**SUPPLEMENTARY MATERIAL**

**1. Inclusion and exclusion criteria**

Individuals with current or past neurological disease or injury, a history of head trauma with loss of consciousness, intellectual disability, current substance use disorder, substance intoxication or withdrawal, or individuals with a corrected visual acuity less than 20/25 as assessed using a Snellen Eye Chart were excluded. Additionally, healthy subjects with a family history of psychotic disorders or mood disorders among first degree relatives were excluded. Four patients and 9 healthy control subjects were excluded due to low visual acuity (assessed by Snellen Eye Chart), positive urine toxicology screen, or an inability to engage in the experiments indicated by random answers to tasks.

**2. Additional information about the administration of psychophysical tasks**

All experimental stimuli were generated in Java Programming Platform using the Psychophysics Programming with Java Package (PsychWithJava, <http://hboyaci.bilkent.edu.tr/PsychWithJava/index.html>).

**Velocity discrimination task**

In the velocity discrimination task, two drifting gradients were presented sequentially for 308 ms with an inter-stimulus interval of 508 ms. Gratings were presented through a circular window of 7.9° in diameter and moved horizontally either to the left or to the right. The direction of movement was randomized from trial to trial. Velocity discrimination threshold of each subject was determined using a two alternative forced choice procedure combined with a standard two-down one-up staircase. Velocities of the gradients in the first trial were 6°/s and 8°/s. If the subject gave correct answers to two consecutive trials, the velocity difference between two stimuli was decreased by 5%; if they gave one incorrect answer, the velocity difference increased by 5% in the next trial. The experimental session was terminated after eight reversals of staircase directions. For each participant, the velocity difference levels in all reversals, except for the first, were averaged to produce a velocity discrimination threshold, which is the Weber fraction (ΔV/ V) (Levitt 1971). Velocity discrimination thresholds correspond to an accuracy level equivalent to 70.7% correct for each subject (Levitt 1971). Patients with schizophrenia were expected to show elevated velocity discrimination thresholds that indicate impaired velocity discrimination.

To reduce the time burden on patients and avoid fatigue, the velocity discrimination task that we adopted was slightly different than previous studies (Chen *et al.* 1999, 2006; Bidwell *et al.* 2006). Instead of using a three-down one-up staircase method, we used a two-down one-up staircase, which is also a commonly used standard method for threshold estimation (Levitt 1971). Another difference was the number of reversals in the staircase. We terminated the sessions after eight reversals of staircase directions, instead of twelve. The recommended procedure is to continue testing until at least six reversals are obtained (Levitt 1971), which is warranted here. The stimulus duration and inter-stimulus interval used in the study were identical to previous studies (Chen *et al.* 1999, 2006; Bidwell *et al.* 2006). For these reasons, although the number of trials was less than previous studies, sufficient data were collected to meet the requirements of standard threshold estimation methods.

**Visual integration and backward masking tasks**

Contour integration has been assessed using the Jittered Orientation Visual Integration (JOVI) task, developed by the Cognitive Neuroscience Test Reliability and Clinical Applications for Schizophrenia (CNTRACS) Consortium with their permission. Adopting the JOVI stimuli provided by the CNTRACS Consortium, the experiment was generated in Java Programming Platform using the Psychophysics Programming with Java Package (PsychWithJava, <http://hboyaci.bilkent.edu.tr/PsychWithJava/index.html>). On each trial, a stimulus with a closed contour formed by Gabor elements was presented. The stimulus duration was 2 sec. An orientational jitter (7°) was added to the elements that formed the contour. The sharp side of the closed contour was pointing either left or right (Figure 1, D2). Participants were asked to indicate the pointing direction of the closed contour. Each stimulus was presented for 2 seconds, followed by an inter-trial interval of 1 second. Prior to the actual task, two demonstration sessions were presented using stimuli that are easily identifiable (Figure1, D1). Subsequently, a practice task composed of 8 trials using the 7° jitter condition was presented. All participants performed higher than the chance level (%50) in the practice session, and proceeded with performing the actual task. In the actual task session, 8 of the 56 trials were easy “catch” trials, to screen for the motivation and attention of the participant. There were two types of catch trials, both derive from the 0° jitter condition. One of them was the same test stimulus with a black continuous contour drawn in through the Gabor elements. In the other type, the background elements were excluded. Participants who failed to give correct answers to more than one catch trials were excluded due to low motivation or attention.

In this experiment, there are minor differences from the original JOVI task that was optimized and validated by Silverstein et. al. These differences were made in accordance with the suggestions provided by the researchers (Silverstein *et al.* 2011). In their study, Silverstein et. al. showed that in the 7° jitter condition there was a significant performance difference between healthy participants and patients. For this reason, instead of using 6 different jitter conditions, we only used the 7° jitter condition. Although the total number of trials in our task is lower than the original task (56 instead of 240), the number of trials for the 7° jitter condition was 40 in the original task. Silverstein et al. (2011) also showed that in the 120 trial version of the task, which includes 20 trials for the 7° jitter condition, main effects of group, jitter condition, and their interaction continued to be significant. Therefore, although this version is shorter than the original task, it collects more data on one of the conditions that was shown to be different in between two groups.

In a second session, a backward masking task was implemented using the JOVI paradigm. In this task, a JOVI task stimulus was followed by another stimulus (masking stimulus) which contained disconnected, randomly oriented Gabor elements that don’t form a closed contour. The target (JOVI stimulus) and the masking stimulus were presented for 508 msec each. The interstimulus interval (ISI) between the target and masking stimuli varied between 25, 42, 58, 75, 92 msec. The interval between the two trials was 1 sec. Subjects were asked to indicate the pointing direction of the closed contour in the first (target) stimulus after the presentation of both target and masking stimuli. This task was comprised of 80 trials and lasted for 5 minutes. Proportions of correct trials at different ISI’s were calculated for each participant.

**Visuospatial working memory task**

The final score was calculated using the method as follows, described by Ziermans, 2013 (Ziermans 2013):

Final score = Highest level achieved – (0.3 x number of incorrect answers on that level) – (0.15 x number of incorrect answers on levels below the highest level achieved).

**Visual Context Processing**

The task has been implemented using an open source example in the PsychwithJava website (http://hboyaci.bilkent.edu.tr/PsychWithJava/Examples/SizesMoA/index.html).

**3. Correlations of task performances with age**

Linear regression analysis showed that there was a relationship between JOVI task performance and age in both groups (for patients, R2 = 0.539, F(1,25) = 28.063, *p* < 0.001; for controls, R2 = 0.479, F(1,28) = 24.792, *p* < 0.001) (Figure S2A).

The association between VSWM performance and age was statistically significant in the patient group (R2 = 0.271, F(1,25) = 8.908, *p* = 0.006), but not in the control group (R2 = 0.121, F(1,28) = 3.709, *p* = 0.065) (Figure S2B).

There was no significant relationship between VD performance and age in either group.

**4. Evaluation of combined scores and their relationship with clinical characteristics**

**Methods**

We also calculated a combined visual performance (VP) score and investigated its relationship with clinical characteristics. For this analysis, we calculated Z scores of performance indicators of each task for each participant. Then, we computed a combined score using this formulation: Combined VP score= ZVSWM + ZJOVI – ZVD. In the formulation, the Z score of the velocity discrimination task was given a negative value, as higher discrimination thresholds indicate compromised performance. We investigated the relationship of combined VP scores with PANSS scores in patients and SPQ scores in healthy individuals using exploratory correlation analysis.

Furthermore, we investigated whether combined VP scores were different among healthy controls with low and high negative schizotypy, and patients with high and low negative symptom severity. For this analysis, the healthy participant group was divided into two groups based on their SPQ negative (interpersonal) scores. Patients whose SPQ negative (SPQ-N) scores were lower than or equal to the median SPQ-N score (Median=2) were included in the low negative schizotypy group (N=17); patients whose SPQ-N score was higher than the median were included in the high negative schizotypy group (N=14). Similarly, patients whose PANSS Negative (PANSS-N) score were lower than or equal to the median score (median=15) were included in the low negative symptom severity group (N=15); patients whose PANSS-N scores were higher than the median score were included in the high negative symptom severity group (N=13). Then, combined visual performance scores of these four groups were compared using a one way ANOVA.

**Results**

The combined VP score was found to be highly correlated with negative symptoms (*r* = -0.629, *p* < 0.001) and total PANSS scores (*r* = -0.584, *p* = 0.002), but not with other symptom dimensions in the patient group. Correspondingly, it was correlated with interpersonal (negative) schizotypal traits (*r* = -0.549, *p* = 0.002) and total SPQ scores (*r* = -0.583, *p* = 0.001), but not with cognitive-perceptual or disorganization traits in healthy participants.

A one-way ANOVA was conducted to compare the combined VP scores in low and high negative schizotypy groups and low and high negative symptom severity groups. There was a significant difference between four groups (F(3,55) = 12.814, *p* < 0.001). A Bonferroni post-hoc test revealed that the mean combined score of healthy participants with low negative schizotypy (M = 1.95, SD = 1.53) was significantly different than high negative schizotypy (M = -0.02, SD = 1.78, *p* = 0.026), low negative symptom severity (M = -0.26, SD = 1.78, *p*= 0.007) and high negative symptom severity groups (M= -2.22, SD = 2.20, *p* < 0.001). There was no significant difference between healthy participants with high negative schizotypy and patients with low negative symptom severity (*p* = 1.000). The mean combined score of patients with high symptom severity was significantly different than patients with low symptom severity (*p* = 0.041), healthy participants with low (*p* < 0.001) and high negative schizotypy (*p* = 0.018) (Figure S3).

These results further support the evidence that visual perceptual changes show a continuum on the psychosis spectrum, and are related to negative symptom dimension in patients as well as in healthy individuals.

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| **Table S1. Correlations between visual task performances** | | | | |
|  | | VSWM | JOVI | VD |
| Patients | VSWM | 1 |  |  |
| JOVI | .309 | 1 |  |
| VD | -.601\*\* | -.259 | 1 |
| Controls | VSWM | 1 |  |  |
| JOVI | .230 | 1 |  |
| VD | -.504\* | -.005 | 1 |
| VSWM: Visuo-spatial working memory task performance, JOVI: Jittered orientation visual integrations task performance, VD: Velocity discrimination threshold. \**p*=.01, \*\**p*=.001 . | | | | |

Figure S1. Backward masking (BM) task performance in patient and control groups. Points represent the proportion of correct trials at different interstimulus intervals. Error bars = 1 SE.

A.

B.

Figure S2. (A) Jittered orientation visual integration (JOVI) and (B) visuo-spatial working memory (VSWM) performance scores plotted as a function of age in patient and control groups.

Figure S3. Mean combined visual performance (VP) scores in healthy participants with low negative schizotypy scores (Low SPQ-N), healthy participants with high negative schizotypy scores (High SPQ-N), patients with low negative symptom severity (Low PANSS-N) and patients with high negative symptom severity (High PANSS-N). Error bars = 1 SE.