001$, in both 15 and 10 items); showing that performance was less accurate in the 5 item condition than in both the 10 item and 15 item conditions. For the high memory load condition, there are differences between the 15 and 10 items conditions ($p=.047$) and between the 10 and 5 items conditions ($p=.009$), but differences between 15 and 5 items conditions do not appear ($p =. 69$); as we can see in Figure 2.

Table 1. Mean and Sd for the proportion of correct responses and RT in experiment 1.

	Proportion of Correct Responses					
	Low Memory Load			High Memory Load		
	5 items	10 items	15 items	5 items	10 items	15 items
Mean	.83	.90	.89	.86	.89	.86
Sd	.08	.06	.04	.08	.07	.08
	Response Time (RT)					
	Low Memory Load			High Memory Load		
	5 items	10 items	15 items	5 items	10 items	15 items
Mean	1011	942	949	972	933	951
Sd	216	252	286	220	262	288

DISCUSSION

The main goal of the present research was to provide additional evidence about the involvement of working memory in the time course of attention. In Experiment 1 we manipulated the set size (number of items in the RSVP stream), as in standard visual search, as well as the amount of memory load in a dual task paradigm. Although the results do not have enough statistical power for RTs, the inefficiency scores show an interaction between both variables: when one item is maintained in working memory there are differences in the processing of target in the RSVP depending on the number of items presented in the stream (the less number of items (5 items) the worse performance in the RSVP stream, although no differences were found between 10 and 15 items); however, when six items are maintained in working memory no differences have been found for the number of items presented in the RSVP stream, at least between the 5 items and the 15 items condition. The results found seem to support (at least partially) those found in Smilek et al. (2006) and also Woodman et al. (2001): the effects of the number of items presented in a visual search task (in the present study a visual search task over time rather than space) disappear when memory is loaded (between 5 and 15 items conditions). Moreover, although there is not a main effect of memory load, a marginally significant effect (p=.06) was found in the 5 items condition between high and low memory load: performance is better in the high memory load condition than in the low memory load condition (see Figure 2). Again, the present results point towards a similar effect to that found in visual search studies manipulating similar variables (Smilek et al, 2006).

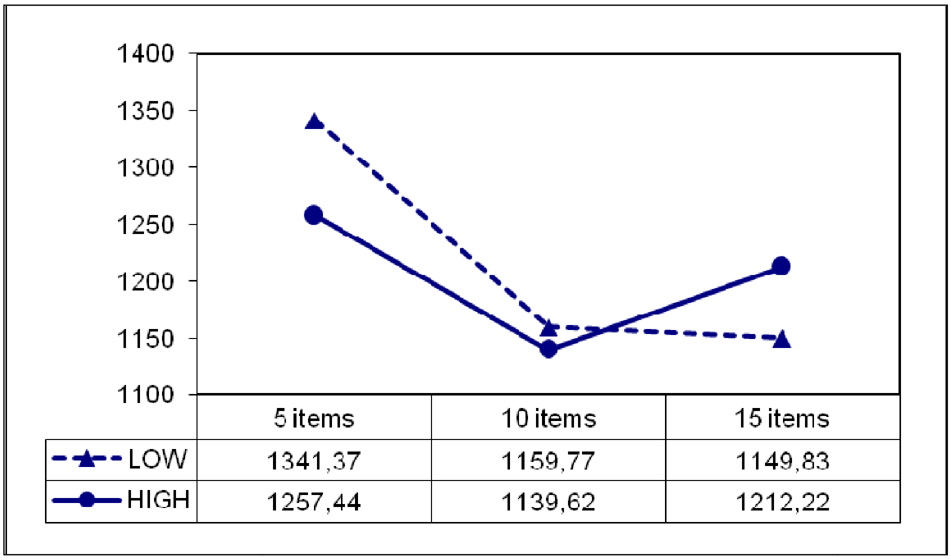

Figure 2. Mean inefficiency scores (average mean RTs/ proportion of mean correct responses) in experiment 1.

However, there is also an important difference between the effects of set size in space and time searches: the set size effects observed here in RSVP (better performance when the number of items presented in the RSVP search is high) are the opposite of those typically observed in visual search (worse performance for conditions with higher number of items). Even though there might be a general system for allocating attentional resources independent of stimulus dimension (Correa et al., 2006; Coull & Nobre, 1998; Doherty et al., 2005), the present results show that there might be some differences between attention immersed in visual search over time and space. Perhaps there is a general endogenous system for allocating attention independent of stimulus dimension, while other attentional mechanisms related to more exogenous driven components may differ in space and time.

On the other hand, the results of the present experiment are not that consistent as we have pointed before. In fact, the lack of effect of the number of items in the high memory load condition appears only between the 5 and 15 items conditions, but not between the 5 and 10 items conditions. It seems to show that it is not that clear that the effect really disappears like in Smilek et al. (2006). Under high memory load conditions performance improves when the number of items decreases (15 to 10), but when they are very few (5 items), performance returns to the same level of the 15 items condition. However, the effect of the number of items in the RSVP under low memory load conditions is the same with 15 and 10 items and it decreases when the number of items diminishes (5 items); it seems that 10 items affect the same way as 15, and the differences appear only when the number of items is very few (5 items).

We have already pointed to another possible explanation that may account for the present results, that of preparedness. Indeed the results do not seem to support an explanation in terms of preparedness or even in terms of the level of vigilance or the amount of resources. Let us suppose that in the high memory load condition there is a higher preparedness, because participants have more time before the RSVP beginning as a result of having 1500 ms more of exposure time than in the low memory load condition. The same could be argued in terms of higher levels of vigilance, or even more resources mobilized, because of the increased difficulty of the task. In all those cases we should have also found no differences in performance between the 5 and 10 items conditions under the high memory load situations. We have also depicted the averages of the several lag conditions, separated for the high and low memory load conditions. Specifically, the order positions of the target for the several set size conditions were 2, 3, 4 (size 5), 4, 5, 6 (size 10), and 7, 8, 9 (size 15). The graphic does not suggest any pattern related to those alternative explanations. Moreover, we conducted a repeated measure ANOVA 2x8 (memory load: low and high & position of the target in the RSVP stream: lags 2, 3, 4, 5, 6, 7, 8 and 9). The results do not seem to support an explanation in terms of preparedness: although there is a main effect of the position [$F(7,49) = 4.39$; $p=.001$] the interaction between factors was not significant [$F(3,21) = 1.89$; $p=.160$] showing that any preparedness effect is the same in the low and high memory load conditions. The difference found between low and high memory load conditions may be due to the memory load effect and it does not seem to be based on different exposure times between memory conditions. However, further research is needed giving the same exposure time before the appearance of the target in any memory load condition to be sure that the observed pattern of results is not due to differences in preparedness, therefore, allowing us to rule out the preparedness explanation. More research is needed also to determine what happens when manipulating the set size in the RSVP during high and low memory load conditions in a dual task context, as well as to determine possible differences in space and time visual searches.

Anyhow, what seems clear is that there is a differential effect between high and low memory load conditions in the time course of attention using an RSVP task with different set sizes in the stream; that result is not predicted from those alternative explanations. Moreover, although there are some differences, the effect seems to be like the effects found under similar conditions in visual search in space (Smilek et al., 2006; Woodman et al., 2001).

In Experiment 2 we simplified the task by making the set size constant and manipulating a typical endogenous attentional variable by using a Stroop-like task. We introduced a Stroop-like task in order to look for the effects of other variables that have shown differential effects with increases in memory load. The relationship between information in working memory and distractors and target in the RSVP task was manipulated in order to look for possible beneficial load effects, as shown by Kim et al. (2005).

EXPERIMENT 2

METHOD

Participants. Twenty four students at the Universidad Autónoma de Madrid voluntarily participated, 17 women and 7 men with a mean age of 21.25 (range 18-28). All of them reported normal or normal-corrected vision.

Stimuli and Materials. Stimuli were the same as in Exp 1. However, in Exp 2, all words were presented in capital letters and colored in the same six colors used as word names in Exp 1. Two variables were manipulated: congruency between color and color-word of the target (50% congruent, 50% incongruent), and memory load as in Exp 1.

Set size was constant across the experiment, with 11 items shown in each trial and again the target in the three central positions of the stream. Likewise, memory load was also manipulated as in Exp 1.

Procedure. The task was to respond, as rapidly and accurately as possible, to the word written in a given color. After the appearance of the set of numbers, an X (or six "Xs" depending on the memory load condition) appeared shown in a given color, indicating the color cue for the target (the word that was to be reported). Then, the RSVP set of words appeared and all else remained the same as in Exp 1.

RESULTS AND DISCUSSION

As in Exp 1, memory task performance was significantly better for the low load condition (93%) than for the high load condition (71%), $t(23) = 9.04$; $p < .001$. Analyses in the attentional task were made only for correct trials in the memory task.

In the target word identification data, there were no main effects for congruency nor for memory load; although performance in the high load condition (96% correct) was marginally better than that in the low load condition (95% correct, $p < .06$). However, there was an interaction between both factors, $F(1,23) = 11.08$; $MSE = 0.001$ $p = .003$. As shown in Figure 3a, there is the typical congruency effect in the low load condition ($p = .02$) whereas it disappears for the high load condition (moreover, it was marginally significant in the opposite direction; $p = .06$). Likewise, for congruent trials there is no effect of memory load ($p = .25$), whereas for incongruent trials there is an effect of memory load ($p < .001$). More importantly, the effect of memory load for incongruent targets showed better performance for the high load condition (97%) than for the low load condition (93%).

Results for correct target identification RTs are very similar to the accuracy results. There is a main effect of congruency, $F(1,23) = 12.32$, $MSE = 4515.35$, $p = .002$, not found for the identification data, but the interaction between memory load and congruency, $F(1,23) = 16.69$, $MSE = 598.73$, $p < .001$, was the same as that for the identification data: there is a considerable congruency effect for the low load condition ($p < .001$) that disappears for the high load condition ($p = .082$). Again, the memory load effect was significant in the RT data only for the incongruent trials, in which RTs in the high load condition (1093 ms) were significantly shorter (p=.024) than for those in the low load condition (1124 ms), as shown in Figure 3b.

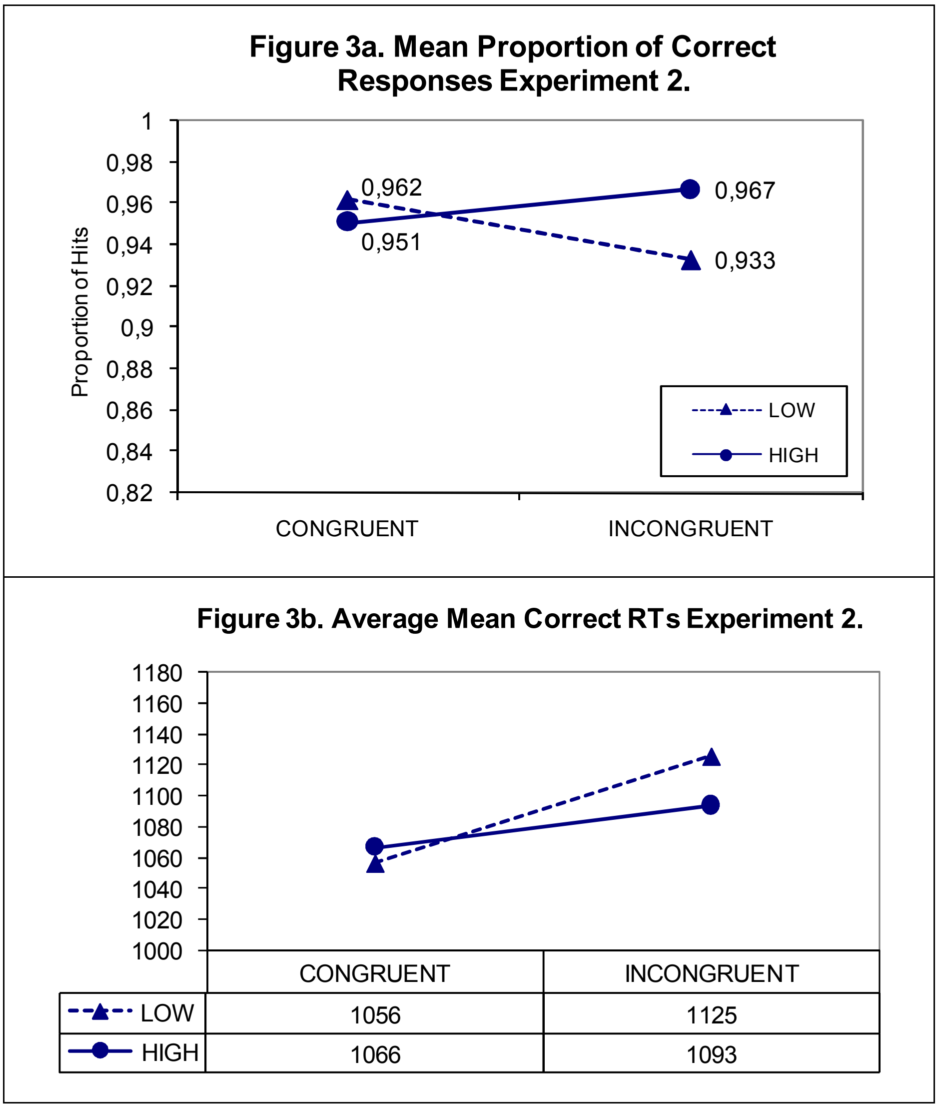

Figure 3. Proportion of mean correct responses and average mean RTs in experiment 2.

The results of Exp 2 support the idea that attention and working memory are closely related. Indeed the results rather surprisingly show that when memory load is high, attentional capacity seems to be improved.

GENERAL DISCUSION

As we have seen before, results of experiment 1 show important similarities to visual search studies manipulating similar variables (Smilek et al. 2006): no differences were found between 15 and 5 items under high memory load conditions, contrary to the low memory load conditions where differences showed better performance for the 10 and 15 items conditions than for the 5 items one. However as we pointed before, there is still a result difficult to interpret in the high memory load condition: in the 10 items condition there is a significantly better performance than in the 15 and 5 items conditions that does not fit with previous studies in the field of visual search in space. Other possible explanations like high levels of vigilance or more resources immersed under high memory load situations cannot either account for those results, as we mentioned before. More importantly, it seems that visual search in time was a little bit more efficient when memory load was high and perceptual load was low for those conditions with less items in the RSVP stream (5 items condition). A possible explanation of those results may be based on the fact that high memory load conditions may prevent proper consolidation of the attentional target, so the short length of the stream might provide the opportunity to look for its identity in the more momentary impressions that can be maintained (i.e., stage 1 in the Chun & Potter (1995) model), where it still lingers. It may explain why RSVP search is more efficient in those conditions with few items in the RSVP stream and high memory load. In fact, other researchers have also found similar results when manipulating similar variables in visual search in space. Although not statistically significant, Woodman et al. (2001) found that the slope of the search function in the dual-task condition was slightly shallower than the slope in the single task condition. Likewise, Smilek et al. (2006) found more efficient visual search when performed concurrently with a memory task than when performed alone. According to the authors, a high load on executive control processes may force automatic processes for directing attention during search making it more efficient. That hypothesis could fit with the idea that those momentary impressions maintained in working memory in an RSVP search task are mediated by a less controlled attention (a more exogenous attention) that operates in the first stages of processing. As the consolidation in working memory has been prevented by the high memory load demands in the secondary task, the attentional system may be forced to "use" a more automatic process related to a former stage in processing that works good enough to allow more efficient performance in the attentional task. In fact, it could also fit with the *sophisticated guessing mechanism* proposed by Botella, Barriopedro & Suero (2001) in their model of the formation of illusory conjunctions in the time domain. According to the authors, the *sophisticated guessing mechanism* (a non controlled attentional mechanism) operates when the focalization (endogenous attention) fails. The *sophisticated guessing mechanism* selects the more salient items that are still floating in the system for a brief period of time depending on the more activated features in the moment to give the response. As the authors pointed out, it sometimes causes errors, but it is not only a "guessing mechanism", so it works better than we would expect for a simply guess. That's why they call it a *"sophisticated" guessing mechanism*. Moreover, recently a model in the context of attention in time (within the A*ttentional Blink* (AB) effect) has proposed that the AB is produced by an overexertion of control. This overexertion is generated by a production rule that blocks target detection during memory consolidation, predicting that adding certain secondary tasks will decrease the AB (Taatgen et al., 2009). However, more research is needed to determine the effects of set size in RSVP tasks during high and low memory load conditions in a dual task context, as well as the variables that may account for those effects. It would also be needed to address with further research the preparedness effect that may have occurred in the present research. Although results found do not seem to support an explanation based on preparedness, the only way to be sure that preparedness has not been taken place is to give the same exposure time before the appearance of the target in any memory load condition. It would allow us to finally rule out the preparedness explanation.

On the other hand, as we previously mentioned, the effects of set size in space and time searches are a little bit different in the light of the results found in the present study: the set size effects observed here in RSVP are the opposite of those typically observed in visual search. Even though a general system for allocating attentional resources independent of stimulus dimension has been previously reported (Correa et al., 2006; Coull & Nobre, 1998; Doherty et al., 2005), the present results show that there might be some differences between attention immersed in visual search over time and space. Perhaps other attentional mechanisms related to more exogenous driven components may differ in space and time, which would again support Smilek et al's (2006) hypothesis: a high load on executive control processes may force automatic processes for directing attention during search making it more efficient. However, those mechanisms could operate differently depending on the distribution of items in the task: in the same position but at different rates (RSVP) or in different positions in space at the same time (the typical Visual Search situation). More research would be needed to determine possible differences between space and time.

A similar pattern of results was found in Exp 2, where the results strongly support that under high memory load conditions performance in the attentional task improves for the most difficult condition: for incongruent trials. In fact, manipulating congruency in a Stroop-like task, Kim et al. (2005) also found a reduction in the congruency effect under high memory load conditions. They proposed that different types of memory load may have different effects on attentional selection depending on whether memory load demands some resources in common with either target or distractor processing. Although Exp 2 supports Kim et al.'s hypothesis, we could also find other ways to explain data of Exp 2. For instance, for low memory load conditions we have enough space in the phonological loop so the color-cue is more likely to be verbally processed (Hitch, Wooding & Baker, 1989; Silverberg & Buchanan, 2005; Walker, Hitch & Duroe, 1993) producing the typical Stroop effect. However, in the high memory load condition there is reduced capacity for processing the color-cue verbally, causing the Stroop effect to be attenuated under those conditions, as shown in the results of Exp 2. On the other hand, we could also explain results of Exp 2 by saying that under high memory load conditions automatic processes are enhanced and the word-color interferes less in the detection of the target (the color cue) because top-down processes are diminished. That is, the high load may decrease the Stroop effect by weakening the perception of the target word so there is less interference. It seems that under certain situations visual search both in space and time could work better with minimal controlled mechanisms.

Summarizing, the most important results in present study show a trend of more efficient visual search in time under high memory load conditions (for the high memory load 5-item condition in experiment 1, and for the high memory load incongruent trials in experiment 2) using different types of attentional manipulations. Depending on the manipulation, a high load on executive control processes might force the use of automatic processes for directing attention during search in time. Perhaps, when a task is highly demanding of executive processes, under certain circumstances more automatic attention is set off making detection in attentional tasks more efficient. We have shown empirical support in both experiments 1 and 2, as well as several models in the context of attention in time (Botella et al., 2001; Chun & Potter, 1995; Taatgen et al., 2009) that provides stronger evidence for a benefit in attentional performance under high cognitive load

(Gil-Gómez de Liaño et al., in press; Kim et al., 2005; Olivers & Nieuwenhuis, 2006; SanMiguel et al., 2008; Smilek et al, 2006). The relationship between working memory and attention is more complex and it is important to determine the variables mediating those relations. Therefore, more research is needed to determine if automaticity, the relationship between information in working memory and the attentional task, or even other possible variables may explain the improvement of attentional performance under high memory load conditions.

RESUMEN

La carga de memoria puede hacer más eficiente la búsqueda en una tarea de PRSV. El efecto perjudicial de la carga de memoria en la atención selectiva ha sido ampliamente estudiado en muy diversas situaciones. Sin embargo, en situaciones de búsqueda visual en el tiempo utilizando Presentaciones Rápidas de Series Visuales (PRSV), no está claro cómo la carga de memoria puede afectar los procesos atencionales involucrados en este tipo de tareas; una ausencia de efecto, así como efectos tanto beneficiosos como perjudiciales de la carga de memoria se han encontrado utilizando este tipo de tareas. El principal objetivo del presente trabajo es aportar más evidencia sobre el papel que la memoria de trabajo juega en situaciones de búsqueda visual en el tiempo. Utilizando un paradigma de PRSV, manipulamos el número de distractores (experimento 1) y la congruencia en una tarea tipo-Stroop (experimento 2), encontrando que bajo situaciones de alta carga de memoria se puede incrementar la eficiencia en la búsqueda visual en el tiempo. Nuestros datos apoyan la existencia de similitudes entre la atención en el espacio y en el tiempo, planteando la posibilidad de que exista un sistema atencional general independiente de la dimensión estimular. Sin embargo, también encontramos importantes diferencias, por lo que se discuten las implicaciones teóricas que puedan explicar los resultados encontrados.

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