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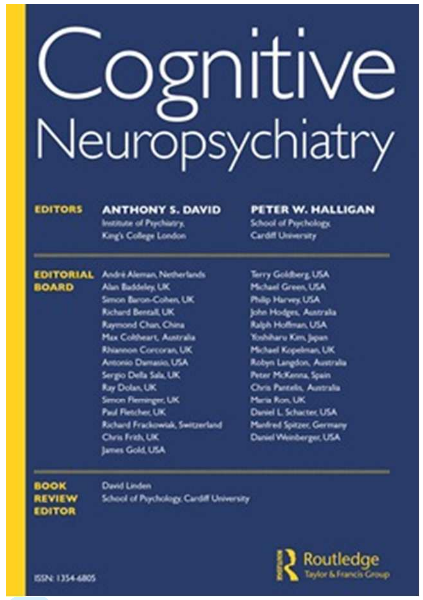

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Visual spatial processing and working memory load as a function of negative and positive psychotic-like experiences

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Abstract

Introduction: Patients with schizophrenia show impairments in working memory and visual spatial processing, but little is known about the dynamic interplay between the two. To provide insight into this important question, we examined the effect of positive and negative symptom expressions in healthy adults on perceptual processing while concurrently performing a working memory task that requires the allocations of various degrees of cognitive resources. ***Methods***: The effect of positive and negative symptom expressions in healthy adults (N=91) on perceptual processing was examined in a dual-task paradigm of visual spatial working memory (VSWM) under three conditions of cognitive load: a baseline condition (with no concurrent working memory demand), a low and a high VSWM load conditions. ***Results***: Participants overall performed more efficiently (i.e., faster) with increasing cognitive load. This facilitation in performance was unrelated to symptom expressions. However, participants with high negative, low positive symptom expressions were less accurate in the low VSWM condition compared to the baseline and the high VSWM load conditions. ***Conclusions***: Attenuated, subclinical expressions of psychosis affect cognitive performance that is impaired in schizophrenia. The "resource limitations hypothesis" may explain the performance of the participants with high negative symptom expressions. The dual-task of visual spatial processing and working memory may be beneficial to assessing the cognitive phenotype of individuals with high risk for schizophrenia spectrum disorders.

Keyword: processing load, psychosis, schizophrenia, visual spatial processing, working memory.

1. Introduction

Disturbances in information processing and maintenance such as working memory and attention are established features of schizophrenia. These deficits have also been observed in individuals belonging to the broader phenotype of schizophrenia such as first-degree relatives, individuals with schizotypal personality disorder, and in healthy adults with high trait schizotypy (Aleman, Hijman, de Haan, & Kahn, 1999; Louise et al., 2015; McClure et al., 2007). Visual spatial processing, while recognized as an area of impairment in schizophrenia, has received less attention (Kim & Park, 2011). While studies have documented visual perceptual and working memory impairments in schizophrenia (Matthews, Collins, Thakkar, & Park, 2014; Tek et al., 2002), to our knowledge, studies investigating the dynamic interplay between working memory and visual spatial processing have been few (Cocchi et al., 2007). In addition, it is unclear to what extent perceptual processing in schizophrenia is affected in tasks requiring participants to encode, in a goal-directed manner, two sets of stimuli of two independent and relevant tasks.

To provide insight into this important question, we set out to examine the effect of subclinical positive and negative symptom expressions in healthy adults on perceptual processing while concurrently performing a working memory task that requires the allocations of various degrees of cognitive resources. Negative symptoms denote the absence of a function and include flat or blunted affect, asociality and avolition, and positive symptoms pertain to the presence of abnormal behavior and include the presence of delusions and hallucinations. Studying the expression of attenuated forms of schizophrenia symptoms in healthy adults enables us to draw inferences about cognitive impairment in schizophrenia, and specifically in the context of dual-task paradigms that require simultaneous allocations of cognitive resources. This approach also has the advantage of avoiding the confounding effects of medication and chronicity on performance in patient samples (Ettinger et al., 2015).

Existing literature suggests that patients with schizophrenia have marked impairment in the ability to maintain mental representation. Impaired maintenance processes have been reported in schizophrenia patients while performing working memory tasks, including spatial working memory (Park & Gooding, 2014). Several meta-analyses (Forbes, Carrick, McIntosh, & Lawrie, 2009; Lee & Park, 2005) have also confirmed that working memory impairments across various paradigms is a robust feature of schizophrenia, although greater impairments appear to be observed when performing visuospatial working memory tasks (Lee & Park, 2005). It is notable that impairment in spatial working memory abilities increases with severity of negative symptoms in schizophrenia (Aleman et al., 1999), including in individuals with ultra high risk of developing psychosis (Wood et al., 2003). Visual-spatial processing, on the other hand, has also been found impaired in schizophrenia. For example, performance on the embedded figure test, which requires participants to discern a simple form from a more complex figure, was worse in schizophrenia individuals with higher scores on the negative and disorganization subscales, but not the positive subscale (Loas, 2004). However, unlike patients with schizophrenia, individuals with schizotypal personality disorder have relatively intact visual perception, but which was impaired when working memory demands were imposed (Farmer et al., 2000). Thus, perceptual abilities appear to be less impaired when working memory maintenance demands are negligible.

In this paper, we investigated the effect of the expression of positive and negative dimensions of psychosis in healthy adults on the processing of visual spatial information under various levels of cognitive load. Cognitive load was manipulated by asking participants to hold information of various loads (in our case the location of various number of disks) en route to performing a visual perception task (see Method; (Cocchi et al., 2011)). Based on previous literature relating impaired spatial working memory abilities with severity of negative symptoms in schizophrenia (Aleman et al., 1999) and ultra high risk of developing psychosis (Wood et al., 2003), we predicted that individuals with high expressions of negative symptoms will demonstrate increasing difficulties in the visual perception task with increasing cognitive load. We do not predict such pattern for participants with high expressions of positive symptoms, as previous research has also suggested that these impairments are unrelated to positive symptoms (Aleman et al., 1999). However, we predict that these participants will have greater difficulties in the visual perception only task (i.e., without concurrent memory demands) compared to participants with low positive, low negative symptoms expressions, based on the link between positive symptoms and aberrant perceptual experiences (Cutting & Dunne, 1986; Ettinger et al., 2015).

2. Method

2.1. Participants

The overall sample consisted of 102 participants (20 males, 82 females; mean age(sd)=19.21(1.19), range=18-24 years), recruited from an undergraduate cohort studying psychology. 11 participants did not complete the task, thus the reported data are for the remaining 91 participants. Participants reported no history of psychiatric illness, epilepsy, neurological disorders, brain injury, or current or past alcohol and/or substance abuse problems. The University of Birmingham Research Ethics Committee approved the study, and written informed consent was obtained from all participants.

Participants first completed a demographics and the Community Assessment of Psychic Experiences (CAPE) questionnaire (Stefanis et al., 2002) for the assessment of negative and positive symptom expressions. Then they completed the Visual-Spatial Working Memory Task (Cocchi et al., 2011) (see section 2.2 below for detailed description of the CAPE questionnaire and the task).

From the pool of 91 participants, we created a bias score based on the difference of their standardized scores on the negative and positive dimensions of CAPE (CAPEn and CAPEp, respectively). We then selected the top and bottom 25% of the scores to form the biased groups, i.e., the high CAPEn low CAPEp group (HNLP) and the low CAPEn high CAPEp group (LNHP). The remaining, scoring low on the CAPEn and CAPEp dimensions (LNLP), formed the balanced group. There were no differences among the groups in gender distribution ($X^2_{(2)}$=4.52, p=.104), handedness (Fisher's exact =4.23, p=.137) or age (F(2,88)=1.75, p=.180). Table 1 summarizes the characteristics of the overall sample and the subgroups.

(Table 1 About Here)

2.2. Measures and Materials

2.2.1. The Community Assessment of Psychic Experiences (CAPE). The CAPE (Stefanis et al., 2002) is a reliable measure for the assessment of psychotic-like experiences in clinical and research settings, consisting of *positive* (20 items), *negative* (14 items), and *depressive* (8 items) subscales. The positive subscale (CAPEp) included items such as "do you ever feel as if there is a conspiracy against you?"; the negative subscale (CAPEn) included items such as "do you ever feel that you have no interest to be with other people?"; and the depressive subscale includes items such as "do you ever feel pessimistic about everything?" Participants completed the CAPE in full, but for current purposes, the study focuses on the positive and negative subscales. In this study, the internal consistency is good for both the positive (Cronbach's α = .77) and negative (Cronbach's α = .83) subscales.

2.2.2. The Visual-Spatial Working Memory Task (VSWM)

The task consisted of five conditions. The three critical conditions are baseline condition, low VSWM load condition, and high VSWM load condition (see Figure 1). In the baseline condition (i.e., in the visual perception task without the VSWM component), participants were simply asked to judge whether a grid, composed of black squares, was organized in rows (see baseline and high VSWM load conditions in Figure 1) or columns (see the low VSWM load condition in Figure 1). In the low and high VSWM load conditions, participants were in addition asked to encode the location of 3 or 6 black disks which appeared before the presentation of the perception task (i.e., the grid)—the 3 disks constituted the condition of the low VSWM load and the 6 disks constituted the condition of the high VSWM load. In these conditions, and following the presentation of a white cross for 500ms, 3 or 6 disks appeared for 1500ms. Participants were then required to maintain the location of the disks for 4500ms before recognition. This was intervened by the perception task (i.e., whether the grid was arranged in columns or rows). Crucially, on 50% of the trials of these conditions, the location of 3 disks was randomly altered from the original location in a random direction by 2.0° visual angle during the encoding phase. During the recognition task, participants were required to judge whether the location of the disks was same or different to the original location during the encoding phase. The two additional conditions (not shown in Figure 1) are VSWM-only conditions (i.e., without the perception (grid) task), one with low VSWM load (3 disks) and one with high VSWM load (6 disks). These two conditions were included in the task to balance the design, and were not included in the analysis.

(Figure 1 About Here)

All stimuli were presented on a grey background. The grid subtended 12.0° visual angle, and consisted of 432 identical black squares (6 × 6 pixels, 0.02° visual angle per square). Each of the disks had a diameter of 1 cm subtending 0.95° visual angle. The disks were presented randomly and non-overlapping within 90% of the screen dimensions to ensure attentional focus across conditions (for complete details see Cocchi et al. (2011)).

Participants completed the task in one block of 50 trials (10 trials for each condition) that were presented in a random order, and the bidirectional association of the respective conditions within the block was counterbalanced. The trial sequences were created using a custom made

MATLAB (MathWorks^{TM}) algorithm and the stimuli were generated with the Psychtoolbox 2.54 for MATLAB (http://psychtoolbox.org).

3. Results

Reaction time (RT) of accurate responses and accuracy scores were analyzed in two separate 3x3 (task condition x group) repeated measures analyses. The analysis for the RT(ms) revealed only a significant main effect for RT ($F(2,176)=13.45$, $p<.001$, $\eta_p^2=.133$) (Figure 2). Post-hoc analyses revealed that participants overall were significantly slower in the baseline (perception task-only) condition (mean(se)=1161.44(28.29)) compared to both the low VSWM load condition (mean(se)=1068.23(33.83); $t_{(90)} = 4.29$, $p <.001$; $d =.31$) and the high VSWM load condition (mean(se)=1036.78(33.53); $t_{(90)} = 5.08$, $p < 0.001$; $d = 0.42$).

(Figure 2 About Here)

With respect to accuracy, the analysis revealed a significant condition x group interaction ($F(4,176)=4.53$, $p=.002$, $\eta_p^2=.093$) (Figure 3). No other main effects or interactions were observed. Post-hoc analyses revealed significant differences among the conditions only for the HNLP group. Specifically, the participants in the HNLP group were significantly less accurate in the low VSWM load condition (mean(se)= 63.86(5.61)) compared to both the baseline (perception task-only) condition (mean(se)= 72.95(3.80); $t_{(22)} = 2.77$, $p = 0.011$; $d = 0.34$) and the high VSWM load condition (mean(se)= 70.00(5.05); $t_{(22)} = -2.33$, $p = 0.029$; $d = 0.24$). In addition, there was an indication for differences among the groups in the low VSWM load condition ($F(2,88)=2.47$, $p=.090$, $\eta_p^2=.053$). Exploratory post-hoc analysis revealed that only the HNLP group was significantly less accurate (mean(se)= 63.86(5.61)) than the LNLP group (mean(se)= 77.10(3.37); $t_{(66)}$ = 2.14, p = 0.036; d = 0.55). No other significant differences were observed.

(Figure 3 About Here)

4. Discussion

We investigated, within a healthy population, the association of positive and negative psychosis symptom expressions with performance on a visual spatial task under various cognitive load conditions. With respect to reaction times, participants overall performed more efficiently (i.e., faster) with increasing cognitive load, thus replicating the finding from a previous study using the paradigm we implemented in this study (Cocchi et al., 2011). This facilitation in performance was unrelated to symptom expressions. With respect to accuracy, the results showed that the extreme negative symptom group (HNLP) performed worse in the low VSWM condition compared to the baseline and the high VSWM load conditions. In addition, there was some indication that this group was also less accurate in this condition compared to the low negative, and low positive symptom group (LNLP).

Our result, showing that individuals were faster with increasing cognitive load, is in contrast to the cost and decrement in performance often observed in studies using dual-task paradigms. In the context of such paradigms, it is assumed that the concurrent working memory load would reduce the availability of attentional and perceptual resources for the secondary task, which has been suggested to result from a serial allocation of resources to the tasks on a first-come, first-served bases (Ruthruff, Pashler, & Klaassen, 2001). One potential explanation to resolving this discrepancy is that increasing cognitive load can result in a shift from a serial mode to a parallel mode of resource allocation. The study by Cocchi et al. (2011) provides some support for this suggestion. In that study, the perceptual facilitation in the low and high VSWM load conditions compared to the baseline condition (without concurrent working memory demands) was associated with occipito-parietal downregulation, and at the same time with increasing involvement of anterior temporal and inferior and dorsal frontal regions. These temporal and frontal regions have been suggested to be involved in the optimization of memory and perceptual resources in tasks requiring the fulfillment of multiple goals (Cocchi et al., 2011; Rissman, Gazzaley, & D'Esposito, 2008). It is thus possible that the additional recruitment of the temporal and frontal regions with increasing cognitive load reflects the shift from a serial to parallel processing mode, which may in turn have contributed to the increased efficiency in performance on the perceptual task. It might be thought that such top-down control of visuo-spatial processing would be disturbed in those with more symptoms (Cocchi et al., 2009), but we found no such effect in this subclinical group. It remains to be seen whether more profound symptomatic presentation, such as that seen in schizophrenia, would have a greater impact on this facilitation.

While we predicted that individuals with high expressions of negative symptoms would exhibit greater errors with increasing cognitive load, it was surprising to observe that their performance during the high VSWM load condition did not differ from the baseline condition, despite showing impairment during the low VSWM load condition. The “resource limitations hypothesis” (Granholm, Asarnow, & Marder, 1996) may offer a potential explanation. According to this hypothesis, it is suggested that patients with schizophrenia have reduced attentional resources compared to controls in high cognitive-load tasks. Under these conditions, it has been shown that performance of patients with schizophrenia (Granholm, Morris, Sarkin, Asarnow, & Jeste, 1997) and schizotypy (Ducato, Thomas, Monestes, Despretz, & Boucart, 2008) is not, or is only slightly affected when processing demands exceed available resources (overload). Thus, it is plausible that individuals with high negative symptoms have more limited resources than individuals with low expression of symptoms or high expression of positive symptoms. This conjecture is consistent with studies reporting an association of reduced processing capacity in patients with schizophrenia with negative (Granholm, Verney, Perivoliotis, & Miura, 2007) but not positive symptom severity (Addington & Addington, 1997). Accordingly, we speculate that their diminished performance during the low VSWM load condition may be due to saturation of processing capacity. In contrast, their better performance during the high VSWM load condition (compared to the low VSWM load condition) may be the consequence of optimizing information processing by recalling resources to information whose demands exceed capacity.

The findings reported in this study are thus consistent with previous reports and theory, and highlight the sensitivity of attenuated, subclinical expressions of psychosis to cognitive performance that is vulnerable within the clinical entity they represent, i.e., schizophrenia spectrum disorders. While it is obvious that replications of our findings within clinical populations are needed before any definitive conclusion can be made about how negative and positive symptoms affect the dynamic interplay between working memory and visual spatial processing, our findings may have clinical implications. First, they imply that symptomatic variations in individuals diagnosed with schizophrenia are important determinants of performance on cognitive tasks that particularly require the maintenance of multiple sources of information. Second, by showing that the effect of sub-threshold clinical expressions on the VSWM task follow a similar trend to those observed in clinical populations, we provide evidence that the risk of the disorder may, at least in part, be mediated by variation in the ability to manage in a goal-direct manner multiple sources of information. In this context, research that examines the cognitive phenotype of individuals with high risk for schizophrenia spectrum disorders may benefit from the use of dual-tasks that combine visual spatial processing and working memory.

The impact of dissociative processes, such as depersonalization, on visual working memory is interesting, particularly in non-pathological samples such as ours, given the evidence that dissociation may play a mediating role in the production of subclinical psychotic experiences (Cole, Newman-Taylor, & Kennedy, 2016). There is a model that suggests that such non-pathological dissociation is dependent on above average attentional and working memory abilities (de Ruiter, Elzinga, & Phaf, 2006), although experimentally induced dissociation may actually impair performance (Brewin & Mersaditabari, 2013). Future work in this population should explore whether the co-occurrence of dissociative symptoms with subclinical psychotic symptomatology affects visual working memory and attention, and if so in what way.

Conclusion

In this study, we have shown that performance was more efficient with increasing cognitive load, thus replicating earlier findings (Cocchi et al., 2011). Moreover, we have shown that increasing cognitive load resulted in reduced accuracy during the low VSWM load condition in individuals with high expressions of negative symptoms. The disappearance of this decrement during the high VSWM load condition might be explained within the framework of the “limited resources hypothesis”, but this needs to be examined in greater detail in future studies. Finally, dual-tasks that combine visual spatial processing and working memory appear sensitive to attenuated expressions of positive and negative symptoms, and thus may be a useful paradigm to assess information processing vulnerabilities in individuals with high risk for schizophrenia spectrum disorders.

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References

Addington, J., & Addington, D. (1997). Attentional vulnerability indicators in schizophrenia and bipolar disorder. *Schizophr Res, 23*(3), 197-204.

Aleman, A., Hijman, R., de Haan, E. H., & Kahn, R. S. (1999). Memory impairment in schizophrenia: a meta-analysis. *Am J Psychiatry, 156*(9), 1358-1366.

Brewin, C. R., & Mersaditabari, N. (2013). Experimentally-induced dissociation impairs visual memory. *Conscious Cogn, 22*(4), 1189-1194.

Cocchi, L., Bosisio, F., Carter, O., Wood, S. J., Berchtold, A., Conus, P., et al. (2009). Visuospatial working memory deficits and visual pursuit impairments are not directly related in schizophrenia. *Aust N Z J Psychiatry, 43*(8), 766-774.

Cocchi, L., Schenk, F., Volken, H., Bovet, P., Parnas, J., & Vianin, P. (2007). Visuo-spatial processing in a dynamic and a static working memory paradigm in schizophrenia. *Psychiatry Res, 152*(2-3), 129-142.

Cocchi, L., Toepel, U., De Lucia, M., Martuzzi, R., Wood, S. J., Carter, O., et al. (2011). Working memory load improves early stages of independent visual processing. *Neuropsychologia, 49*(1), 92-102.

Cole, C. L., Newman-Taylor, K., & Kennedy, F. (2016). Dissociation mediates the relationship between childhood maltreatment and subclinical psychosis. *J Trauma Dissociation*, 1-16.

Cutting, J., & Dunne, F. (1986). The nature of the abnormal perceptual experiences at the onset of schizophrenia. *Psychopathology, 19*(6), 347-352.

de Ruiter, M. B., Elzinga, B. M., & Phaf, R. H. (2006). Dissociation: cognitive capacity or dysfunction? *J Trauma Dissociation, 7*(4), 115-134.

Ducato, M. G., Thomas, P., Monestes, J. L., Despretz, P., & Boucart, M. (2008). Attentional capture in schizophrenia and schizotypy: effect of attentional load. *Cogn Neuropsychiatry, 13*(2), 89-111.

Ettinger, U., Mohr, C., Gooding, D. C., Cohen, A. S., Rapp, A., Haenschel, C., et al. (2015). Cognition and brain function in schizotypy: a selective review. *Schizophr Bull, 41 Suppl 2*, S417-426.

Farmer, C. M., O'Donnell, B. F., Niznikiewicz, M. A., Voglmaier, M. M., McCarley, R. W., & Shenton, M. E. (2000). Visual perception and working memory in schizotypal personality disorder. *Am J Psychiatry, 157*(5), 781-788.

Forbes, N. F., Carrick, L. A., McIntosh, A. M., & Lawrie, S. M. (2009). Working memory in schizophrenia: a meta-analysis. *Psychol Med, 39*(6), 889-905.

Granholm, E., Asarnow, R. F., & Marder, S. R. (1996). Dual-task performance operating characteristics, resource limitations, and automatic processing in schizophrenia. *Neuropsychology, 10*, 11-21.

Granholm, E., Morris, S. K., Sarkin, A. J., Asarnow, R. F., & Jeste, D. V. (1997). Pupillary responses index overload of working memory resources in schizophrenia. *J Abnorm Psychol, 106*(3), 458-467.

Granholm, E., Verney, S. P., Perivoliotis, D., & Miura, T. (2007). Effortful cognitive resource allocation and negative symptom severity in chronic schizophrenia. *Schizophr Bull, 33*(3), 831-842.

Kim, J., & Park, S. (2011). Visual Perception Deficits Associated with the Magnocellular Pathway in Schizophrenia. *Korean Journal of Schizophrenia Research, 14*, 61-75.

Lee, J., & Park, S. (2005). Working memory impairments in schizophrenia: a meta-analysis. *J Abnorm Psychol, 114*(4), 599-611.

Loas, G. (2004). Visual-spatial processing and dimensions of schizophrenia: a preliminary study on 62 schizophrenic subjects. *Eur Psychiatry, 19*(6), 370-373.

Louise, S., Gurvich, C., Neill, E., Tan, E. J., Van Rheenen, T. E., & Rossell, S. (2015). Schizotypal Traits are Associated with Poorer Executive Functioning in Healthy Adults. *Front Psychiatry, 6*, 79.

Matthews, N. L., Collins, K. P., Thakkar, K. N., & Park, S. (2014). Visuospatial imagery and working memory in schizophrenia. *Cogn Neuropsychiatry, 19*(1), 17-35.

McClure, M. M., Romero, M. J., Bowie, C. R., Reichenberg, A., Harvey, P. D., & Siever, L. J. (2007). Visual-spatial learning and memory in schizotypal personality disorder: continued evidence for the importance of working memory in the schizophrenia spectrum. *Arch Clin Neuropsychol, 22*(1), 109-116.

Park, S., & Gooding, D. C. (2014). Working Memory Impairment as an Endophenotypic Marker of a Schizophrenia Diathesis. *Schizophr Res Cogn, 1*(3), 127-136.

Rissman, J., Gazzaley, A., & D'Esposito, M. (2008). Dynamic adjustments in prefrontal, hippocampal, and inferior temporal interactions with increasing visual working memory load. *Cereb Cortex, 18*(7), 1618-1629.

Ruthruff, E., Pashler, H. E., & Klaassen, A. (2001). Processing bottlenecks in dual-task performance: structural limitation or strategic postponement? *Psychon Bull Rev, 8*(1), 73-80.

Stefanis, N. C., Hanssen, M., Smirnis, N. K., Avramopoulos, D. A., Evdokimidis, I. K., Stefanis, C. N., et al. (2002). Evidence that three dimensions of psychosis have a distribution in the general population. *Psychol Med, 32*(2), 347-358.

Tek, C., Gold, J., Blaxton, T., Wilk, C., McMahon, R. P., & Buchanan, R. W. (2002). Visual perceptual and working memory impairments in schizophrenia. *Arch Gen Psychiatry, 59*(2), 146-153.

Wood, S. J., Pantelis, C., Proffitt, T., Phillips, L. J., Stuart, G. W., Buchanan, J. A., et al. (2003). Spatial working memory ability is a marker of risk-for-psychosis. *Psychol Med, 33*(7), 1239-1247.

Table 1. Characteristics of overall sample and subgroups

Overall/ Group	Gender (Males/Females)	Handedness (Left/Right)	Age (SD)	CAPEn (SD)	CAPEp (SD)
Overall (N=91)	18/73	12/79	19.16 (1.20)	25.45 (5.47)	26.98 (5.07)
LNLP (N=45)	6/39	7/38	19.18 (1.07)	24.22 (4.99)	25.64 (4.23)
HNLP (N=23)	4/19	3/20	19.48 (1.44)	30.27 (4.93)	25.13 (4.04)
LNHP (N=23)	8/15	2/21	18.83 (1.11)	23.04 (3.86)	31.43 (5.00)

CAPEn= CAPE negative dimension; CAPEp= CAPE positive dimension; LN= Low negative; HN= High negative; LP= Low positive; HP= High positive.

Legends

Table 1. Characteristics of overall sample and subgroups

Figure 1. Schematic depiction of baseline, low and high load conditions of the Visual-Spatial Working Memory task (VSWM). (Figure is from Cocchi et al. (2011) with permission).

Figure 2. Mean reaction time in the baseline, and low and high Visual-Spatial Working Memory task (VSWM) load conditions. Bars represent standard errors. *** $p < 0.001$.

Figure 3. Mean percent accuracy of the balanced (LNLP) and the biased groups (HNLP and LNHP) groups on the Visual-Spatial Working Memory task (VSWM) task. Bars represent standard errors. * $p < 0.05$.

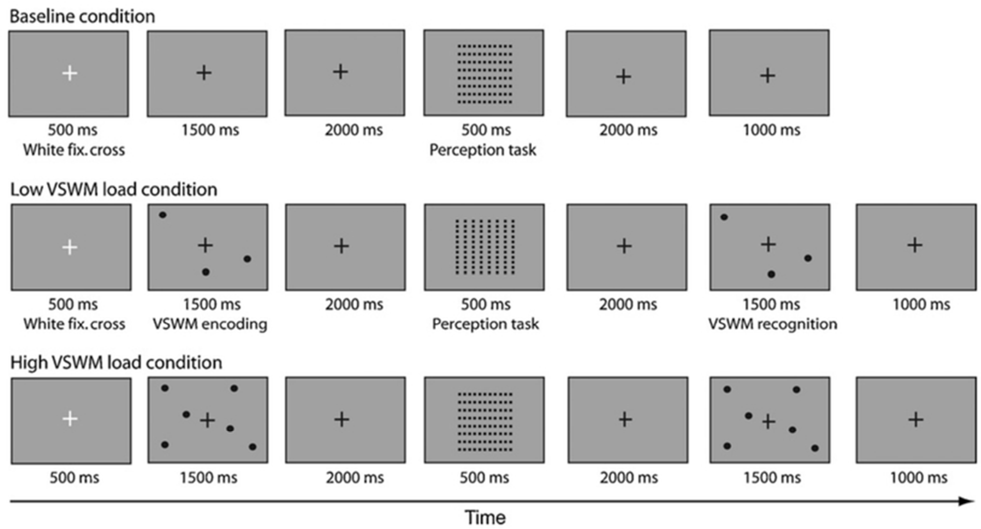

Figure 1. Schematic depiction of baseline, low and high load conditions of the Visual-Spatial Working Memory task (VSWM). (Figure is from Cocchi et al. (2011) with permission).
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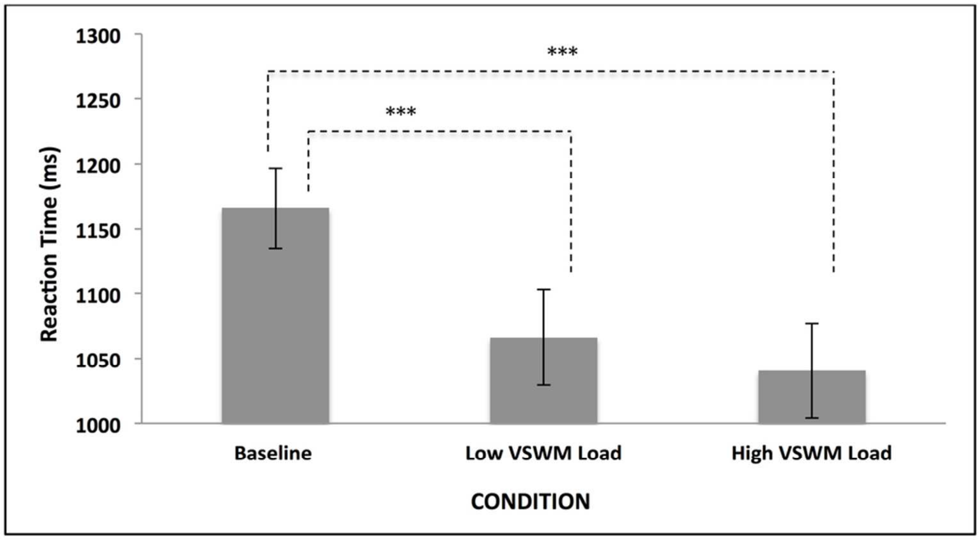

Figure 2. Mean reaction time in the baseline, and low and high Visual-Spatial Working Memory task (VSWM) load conditions. Bars represent standard errors. *** $p < 0.001$.

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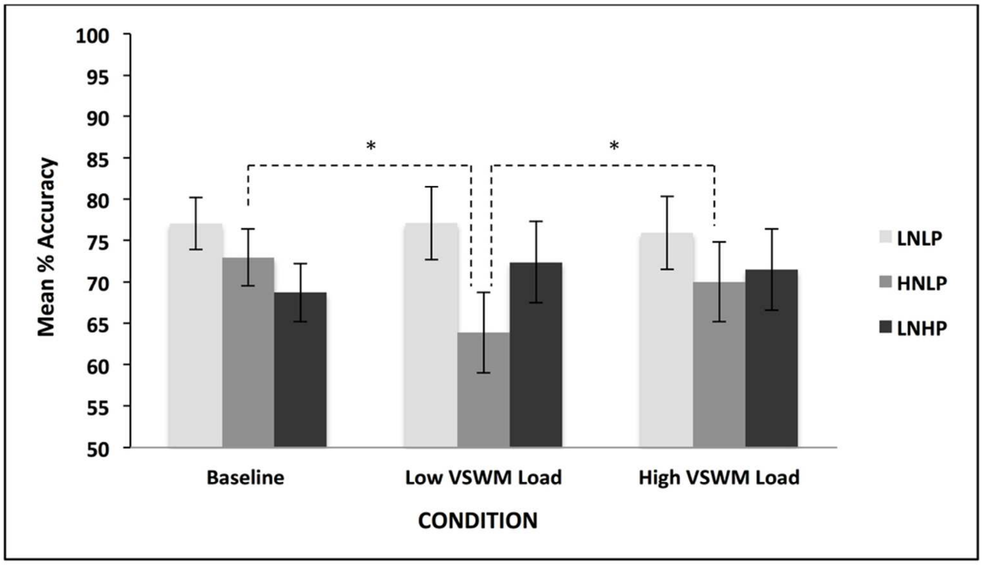

Figure 3. Mean percent accuracy of the balanced (LNLP) and the biased groups (HNLP and LNHP) groups on the Visual-Spatial Working Memory task (VSWM) task. LNLP=Low Negative Low Positive; HNLP= High Negative, Low Positive; LNHP= Low Negative, High Positive. Bars represent standard errors. * $p < 0.05$.
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