Supplementary Online Content

Bansal S, Bae GY, Robinson BM, et al. Association between failures in perceptual updating and the severity of psychosis in schizophrenia. *JAMA Psychiatry*. Published online December 1, 2021. doi:10.1001/jamapsychiatry.2021.3482

This supplementary material has been provided by the authors to give readers additional information about their work.

eMethods 1. Participants, Materials, and Procedures

Participants

For both samples, diagnosis was confirmed using the Structured Clinical Interview for DSM-IV (SCID) All participants (PSZ as well as HCS) had normal or corrected-to-normal vision, and were free of other medical or neurologic comorbidity that could reasonably influence test performance, including substance abuse or dependence within the last 12 months. This protocol was approved by the Institutional Review Board(IRB) at the University of Maryland, Baltimore and the Yale IRB board and all participants gave written informed consent before taking part in this study. Two standardized neuropsychological measures were administered to examine current and premorbid cognitive functioning in PSZ and HCS: (1) the MATRICS Consensus Cognitive Battery and (2) the Reading Subtest of the Wide Range Achievement Test 4.

Stimuli and Procedure

Stimuli were generated in Matlab (The Mathworks, Inc.) using PsychToolbox (Brainard, 1997; Pelli, 1997) and were presented at 60 Hz on an LCD monitor with a white background (87.6 cd/m2) and a continuously visible black circular aperture (diameter 5°, <0.1 cd/m2) at a viewing distance of 100 cm. The motion stimulus was generated using a standard random dot kinematogram (RDK) algorithm (Roitman and Shadlen, 2002; Gold and Shadlen, 2003). A set of white dots was presented at random locations inside the circular aperture. Each dot remained stationary for one video frame (16.67 ms) and was then replotted two frames later (different dots appeared in different frames so that 1/3 of the dots were visible in any given frame). When replotted, a given dot had a 35% or 100% chance (depending on the coherence level) of moving in the coherent direction of motion. Otherwise, the dot was replotted at a random location within the aperture. Thus, even at the higher coherence level, a given dot rarely moved in the direction of coherent motion for more than a few cycles, making it difficult to perceive the direction by tracking an individual dot. When the offset position of a dot was outside the aperture, that dot was replotted at a random location on the circumference of the aperture to maintain the dot density(16.7 dots per deg2/s, with speed of motion was set to 6°/s).

The task is depicted in Figure 1. There were two types of trials: (i) No motion change trials, in which motion direction stayed constant through 0.5s or 1s of stimulus presentation (ii) Motion change trials, in which, midway(at 0.5s) through the visual display, the direction of motion changed by 90°, resulting in 0.5s of initial direction, followed by 0.5s of changed direction. We tested one main coherence level(35%), with few interspersed 100% coherence trials.

The net initial direction of motion on a given trial was selected unpredictably from sixteen bins of discrete motion directions (0°, 22.5°, 45°, 67.5°, 90°, 112.5°, 135°, 157.5°, 180°, 202.5°, 225°, 247.5°, 270°, 292.5°, 315°, and 337.5°). On each trial, the actual direction of motion was selected at random from within the ±11.25° range of the selected bin, with the same number of trials (12 for change trials, 6 each for 0.5s and 1s no change trials) in each bin. This yielded 192 change trials and 96 each for 0.5s and 1s no change trials respectively. For 100 % coherence trials, we presented 24 each for the three trial types (change, no change 0.5s, and no change 1s). The trials were evenly spread among 10 blocks and presented in random order. Each session began with a minimum of 16 practice trials during which a response feedback indicating the true motion direction was provided after each report. These trials were not included in the analyses.

Each trial began with a 500-ms presentation of a red fixation dot (RGB = [200, 0, 0]) at the center of the circular aperture, and this was followed by a presentation of the RDK (duration depended on trial type as described above). Participants were instructed to attend carefully to the direction of motion during the entire motion period. At the end of the motion display, the dots disappeared, and the fixation dot turned green (RGB = [0, 200, 0]) to indicate that a response should be made. Once the participant started moving the mouse to respond, a green probe dot appeared at a point on the circumference of the aperture that was in line with the position of the mouse cursor. A green line connecting the central dot and the probe dot was presented to indicate the direction. Participants were instructed to adjust the dot and line so that they matched the perceived direction of motion. The orientation of the line was continuously updated while the mouse moved so that participants could report the direction of motion in a continuous manner. Once participants were satisfied with the direction, they finalized the report by clicking a mouse button. The display then blanked completely, and the next trial started after a 1000-ms delay.

Data Analysis

On each trial, behavioral performance was quantified as the response error (the angular difference between the true motion direction and the reported motion direction). Supplemental Figure S1.B shows the distributions of response errors for each group for the motion change trials. The vast majority of response errors were clustered around 0°, and as observed previously (Bae and Luck, 2018,2019), there was a cluster of response errors near ±180°, indicating a tendency for observers to perceive the motion in the direction opposite to the true changed direction. Critically, we also observed response errors clustered around ±90°, indicating that participants perceive initial motion as opposed to changed motion. There were also occasional errors at intermediate directions, which may reflect lapses/random guesses.

To formally quantify these types of responses, we derived the proportions of responses centered around the true changed direction, around the initial direction(in change trials) and around opposite direction. This was done by categorizing responses in □15□ bins around the respective directions. For example, if the initial motion direction of dots was from the bottom of the aperture northwards to 0□, and the changed motion direction at +90□, the response was categorized as 'initial' if the direction report was indicated between >345° and <15°, as 'changed'(i.e. accurate) if it fell between 75° and 105°, and as 'opposite'(i.e. 180° from changed direction) if it fell between 255° and 285°. If the direction report was not in any of these bins, it was categorized as a lapse. For each response type, we also derived mean amount of time taken to finalize the report by clicking the mouse button after the offset of the RDK(response RTs).

Further, we conducted a quantification using a 4-parameter model that characterized the distribution of response errors as a mixture of a von Mises distribution centered at 0° error (true motion perception), another von Mises distribution centered at 90° error (initial motion perception), another distribution centered at 180° (error opposite-direction perception), and a uniform distribution (random guesses). These results are provided in supplemental materials.

Statistics

All statistical tests employed a two-tailed significance threshold of $\alpha<0.05$ and were performed using MATLAB and JASP software (JASP Version 0.8.5; jasp-stats.org).

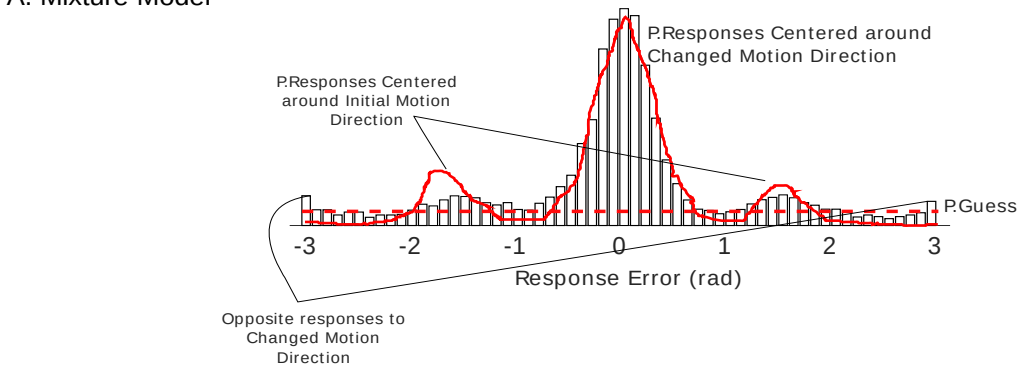
For the no change trials, each measure was analyzed in a 2-way ANOVA with factors of group (PSZ vs. HCS) and duration of RDK presentation (0.5 or 1s), while for the change trials, we conducted between group t-tests for each measure. We used Pearson correlations to examine the relationships amongst performance measures and with neurocognitive and clinical measures.

eMethods 2. Mixture Model and Response Distributions

As described in the manuscript and as observed in the figure(Part B) to the right, the vast majority of response errors ***(for 35% coherence trials)*** were clustered around 0°, there was a cluster of response errors near ±180°, indicating a tendency for observers to perceive the motion in the direction opposite to the true changed direction. We also observed response errors clustered around ±90°, indicating that participants perceive initial motion as opposed to changed motion. There were also occasional errors at intermediate directions, which may reflect lapses/random guesses.

In ancillary analyses, we conducted a quantification using a 4-parameter model that characterized the distribution of response errors as a mixture of a von Mises distribution centered at 0° error (true motion perception), another von Mises distribution centered at 90° error (initial motion perception), another distribution centered at 180° (error opposite-direction perception), and a uniform distribution (random guesses).(Right figure,A) This leads to one parameter for precision (the kappa parameter from the von Mises distributions), one parameter indicating the probability of initial motion perception, probability of an opposite-direction error, and one parameter indicating the probability of a random guess. For each type of no change trials, the same mixture model was applied to capture three parameters: precision (the kappa parameter from the von Mises distributions), one parameter indicating the probability of an opposite-direction error, and one parameter indicating the probability of a random guess.

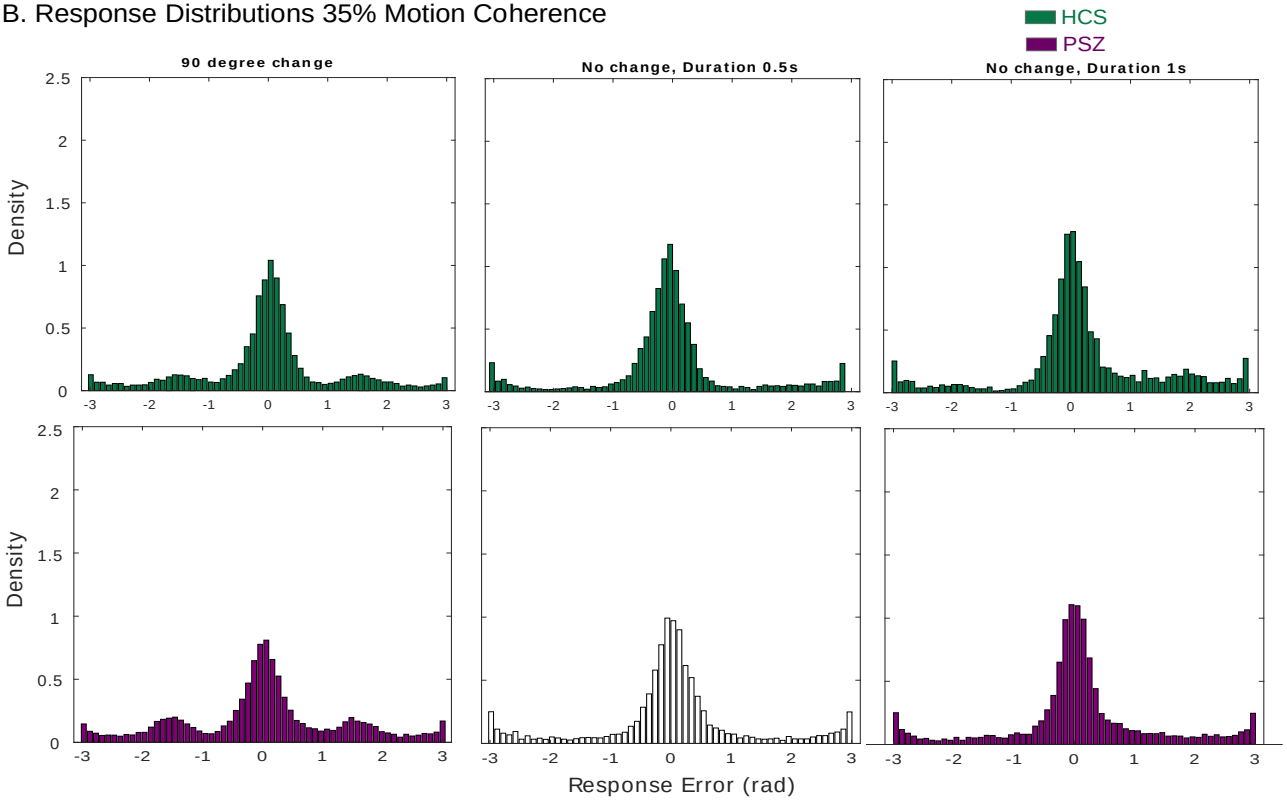
A. Mixture Model



$$P(\theta) = \alpha*\text{vonMises}(0, \kappa) + \beta*\text{vonMises}(\text{pi}/2, \kappa) + \gamma*\text{vonMises}(\text{pi}, \kappa) + (1-\alpha-\beta-\gamma)/2\pi$$

reports based on the true direction (at end of trial) — *reports based on the initial motion direction* — *reports based on the opposite direction* — *random guesses*

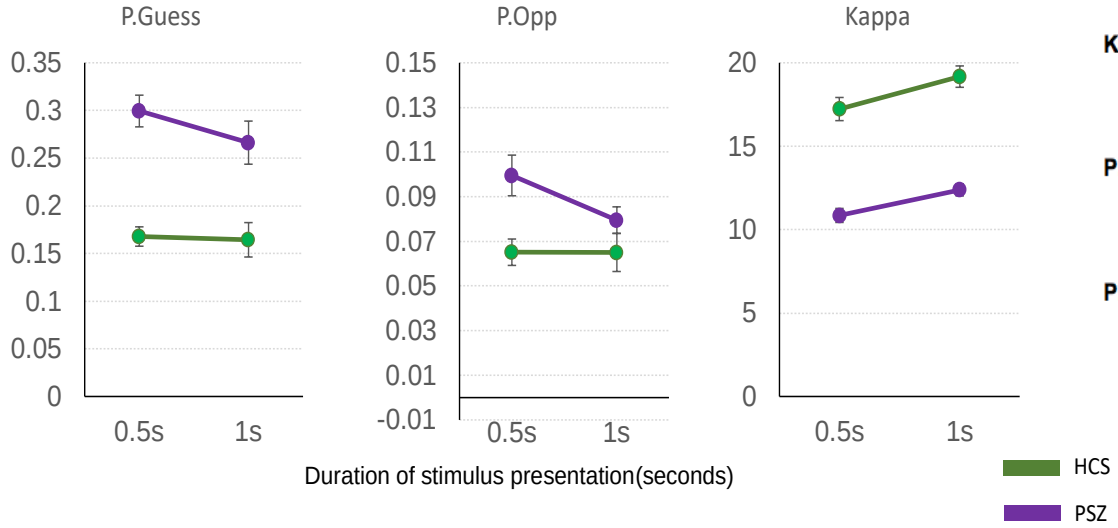
B. Response Distributions 35% Motion Coherence



eFigure 1. Mixture Model and Response Distributions

eMethods 3. Mixture Model Parameters Sample 1 (35% Coherence)

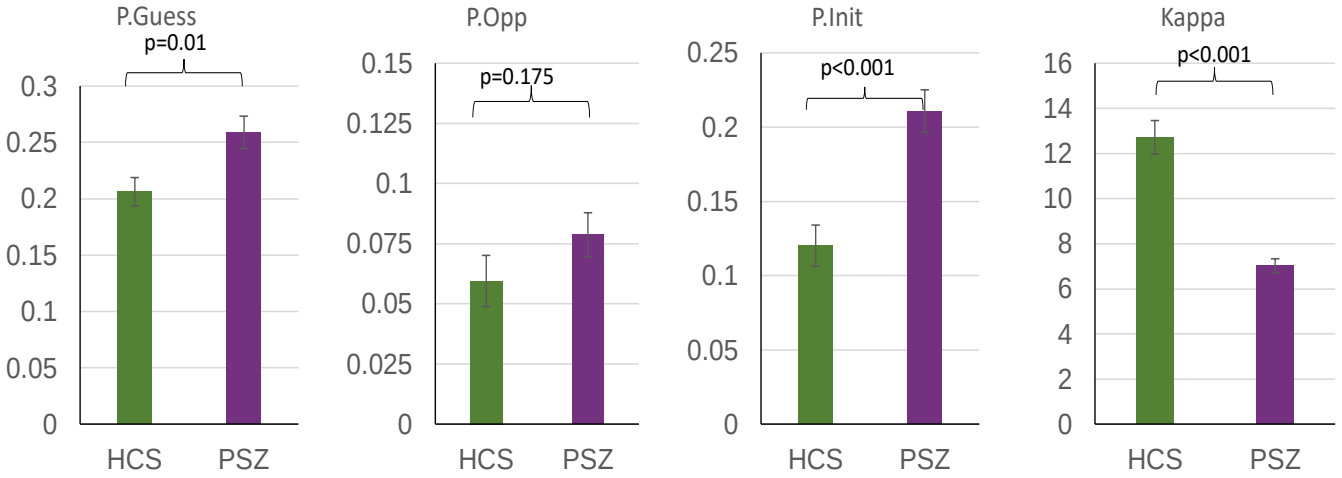
A. No Change Trials Parameter Estimates



No Change Trials

		F	p	η^2_p
Kappa				
	Duration	47.77	< .001	0.37
	Duration * Group	3.50	0.07	0.04
	Group	103.83	< .001	0.56
P.Opp				
	Duration	3.29	0.07	0.04
	Duration * Group	3.21	0.08	0.04
	Group	6.73	0.01	0.08
P.Guess				
	Duration	1.97	0.16	0.02
	Duration * Group	1.29	0.26	0.02
	Group	26.43	< .001	0.24

B. Change Trials Parameter Estimates



Change Trials

	t	p	Cohen's d
P.Guess	-2.64	0.01	-0.581
P.Init	-4.43	< .001	-0.976
P.Opp	-1.37	0.175	-0.302
Kappa	7.71	< .001	1.622

Kappa: The concentration parameter Kappa corresponds to the variability of perception of motion direction, where greater Kappa corresponds to lower variability in the distribution. For the No-change trials, we observed that this precision measure increased with a longer display of the RDK stimulus in both groups (Main effect of Duration: Original sample, $F=47.77$, $p<0.001$); Replication Sample $F=37.38$, $p<0.001$). PSZ were less precise overall(Main effect of Group: Original sample, $F=103.83$, $p<0.001$); Replication Sample $F=87.57$, $p<0.001$), but the increased precision with longer stimulus presentation duration was comparable across groups as evidenced by a lack of Group X Duration interaction effect(Original sample, $F=3.80$, $p=0.07$); Replication Sample $F=1.09$, $p=0.30$). In Change-trials, precision (as indexed by Kappa) was lower in PSZ as compared to HCS (Original sample $t=7.71$, $p<0.001$; Replication Sample $t=7.40$, $p<0.001$). As reported in the main manuscript with model-free results, this estimation of precision was lower in PSZ overall.

P.Opp: As discovered previously by Bae & Luck (2018), participants sometimes made 180° errors. The variable P.Opp corresponds to these 180° errors that were responses where participants perceived the motion in the direction opposite to the true changed direction (or target direction in no-change trials). This proportion of this opposite direction reports was small in both groups, however higher for PSZ in no-change trials. (Main effect of Group: Original sample, $F=6.73$, $p=0.01$); Replication Sample $F=5.47$, $p=0.02$). There was no main effect of Duration(Main effect of Duration: Original sample, $F=3.29$, $p=0.07$); Replication Sample $F=0.77$, $p=0.39$) and no Group X Duration interaction effect(Original sample, $F=3.21$, $p=0.07$); Replication Sample $F=1.48$, $p=0.23$). There was no difference in P.Opp for change-trials (Original sample $t=1.37$, $p=0.175$; Replication Sample $t=0.1$, $p=0.92$).

P.Guess: This estimated variable corresponds to the proportion of trials where participants were guessing, i.e., responding at random or due to attention lapses. In no -change trials, there was no main effect of Duration(Main effect of Duration: Original sample, $F=1.97$, $p=0.16$); Replication Sample $F=0.82$, $p=0.37$) and no Group X Duration interaction effect(Original sample, $F=1.29$, $p=0.26$); Replication Sample $F=1.94$, $p=0.17$). In both No-Change PSZ had a higher lapse rate [No-change trials:Original sample, $F=6.73$, $p=0.01$; Replication Sample $F=17.15$, $p<0.001$). In Change-trials, even though lapse rates were estimated to be higher in PSZ, this difference was not significant. (Original sample $t=1.37$, $p=0.175$; Replication Sample $t=1.17$, $p=0.24$)]

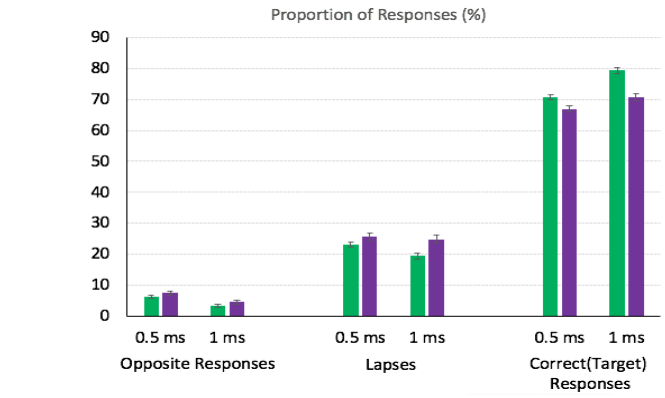
P.Init: In Change-trials, as observed in response distributions and results in the main manuscript, we also observed response errors clustered around ±90°, indicating that participants perceive initial motion as opposed to changed motion. These responses can be captured by von Mises distributions with an additional parameter indicating the probability of initial motion perception. Paralleling the results in the main manuscript, we observed that PSZ had a higher probability of these responses. (Original sample $t=4.43$, $p<0.001$; Replication Sample $t=4.69$, $p<0.001$)].

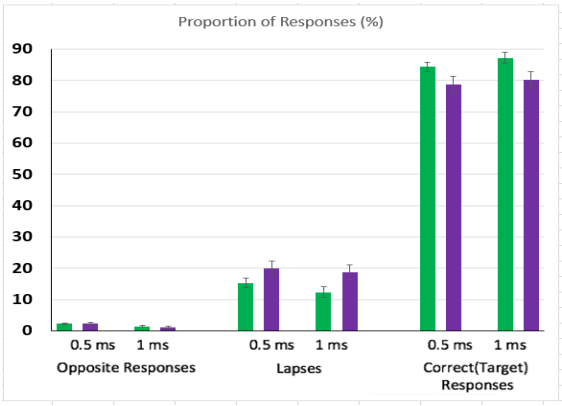
eMethods 4. Model-Free Results for 100% Coherence Trials

A. NO CHANGE TRIALS

a) Proportion of responses

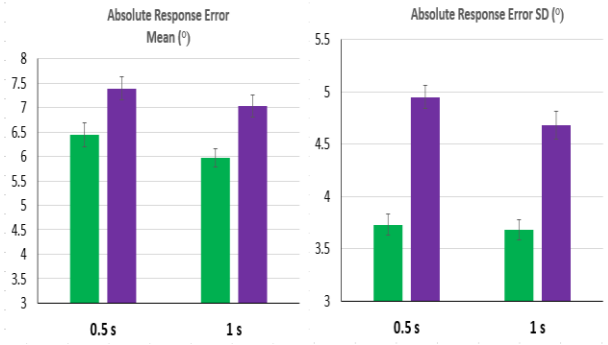
	SAMPLE 1 (HCS, N=36; PSZ=48)			SAMPLE 2 (HCS, N=34; PSZ=42)		
	F	p	η^2_p	F	p	η^2_p
P.Target						
Duration	13.18	< .001	0.14	2.63	0.11	0.03
Duration ✻ Group	1.04	0.31	0.01	0.29	0.59	0.00
Group	9.68	0.00	0.11	4.98	0.03	0.06
P.Opposite						
Duration	14.42	< .001	0.15	0.057	0.94	0.00
Duration ✻ Group	0.01	0.94	0.00	0.32	0.57	0.00
Group	1.11	0.30	0.01	4.75	0.03	0.06
P.Lapses						
Duration	2.57	0.11	0.03	2.68	0.11	0.03
Duration ✻ Group	1.01	0.32	0.01	0.43	0.52	0.01
Group	4.43	0.04	0.05	4.03	0.05	0.05





b) Absolute Response Error

	F	p	η^2_p	F	p	η^2_p
Mean						
Duration	0.74	0.39	0.01	4.81	0.03	0.06
Duration ✻ Group	0.02	0.88	0.00	0.08	0.77	0.00
Group	0.15	0.70	0.00	4.48	<.001	0.16
SD						
Duration	0.00	0.95	0.00	3.11	0.08	0.04
Duration ✻ Group	0.54	0.46	0.01	1.43	0.24	0.02
Group	4.97	0.03	0.06	74.36	<.001	0.50



B. CHANGE TRIALS

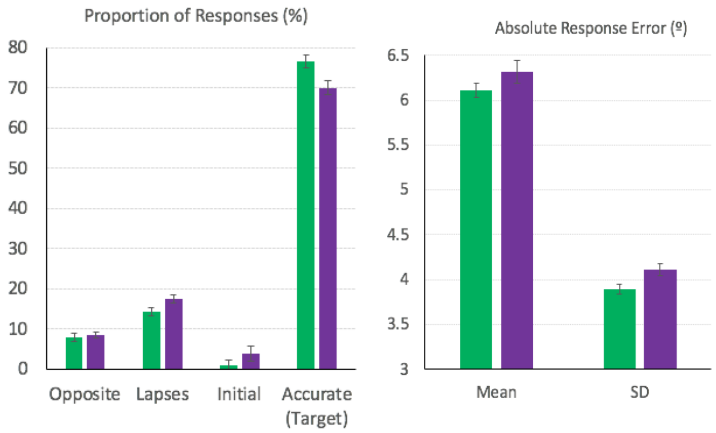
SAMPLE 1 (HCS, N=36; PSZ=48)

a) Proportion of responses

	t	p	Cohen's d
P.Target	1.83	0.07	0.40
P.Lapses	-1.36	0.18	-0.05
P.Opp	-0.21	0.84	-0.30
P.Init	-2.28	0.03	-0.44

b) Absolute Response Error

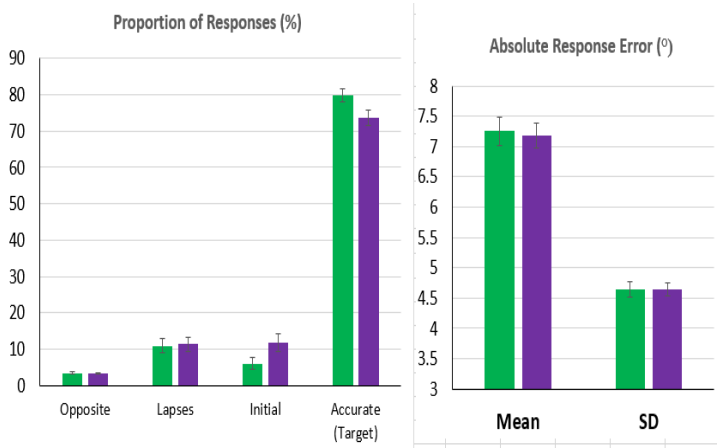
	t	p	Cohen's d
Mean	-1.334	0.19	-0.294
SD	-1.296	0.20	-0.287



SAMPLE 2 (HCS, N=34; PSZ=42)

	t	p	Cohen's d
	2.32	0.02	0.53
	-0.20	0.84	-0.05
	0.009	0.99	0.00
	-1.98	0.05	-0.45

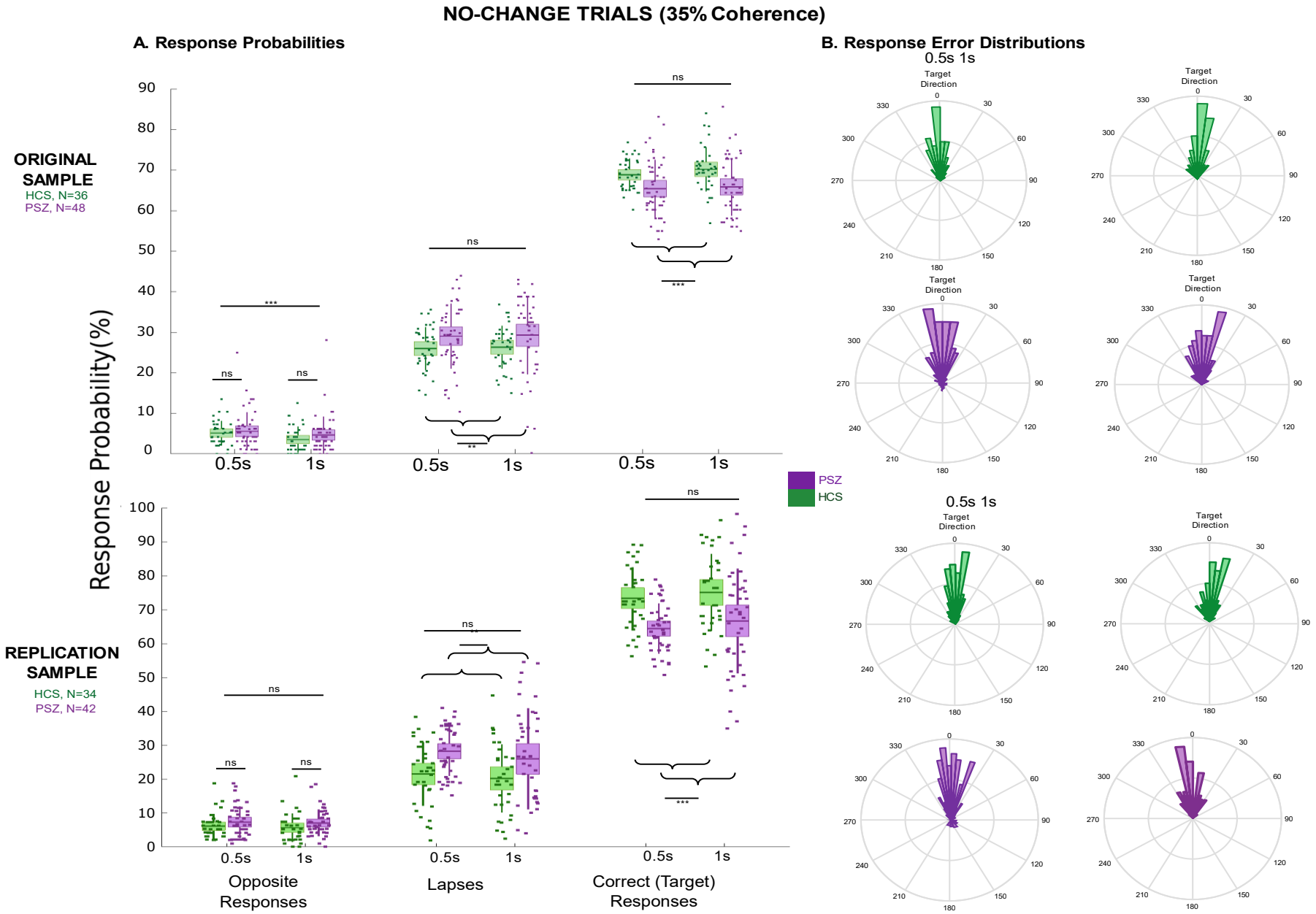
	t	p	Cohen's d
	0.21	0.83	0.05
	-0.06	0.95	-0.01



In brief, for the no-change 100% coherence condition, proportion of responses to the target were lower for PSZ(main effect of group in both samples), lower when the stimulus was presented for a shorter time (main effect of duration in Sample 1, p=0.11 in Sample 2), but the duration by group interaction was not significant in either Sample. In Sample 1, we observed a higher proportion of responses made opposite to the correct motion direction when the stimulus was presented for a shorter time, and in both samples, PSZ had higher lapse rates overall, regardless of duration of presentation(main effect of group, nonsignificant duration X group interaction). With regard to the precision measures, in both samples, we observed an overall main effect of group, whereby PSZ had more variability in their responses (as indicated by higher SDs).

For the 100% coherence change trials, the two main between group observations, consistent across both samples, were a lower proportion of responses centered around the correct motion direction(I.e. the changed direction of motion at the end of the trial) in PSZ(p=0.07 ad p=0.02) and the proportion of responses centered around initial motion direction was significantly higher in PSZ(p=0.03 and p=0.05).

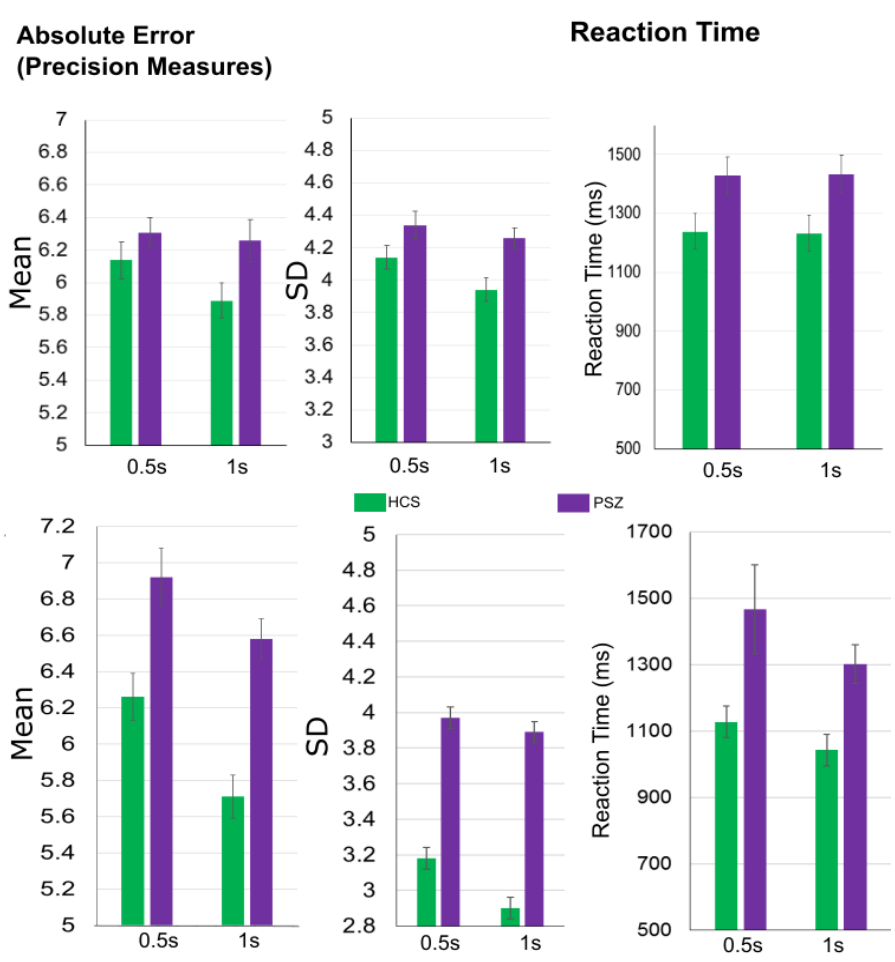
eMethods 5. No-Change Trials (35%)



A. Response Probabilities for 35% No-Change trials: In this figure these proportions are displayed for each duration(0.5s trials and 1s) of motion RDK display. Each filled circle represents the proportion for a single subject. These points are layed over a 1.96 SEM (95% confidence interval) in the boxplot and over a 1 SD vertical line, with mean group proportion indicated as a horizontal line within each boxplot. Data for PSZ is displayed in purple, while that for HCS in green. The top panel displays proportions for the original sample, while the lower panel for the replication sample. Here we observe that, for both samples, PSZ had a lower proportion of responses centered on the target direction and had more lapses. **B. Response error distributions**: On each trial, behavioral performance was quantified as the response error (the angular difference between the true motion direction and the reported motion direction). The roseplots here show the distributions of response errors for each group for the no-change trials. The roseplots have been rotated so the target motion direction appears at the top (12 o'clock) position. The vast majority of response errors were clustered around 0°. The four roseplots in the top panel display distributions (HCS and PSZ, respectively) for the original sample, while the four roseplots in the lower panel for the replication sample.

eMethods 6. Results for 35% Coherence No-Change Trials

		SAMPLE 1			SAMPLE 2		
a) Proportion of responses		F	p	η^2_p	F	p	η^2_p
P.Target							
	Duration	3.67	0.06	0.04	1.58	0.21	0.02
	Duration ✻ Group	0.65	0.42	0.01	0.04	0.84	0.00
	Group	18.81	**< .001**	0.19	17.01	**< .001**	0.19
P.Opposite							
	Duration	14.18	**< .001**	0.15	0.44	0.51	0.01
	Duration ✻ Group	0.95	0.33	0.01	0.05	0.83	0.00
	Group	0.90	0.35	0.01	2.46	0.12	0.03
P.Lapses							
	Duration	0.29	0.59	0.00	1.26	0.27	0.02
	Duration ✻ Group	1.34	0.25	0.02	0.09	0.77	0.00
	Group	7.65	**0.01**	0.09	10.34	**0.00**	0.12
b) Absolute Response Error		F	p	η^2_p	F	p	η^2_p
Mean							
	Duration	2.68	0.11	0.03	15.52	**<.001**	0.17
	Duration ✻ Group	1.15	0.29	0.01	0.85	0.36	0.03
	Group	4.27	**0.04**	0.05	14.81	**<.001**	0.01
SD							
	Duration	3.63	0.06	0.04	11.73	**0.00**	0.14
	Duration ✻ Group	0.69	0.41	0.01	3.39	0.07	0.04
	Group	10.50	**0.002**	0.11	164.00	**<.001**	0.69
		F	p	η^2_p	F	p	η^2_p
Overall Reaction Time							
	Duration	0.001	0.97	0.00	2.83	0.10	0.04
	Duration ✻ Group	0.05	0.82	0.00	0.29	0.59	0.00
	Group	4.76	**0.03**	0.06	6.00	**0.02**	0.07

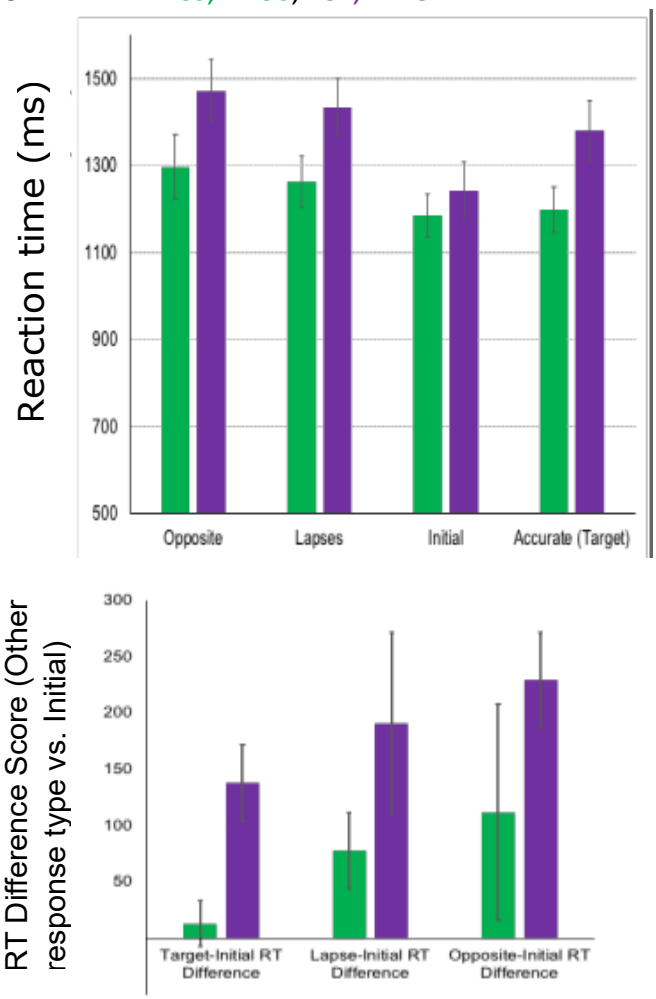


In both samples, (See Figure, section V, Top and Bottom) we found that the proportion of responses centered around the target(accurate) was slightly higher when the motion RDK was presented for longer (1s vs. 0.5s trials), and higher for HCS than for PSZ. In terms of aligning the mouse in the correct direction bin, both groups benefitted equally from a longer display than PSZ as evidenced by lack of a significant Duration X Group interaction. As can be seen in section A of the figure, top panel, both groups had significantly higher proportions of opposite-direction reports for 0.5s versus 1s trials (main effect of duration, Sample 1),and PSZ slightly more so, but neither the main effect of group($p=0.35$), nor the duration X group interaction effect($p=0.33$) reached significance. In both samples, PSZ manifested a higher probability of lapses(Figure panel A, center) than HCS overall (significant main effect of group), but the duration of stimulus presentation did not have an effect on lapse rate in either group(neither the main effect of duration nor duration X group interaction effect were significant).

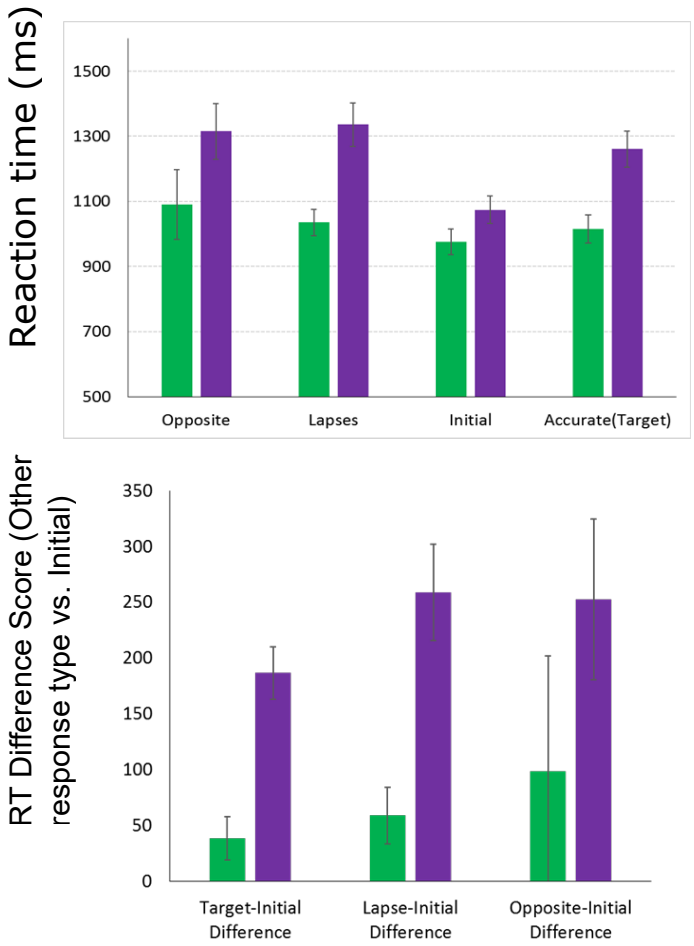
- Panel A of the figure above displays the absolute error(derived as the absolute magnitude of angular deviation between reported motion direction and the true motion direction) mean and standard deviation(SD) for 0.5s and 1s trials. In Sample 1 (Top half, Panel A), the pattern of results was similar for both measures, whereby PSZ were less precise (greater error magnitude and standard deviation)(main effect of Group for both measures), and more so for 0.5s trials, but neither duration, nor the duration X group interaction effect reached significance). In Sample 2, duration had an effect on precision such that both groups were more precise for longer stimulus presentations (In addition to main effect of group, there was a main effect of duration for both absolute error and standard deviation).
- Reaction Time: As displayed in Panel B, in both samples (top and bottom part of figure), PSZ were slower than HCS in making a perceptual judgement about motion direction, regardless of duration of presentation (significant main effect of group, no significant effect of duration, nor duration X group interaction effect.

eMethods 7. Reaction Times for 35% Change Trials

SAMPLE 1 HCS, N=36, PSZ,N=48



SAMPLE 2 HCS, N=34, PSZ,N=42



eMethods 8. Discussion of Correlations

Cognitive Measures: People with schizophrenia are impaired on a wide range of cognitive tasks. We administered Two standardized neuropsychological measures were administered to examine current and premorbid cognitive functioning in PSZ and HCS: (1) parts of the MATRICS Consensus Cognitive Battery(MCCB) and (2) the Reading Subtest of the Wide Range Achievement Test 4 (WRAT).
In the Original Sample, Reaction times were negatively associated with the Processing Speed domain of the MCCB, and lapse rates were negatively associated with WRAT, used as an estimate of premorbid IQ.
In the replication sample, interestingly, accuracy in terms of proportion of responses centered around the target (changed) direction was associated with the Working memory domain of the MCCB as well as with premorbid IQ. While these relationships between task measures and standard assessments of neurocognitive function in our study are exploratory, a more nuanced examination of various cognitive functions would be necessary to dissect interactions between cognition and perceptual aberrances reported here. For example, future work using motion perception tasks could potentially include a delay/retention period to assess the impact of working memory along with the effect of task-based priors. That said, we believe our task is beneficial in examining perceptual performance which is not so heavily influenced by reported deficits in learning, memory, executive function, etc.

Other clinical factors:
To determine the effect of medication on the performance, we examined whether the task measures (*namely: Proportion of Responses centered around initial motion direction; Proportion of responses centered around correct(changed) motion direction; absolute mean error around accurate trials ; proportion of responses centered around the target(changed) direction in 0.5s duration No-change trials proportion of responses*), and the dose of antipsychotic drugs (CPZ equivalent) were correlated and did not find significant relations between these variables in both samples, suggesting that patients' impaired performance in the motion tasks are not attributable to antipsychotic drugs. This is in accordance with the findings of Chen et al. (2004), where they found that accuracy of detecting the direction of coherent motion was not associated with antipsychotic medications. Similar to Chen et al., we also found no significant correlation between duration of illness and task performance in the patients.

eTable 1. Sample 1 PSZ Correlations

		RT for Correct Resp	RT for Init Resp	P.Targ	P.Init	P.Lapse	Mean abs error	P.Targ NoChange	MD WM	MD ProcSpd	WRAT	PDI Conv	PDI Pre	Total PDI	BPRS RealDist	BPRS Neg	BPRS Disorg	BPRS Total	Total CPZ	DOI*
RT for Correct Resp	Pearson's r	—																		
	p-value	—																		
RT for Init Resp	Pearson's r	***0.87***	—																	
	p-value	***< .001***	—																	
P.Targ	Pearson's r	**-0.29**	-0.27	—																
	p-value	**0.05**	0.07	—																
P.Init	Pearson's r	0.15	0.14	**-0.41**	—															
	p-value	0.30	0.36	**0.00**	—															
P.Lapse	Pearson's r	-0.05	-0.01	-0.09	-0.26	—														
	p-value	0.73	0.94	0.53	0.08	—														
Mean abs Error	Pearson's r	-0.23	-0.21	-0.06	0.04	0.25	—													
	p-value	0.11	0.17	0.71	0.81	0.09	—													
P.Targ NoChange	Pearson's r	-0.09	-0.05	0.20	-0.10	-0.03	0.06	—												
	p-value	0.55	0.71	0.18	0.51	0.83	0.68	—												
MD WM	Pearson's r	0.08	-0.06	-0.15	0.14	-0.22	-0.15	-0.15	—											
	p-value	0.59	0.70	0.31	0.35	0.14	0.34	0.33	—											
MD ProcSpd	Pearson's r	***-0.31***	***-0.35***	-0.05	0.24	-0.25	0.15	-0.21	0.44	—										
	p-value	***0.04***	***0.02***	0.77	0.12	0.09	0.34	0.16	0.00	—										
WRAT	Pearson's r	-0.04	-0.05	-0.10	0.09	**-0.44**	0.09	-0.16	-0.09	0.14	—									
	p-value	0.78	0.75	0.51	0.55	**0.00**	0.57	0.29	0.57	0.36	—									
PDI Conv	Pearson's r	-0.13	-0.11	-0.03	***0.30***	-0.09	0.12	-0.17	0.08	0.08	0.10	—								
	p-value	0.41	0.49	0.86	***0.05***	0.54	0.44	0.25	0.62	0.61	0.49	—								
PDI Pre	Pearson's r	-0.02	0.02	0.14	0.24	-0.11	0.28	-0.13	-0.12	-0.04	0.16	0.67	—							
	p-value	0.92	0.89	0.38	0.12	0.46	0.07	0.39	0.42	0.78	0.31	< .001	—							
Total PDI	Pearson's r	-0.05	0.02	0.17	0.03	-0.14	0.00	0.09	-0.25	-0.13	0.10	0.35	0.38	—						
	p-value	0.75	0.92	0.28	0.86	0.36	0.98	0.57	0.10	0.40	0.52	0.02	0.01	—						
BPRS RealDist	Pearson's r	-0.01	0.10	-0.05	***0.35***	-0.38	-0.01	-0.09	-0.02	0.17	0.11	0.35	0.27	0.04	—					
	p-value	0.95	0.52	0.75	***0.02***	0.01	0.94	0.56	0.91	0.26	0.45	0.02	0.08	0.79	—					
BPRS Neg	Pearson's r	0.02	0.05	-0.54	-0.03	-0.05	0.01	0.07	0.07	-0.19	-0.05	-0.04	0.01	0.11	-0.12	—				
	p-value	0.88	0.73	< .001	0.85	0.72	0.97	0.65	0.64	0.22	0.73	0.79	0.95	0.47	0.43	—				
BPRS Disorg	Pearson's r	0.14	0.19	-0.33	-0.14	0.12	0.00	-0.24	0.10	-0.04	-0.25	0.00	-0.16	0.01	-0.12	0.51	—			
	p-value	0.34	0.19	0.02	0.36	0.40	0.98	0.11	0.50	0.81	0.09	0.98	0.30	0.94	0.40	< .001	—			
BPRS Total	Pearson's r	-0.09	-0.14	0.04	0.10	-0.02	-0.03	0.26	-0.28	0.07	0.08	0.17	0.19	0.10	0.29	-0.05	-0.01	—		
	p-value	0.53	0.34	0.81	0.51	0.87	0.82	0.08	0.06	0.65	0.59	0.27	0.23	0.52	0.05	0.75	0.93	—		
Total CPZ	Pearson's r	-0.18	-0.24	-0.11	0.09	0.08	0.19	0.10	0.05	-0.03	-0.16	-0.22	-0.14	-0.07	-0.22	0.08	-0.08	-0.17	—	
	p-value	0.24	0.13	0.48	0.57	0.60	0.24	0.54	0.75	0.83	0.32	0.19	0.40	0.66	0.15	0.60	0.61	0.28	—	
DOI*	Pearson's r	-0.11	0.07	0.14	0.13	-0.03	0.03	0.17	0.2	0.07	-0.38	0.14	0.17	-0.28	0.2	0.05	0.1	-0.15	-0.04	—
	p-value	0.58	0.74	0.46	0.51	0.9	0.9	0.4	0.33	0.74	0.05	0.49	0.39	0.16	0.31	0.78	0.61	0.43	0.86	—

P.Init= Responses centered around initial motion direction; **P.Targ**= Proportion of responses centered around correct(changed) motion direction; **P.Init**= Proportion of responses centered around initial motion direction; Mean abs error: Precision measure, absolute mean error around "accurate" trials (i.e. trials that were marked to be centered around changed/target motion direction);**P.Targ No change**=P.Target in 0.5s duration No-change trials **MD ProcSpd**= Processing Speed domain from MATRICS neurocognitive battery; **MD WM**= Working Memory domain from MATRICS neurocognitive battery; ;**WTAR**: Wide Range Achievement Test to assess current and premorbid cognitive functioning; **PDI Conviction**= Average conviction score associated with delusions from Peters Delusion Inventory; **PDI Preoccupation**= Average preoccupation score associated with delusions from Peters

Delusion Inventory; **Total PDI**=Peter's Delusions Inventory Total score; **Total CPZ**= Total Chlorpromazine Equivalent; **BPRS RealDist**= Reality Distortion factor from Brief Psychiatric Ratings Scale**; BPRS Neg**= Negative symptoms from Brief Psychiatric Ratings Scale; BPRS Disorg: Disorganization symptoms from BPRS; **BPRS Total**= Brief Psychiatric Ratings Scale total score**; DOI***= Duration of illness (This information was available for 28 PSZ)

eTable 2. Sample 2 PSZ Correlations

		RT for Correct Resp	RT for Init Resp	P.Targ	P.Init	P.Lapse	Mean abs error	P.Targ NoChange	MD WM	MD ProcSpd	WRAT	PDI Conv	PDI Pre	Total PDI	BPRS RealDist	BPRS Neg	BPRS Disorg	BPRS Total	Total CPZ	DOI
RT for Correct Resp	Pearson's r	—																		
	p-value	—																		
RT for Init Resp	Pearson's r	***0.92***	—																	
	p-value	***< .001***	—																	
P.Targ	Pearson's r	0.11	0.08	—																
	p-value	0.47	0.6	—																
P.Init	Pearson's r	-0.11	-0.08	**-0.87**	—															
	p-value	0.5	0.61	**< .001**	—															
P.Lapse	Pearson's r	-0.03	-0.06	**-0.67**	0.35	—														
	p-value	0.86	0.69	**< .001**	0.02	—														
Mean abs Error	Pearson's r	-0.08	-0.14	-0.01	0	-0.06	—													
	p-value	0.62	0.37	0.94	0.97	0.72	—													
P.Targ NoChange	Pearson's r	0.04	0.02	0.08	-0.04	0.17	0	—												
	p-value	0.8	0.91	0.64	0.82	0.28	1	—												
MD WM	Pearson's r	*0.19*	*0.14*	**0.49**	-0.36	-0.35	0.04	0.05	—											
	p-value	*0.23*	*0.37*	**0.00**	0.02	0.03	0.8	0.75	—											
MD ProcSpd	Pearson's r	0.25	0.22	0.23	-0.09	-0.19	-0.27	0.18	0.73	—										
	p-value	0.16	0.22	0.21	0.61	0.3	0.13	0.33	< .001	—										
WRAT	Pearson's r	0.17	0.11	**0.34**	*-0.31*	-0.29	0	-0.15	0.59	0.6	—									
	p-value	0.35	0.56	**0.05**	*0.09*	0.11	0.99	0.42	< .001	< .001	—									
PDI Conv	Pearson's r	0.08	0.17	-0.24	**0.32**	-0.05	0.02	-0.02	-0.32	-0.27	-0.3	—								
	p-value	0.62	0.29	0.15	**0.04**	0.77	0.89	0.92	0.05	0.15	0.11	—								
PDI Pre	Pearson's r	0.1	0.12	0.31	-0.2	-0.18	-0.16	0.01	0.18	0.33	0.15	0.34	—							
	p-value	0.53	0.49	0.06	0.21	0.28	0.32	0.93	0.29	0.08	0.45	0.03	—							
Total PDI	Pearson's r	-0.11	-0.04	-0.01	*0.13*	-0.13	-0.26	-0.07	-0.07	-0.05	-0.22	0.06	0.19	—						
	p-value	0.51	0.8	0.93	*0.44*	0.43	0.11	0.67	0.67	0.8	0.25	0.72	0.24	—						
BPRS RealDist	Pearson's r	-0.06	-0.09	**-0.46**	**0.55**	0.21	-0.17	-0.03	-0.31	-0.08	-0.22	-0.01	-0.21	0.32	—					
	p-value	0.74	0.61	**0.01**	**< .001**	0.23	0.33	0.85	0.08	0.7	0.28	0.95	0.24	0.06	—					
BPRS Neg	Pearson's r	-0.11	-0.08	-0.21	0.01	0.15	0.08	-0.07	-0.33	-0.52	-0.27	0.08	-0.29	-0.22	-0.08	—				
	p-value	0.55	0.64	0.23	0.94	0.38	0.64	0.7	0.06	0.01	0.17	0.65	0.1	0.22	0.66	—				
BPRS Disorg	Pearson's r	0.19	0.19	-0.31	0.14	0.3	-0.17	0.12	-0.16	-0.15	-0.21	-0.21	-0.34	0.2	0.17	0.44	—			
	p-value	0.26	0.27	0.07	0.43	0.08	0.33	0.47	0.37	0.46	0.29	0.24	0.05	0.26	0.35	0.01	—			
BPRS Total	Pearson's r	-0.06	-0.03	-0.34	0.31	0	0.01	-0.14	-0.25	-0.37	-0.37	-0.13	-0.34	0.39	0.45	0.55	0.7	—		
	p-value	0.75	0.89	0.05	0.07	0.98	0.95	0.44	0.17	0.06	0.06	0.46	0.06	0.03	0.01	< .001	< .001	—		
Total CPZ	Pearson's r	-0.19	-0.15	-0.23	0.21	0.13	-0.25	0.28	-0.28	-0.04	-0.51	0.19	-0.14	-0.11	0.16	0.31	0.83	0.61	—	
	p-value	0.38	0.5	0.3	0.34	0.56	0.25	0.19	0.19	0.85	0.02	0.39	0.53	0.63	0.51	0.17	< .001	0	—	
DOI	Pearson's r	-0.03	-0.05	0.01	-0.13	-0.12	0	0.06	-0.2	0.35	0.12	-0.16	-0.08	0.07	-0.12	-0.02	0.25	0.08	0.39	—
	p-value	0.85	0.76	0.96	0.41	0.45	0.98	0.71	0.23	0.05	0.52	0.35	0.62	0.68	0.49	0.92	0.16	0.64	0.07	—

P.Init= Responses centered around initial motion direction; **P.Targ**= Proportion of responses centered around correct(changed) motion direction; **P.Init**= Proportion of responses centered around initial motion direction**; Mean abs error:** Precision measure, absolute mean error around "accurate" trials (i.e. trials that were marked to be centered around changed/target motion direction);**P.Targ NoChange**=P.Target in 0.5s duration No-change trials **MD**

ProcSpd= Processing Speed domain from MATRICS neurocognitive battery**; MD WM**= Working Memory domain from MATRICS neurocognitive battery; ;**WTAR**: Wide Range Achievement Test to assess current and premorbid cognitive functioning; **PDI Conviction**= Average conviction score associated with delusions from Peters Delusion Inventory; **PDI Preoccupation**= Average preoccupation score associated with delusions from Peters Delusion Inventory; **Total PDI**=Peter's Delusions Inventory Total score; **BPRS RealDist**= Reality Distortion factor from Brief Psychiatric Ratings Scale; **BPRS Neg**= Negative symptoms from Brief Psychiatric Ratings Scale**; BPRS Disorg**: Disorganization symptoms from BPRS; **BPRS Total**= Brief Psychiatric Ratings Scale total score; ; Total CPZ= Total Chlorpromazine Equivalent**; DOI**= Duration of Illness