

Perceptual organization and its visual subcomponents in schizophrenia and schizotypy: A systematic review

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ABSTRACT

Perceptual organization (PO) deficits have long been considered a hallmark of schizophrenia (SZ), reflecting disruptions in the integration of visual information. This systematic review critically evaluates the behavioral evidence for PO impairments in SZ and individuals with high schizotypal traits, focusing on three key mid-level processes: contour integration, perceptual grouping, and figure-ground segmentation. Forty-four studies were included, identified through a systematic search and evaluated for bias using the QUADAS-2 tool.

Findings reveal robust and replicable deficits in contour integration among individuals with SZ, especially in those with disorganization symptoms, suggesting impaired lateral interactions in early visual areas. Perceptual grouping deficits were also prominent but appeared more sensitive to cognitive load and stimulus complexity, consistent with top-down integration failures. Figure-ground segmentation impairments were less consistently reported and often dependent on task demands, emerging more clearly under challenging conditions.

In schizotypy, evidence of PO deficits was more variable. Some studies identified subtle impairments in contour integration and grouping, particularly under high attentional load or in individuals with disorganized traits, while others reported intact performance. The heterogeneity of methods across studies, particularly differences in stimulus type, complexity, and grouping cues, was a major limiting factor for cross-study comparisons.

Findings from this review support a dimensional view of PO deficits, where specific symptom clusters, rather than diagnosis alone, predict perceptual dysfunction. PO impairments, particularly in contour integration, may serve as sensitive cognitive markers for early detection and targeted intervention in SZ-spectrum disorders.

1. Introduction

In our complex and diverse world, people engage with multiple streams of information simultaneously. For most, this process occurs effortlessly, without awareness of the information being integrated. The concept of Perceptual Organization (PO) has been put forward to describe how the perceptual system dynamically combines raw sensory data into higher-level and coherent representations, so that instead of experiencing isolated sensory elements (such as patches of color or lines), we perceive coherent objects and scenes (Feldman, 2003; Peterson and Kimchi, 2013; Wagemans et al., 2012). PO is concerned with intermediate stages of visual processing that transform distributed visual inputs into spatially extended and behaviorally meaningful units, allowing us to experience structured environments and effectively interact with the world. It can be divided into grouping and segregating

mechanisms (Pomerantz, 1981; Reisberg, 2013) with key components including contour integration, figure-ground segmentation, and perceptual grouping. These processes operate at a level beyond basic feature detection but prior to object recognition and semantic interpretation, making them central to surface-based perception and interaction with the environment.

Perceptual grouping involves organizing visual elements into larger, meaningful units, or wholes. Historically, the grouping principles were introduced by Wertheimer (1923) and further developed by Köhler (1929) and Koffka (1935). Some of the main Gestalt principles are: proximity (elements that are close together tend to be grouped), similarity (elements sharing visual features are grouped), common fate (elements that move in the same direction are grouped), closure (incomplete figures are perceived as complete), and figural goodness or prägnanz (the tendency to perceive the simplest, most regular, and

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symmetrical forms) (Koffka, 1935; Palmer, 1992; Treisman, 1982).

Contour integration is a specific case of grouping and refers to the ability to detect and integrate edge segments into a continuous contour (Field, 1987; Hess et al., 2003), a process critical for identifying object boundaries in natural scenes. It relies on principles such as good continuation, proximity, and smoothness, enabling the visual system to find a consistent path, even when gaps or noise are present (Wagemans et al., 2012).

Figure-ground segmentation is the process of distinguishing between a foreground object (the “figure”) and its background (the “ground”) (Rubin, 2001). This process depends on depth cues (i.e. binocular disparity) and other spatial factors such as convexity, symmetry, and surroundedness to determine which regions are assigned to the foreground and which to the background, enabling image segmentation (Bertamini and Lawson, 2008; Field et al., 1993; Kovács and Julesz, 1993). Fig. 1 shows examples of experimental tasks investigating these subcomponents. It is important to note that contour integration, figure-ground segmentation, and perceptual grouping are not independent. At the same time, the division into subcomponents (Wagemans

et al., 2012) is helpful to understand how different processes interact and together contribute to PO.

These mechanisms operate effortlessly in healthy individuals. However, in some clinical populations PO has been shown to be different compared to controls. One such condition is schizophrenia. Schizophrenia (SZ) is widely recognized as a cognitive disorder (Elvevag and Goldberg, 2000; Kahn and Keefe, 2013), with deficits in multisensory perception (Ross et al., 2007), memory (Park and Holzman, 1992; Stone et al., 1998), attention (Cornblatt and Keilp, 1994; Luck and Gold, 2008) and speech (DeLisi, 2001), which collectively contribute to a decline in everyday functioning. Research has also shown that people on the SZ spectrum experience difficulties in the integration of different visual events (Chey and Holzman, 1997; Schwartz Place and Gilmore, 1980; Silverstein et al., 2000; Silverstein and Keane, 2011), with a prevalence of 40–62% (Phillipson and Harris, 1985). These difficulties have been reported in individuals at high risk of developing the disorder as well, such as siblings and offspring of people with a diagnosis of SZ (de la Serna et al., 2011), as well as in people with high schizotypal traits (Mason et al., 2004; Panton et al., 2016), although the effects in these groups are more moderate (Ettinger et al., 2015; Panton et al., 2016).

While much of the existing literature acknowledges impairments in PO among individuals with SZ, the specificity of deficits across distinct processes of PO is often overlooked. For example, the latest meta-analysis has shown that deficits in PO are not universally present across all paradigms and task designs (Panton et al., 2016). Performance on tasks requiring figure-ground segmentation, such as the Embedded Figures Test (EFT; Happé, 2021; Witkin et al., 1971), varies depending on the level of task complexity and the specific population under investigation, with some high-risk groups showing comparable or even enhanced performance. Similarly, Kim et al. (2005) found no differences between SZ patients and controls in a contour integration task, contrasting with earlier findings by Silverstein et al. (2000), which reported strong deficits in SZ patients under similar conditions. The use of different stimuli, such as Gabors versus lines, and variations in design (staircase versus four-alternative forced-choice), were proposed as contributing factors to these discrepancies, suggesting that methodological factors can influence whether deficits are observed.

PO sits at a mid-level within the visual processing hierarchy, bridging the gap between basic feature detection and higher-level functions like object recognition. This makes it difficult to establish whether PO deficits arise from low-level or high-level disruptions, as PO tasks engage both local and global processing (Wagemans et al., 2012). By focusing specifically on contour integration, perceptual grouping, and figure-ground segmentation, this review targets the three subcomponents that most directly implement mid-level operations: binding local edges into extended contours, assembling elements into coherent units, and assigning borders to figure or ground. These processes were selected because they share a common functional role: transforming local visual signals into coherent surfaces and object-level representations that directly support interaction with the environment. This focus allows us to synthesize evidence across paradigms while avoiding confounds from earlier sensory mechanisms or higher-level semantic processes, thereby clarifying what is disrupted in visual integration in schizophrenia-spectrum conditions and why. This level of specificity does not by itself localize deficits to either low-level or high-level processing, but it constrains the space of plausible explanations by identifying which mid-level integrative operations are selectively affected. Recent evidence points out that individuals with psychotic-like experiences exhibit imprecision in both top-down and bottom-up processes during perceptual decision-making, suggesting that disruptions can occur at multiple levels (Goodwin et al., 2023), but consensus still lacks about the relative contribution of these disturbances to specific stages of PO (Goodwin et al., 2025).

Another important question addressed in this review is how consistently PO deficits extend beyond clinical manifestations of SZ to non-clinical expression of vulnerability. We examine evidence from studies

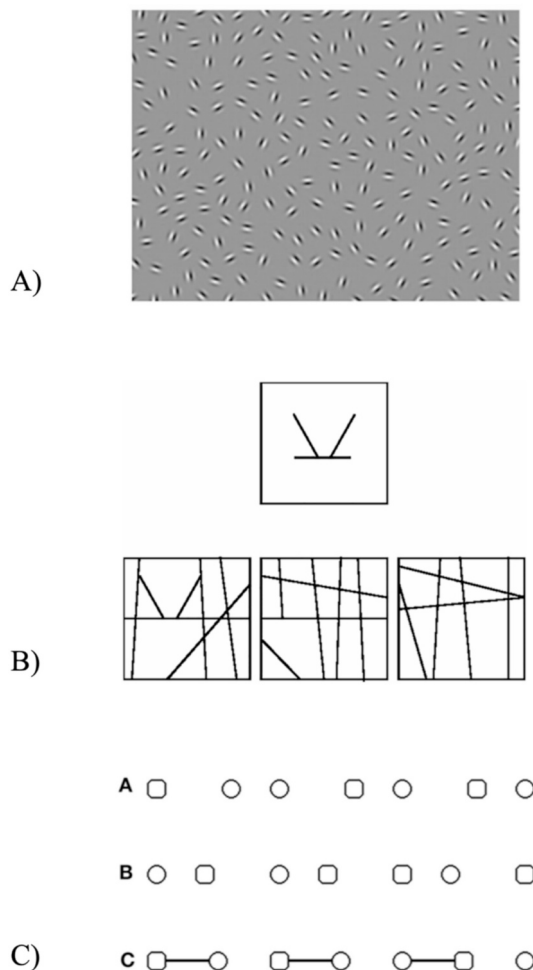


Fig. 1. Examples of experimental tasks assessing the three Perceptual Organization processes examined in this review. A) Contour integration task (Feigenson et al., 2014a, 2014b): participants are asked to detect or discriminate a rounded contour formed by aligned elements embedded in a background of randomly oriented Gabors. B) Figure-ground segmentation demonstrated by the Embedded Figures Task (EFT) (Favrod et al., 2022): participants are asked to locate a simple shape (e.g., triangle, square) hidden within a series of line drawings. C) Grouping based on the Gestalt principle of similarity (Giersch et al., 2012): participants are asked to identify rows or columns of items that group together based on shared visual features (e.g., shape).

of schizotypy, which reflects a continuum of personality traits distributed in the general population and is conceptualized as a dimensional, trait-like expression of liability rather than a clinical risk state (Debbané and Barrantes-Vidal, 2015; Nelson et al., 2013). This allows investigation of whether perceptual alterations associated with SZ are detectable in individuals who do not present psychotic symptoms and who function within the non-clinical range.

Schizotypy is distinct from clinical high-risk (CHR) or ultra-high risk (UHR) states, which are defined in clinical settings by attenuated or transient psychotic symptoms, brief psychotic episodes, or genetic risk plus functional decline (Fusar-Poli et al., 2013; Yung et al., 2003, 2006). Because CHR/UHR individuals already exhibit subthreshold psychotic features and show elevated rates of transition to SZ, they are closer to the clinical end of the spectrum and less informative for testing models that posit a broad, continuous distribution of schizophrenia-related liability across the population (Debbané and Barrantes-Vidal, 2015; Mason, 2015).

By focusing on schizotypy, the present reviews aims at investigating whether PO deficits are detectable in the general population, where liability is expressed as stable, trait-like variation rather than as early clinical symptoms (Flückiger et al., 2019). Although schizotypy is not synonymous with clinical risk, longitudinal population studies indicate that higher levels of schizotypal traits are associated with an increased probability of later schizophrenia-spectrum diagnoses, particularly over long time horizons (Chapman et al., 1994; Gooding et al., 2005; Kwapil et al., 2013). At the same time, schizotypy adds limited predictive value for short-term transition to psychosis in CHR/UHR samples (Debbané and Barrantes-Vidal, 2015; Mason et al., 2004), reinforcing the distinction between trait liability and clinical risk states. This supports the view that schizotypy indexes shared vulnerability at a subclinical level, without implying imminent transition or diagnostic equivalence. From this perspective, demonstrating PO deficits in schizotypy provides a more stringent and theoretically informative test of the continuum hypothesis than findings in CHR/UHR samples, where such deficits would be more expected (Bang et al., 2019).

Finally, a challenge of describing PO deficits comes from the heterogeneity of SZ. SZ includes subgroups with distinct cognitive-perceptual profiles, making it likely that people with little symptom overlap share the same diagnosis (Andreasen, 1999; Bentall, 2013). This has led to increasing interest in moving beyond categorical comparisons and considering how specific symptom clusters may differentially affect perceptual processes. Rather than viewing PO deficits as a characteristic of the entire diagnostic category, it might be more informative to determine how specific symptom clusters, such as cognitive disorganization or negative symptoms, are associated with specific PO deficits. This perspective aligns with the growing recognition that SZ represents a collection of subtypes, each with a unique underlying pathophysiology, premorbid functioning and illness phase (Dollfus et al., 1996; Weickert et al., 2013). For example, patients with poor premorbid social functioning tend to show greater PO impairments than those with good premorbid functioning (Silverstein et al., 1996), and performance is typically worse during acute episodes than in remission, with improvements reported during inpatient treatment as disorganized symptoms resolve (Silverstein et al., 1996; Uhlhaas et al., 2005).

Earlier reviews have summarized research on PO in SZ. Uhlhaas and Silverstein (2005) emphasized that PO deficits are a consistent feature of SZ spectrum disorders, particularly in patients with disorganized symptoms, and argued that these impairments provide a window into abnormal interactions between early visual and higher-order processes. Silverstein and Keane (2011) built on this by reviewing evidence for the neural mechanisms and functional consequences of PO deficits, highlighting their impact on everyday functioning and their potential as candidate biomarkers. Panton et al. (2016) conducted a meta-analysis of Embedded Figures Tests, confirming moderate PO impairments in SZ and high-risk groups, though schizotypy findings were mixed. More recently, reviews of related constructs such as visuospatial context

processing have reinforced the relevance of visual integration deficits to SZ-spectrum conditions (Pokorny et al., 2025).

However, none of these reviews systematically compared different PO subcomponents or examined how findings converge or diverge across schizophrenia and schizotypy. In this review, we take a systematic approach that, for the first time, focuses specifically on three core subcomponents of PO (contour integration, perceptual grouping, and figure-ground segmentation) across both SZ and schizotypy. This broader perspective goes beyond earlier narrative reviews and complements narrower meta-analyses focused on single paradigms. In contrast to the narrower focus of recent meta-analyses on single task paradigms, our review adopts a broader lens, comparing evidence across different paradigms within each subcomponent. This approach allows us to provide a more integrated and up-to-date picture of how PO deficits manifest across the SZ spectrum.

Finally, researchers have long sought biomarkers for SZ (Freedman et al., 2005; Goldsmith et al., 2018; Szymanski et al., 1991; Weickert et al., 2013), but the disorder's heterogeneity complicates this goal (Tandon et al., 2013; Weickert et al., 2013). Rather than assuming a single marker, this review investigates whether PO deficits can reveal subgroups defined by shared perceptual and symptom profiles (Uhlhaas et al., 2005; Uhlhaas and Silverstein, 2005).

The present work has four main goals: (a) to identify specific PO subcomponent deficits in SZ; (b) distinguish low- vs. high-level processing impairments; (c) assess early markers in healthy individuals; (d) explore associations with symptom clusters. With these goals in mind, the review aims to provide a more comprehensive and integrated picture of PO deficits across the schizophrenia spectrum, clarifying both their specificity and their potential role as markers of vulnerability.

2. Methods

2.1. Eligibility criteria

This systematic review was conducted according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) recommendations (Page et al., 2021).

To be included, studies had to meet the following PICO criteria (Methley et al., 2014): (a) Population: adults with SZ or varying schizotypy levels using validated scales; (b) Intervention: behavioral tests on contour integration, figure-ground segmentation, or perceptual grouping; (c) Comparison: non-PO tasks, controls, or other clinical groups; (d) Outcome: performance fluctuations. Only articles written in English and published in peer-reviewed journals were included. We excluded studies (a) investigating PO without targeting any of the three subcomponents of interest; (b) focusing on perceptual modalities other than vision; (c) involving treatment strategies to restore visual perceptual abilities in impaired populations; (d) employing moving stimuli and/or complex higher-level stimuli, such as faces and other real-world objects; or (e) employing only neuroimaging or brain activity recording techniques in the absence of behavioral measures.

2.2. Search methodology

A literature search was conducted in April 2024 using PubMed and Scopus search engines. We only searched for articles published after 2000. The following terms were entered as index terms: “schizophrenia” or “schizotypy” and “perceptual organization”, “contour integration”, “figure ground segregation” or “figure ground segmentation” and “perceptual grouping” or “perceptual binding”. On Scopus, the document type filter was set to only include research papers. The online software Rayyan (Ouzzani et al., 2016) was used to store and manage the references and to automatically detect duplicates, which were then resolved manually by analyzing and comparing all of them. Two reviewers (R.C. and E.C.) independently screened article titles and abstracts produced from literature search. Conflicts in ratings were

discussed until agreement between reviewers was obtained, and in case of need for further confirmation, M.B. and A.G. were also involved in the decision.

2.3. Risk of bias evaluation

The risk of bias for the included studies was systematically evaluated using the QUADAS-2 tool, which assess diagnostic accuracy studies across four domains: *Patient Selection*, *Index Test*, *Reference Standard*, and *Flow and Timing* (Whiting et al., 2011). *Patient Selection* addresses how participants are recruited, emphasizing the need to avoid restrictive eligibility criteria and to use consecutive (all eligible patients as they present) or random (unbiased) sampling. In this domain, we also considered and discuss spectrum bias, which occurs when study samples do not capture the full range of illness severity, leading to distorted group differences (Rutjes et al., 2006; Whiting et al., 2011). *Index Test* considers the way the diagnostic test is administered and interpreted. *Reference Standard* examines the validity and consistency of the “gold standard” assessment, including whether it is applied independently of the *Index Test*. Lastly, *Flow and Timing* explores whether participants undergo the same *Reference Standard* within an appropriate interval and whether all eligible individuals are included in the final analyses. Collectively, these four domains explore how each study’s design might influence actual diagnostic performance (Whiting et al., 2011). Each domain was rated as having a “low,” “high,” or “unclear” risk, with additional evaluation of applicability for the first three domains. Detailed domain-specific assessments are summarized in Fig. 3.

3. Results

A total of 2221 publications from 2000 until April 2024 were retrieved (2079 from Scopus and 142 from PubMed). After duplicate removal using Rayyan software and manual screening, 1667 references remained. Titles and abstracts were then screened against our inclusion criteria, yielding 71 articles that were judged potentially eligible. At the full-text stage, studies were excluded if they (a) did not employ one of the three PO subcomponents as the main outcome, (b) focused exclusively on treatment effects, complex ecological stimuli (e.g., faces, natural scenes), or neuroimaging without behavioral measures, or (c) did not meet diagnostic/trait validation requirements. After applying these criteria, 44 studies were included in the final review. Fig. 3 presents the PRISMA flow diagram summarizing the selection process.

3.1. Risk of bias and applicability

3.1.1. Schizophrenia studies

A major limitation in SZ studies was the pervasive high risk of bias in **Patient Selection**, observed across most included studies. This was the result of the overuse of case-control designs that limited generalizability of findings (Liberati et al., 2009). Most samples came from outpatient convenience populations, who tend to be higher functioning, less symptomatic, and often without major comorbidities. In most cases this likely leads to an underestimation of deficits. In contrast, studies that recruited acutely ill inpatients may have overstated group differences compared to community-dwelling patients. This reflects spectrum bias (Rutjes et al., 2006), where recruitment captures only a narrow part of the illness spectrum and produces distorted effect estimates. **Index test** bias remained consistently low, reflecting validated diagnostic measures and predefined thresholds, consistent with prior findings on DSM-based frameworks’ reliability (Chmielewski et al., 2015). The **Reference Standard** domain was also generally low risk, although two studies were rated “unclear” due to insufficient reporting on diagnostic reliability (Whiting et al., 2011). **Flow and Timing** bias was minimal overall. The prevalent use of case-control designs likely inflated diagnostic accuracy through spectrum bias (Rutjes et al., 2006), raising concerns about generalizability to clinical populations with

comorbidities and subthreshold symptoms. A summary of the assessment can be found in Fig. 2A.

3.1.2. Schizotypy studies

Overall, schizotypy studies showed a low risk of bias across most domains. Two studies received “unclear” risk ratings in *Patient Selection* due to insufficient reporting. Additionally, Panton et al. (2018) was rated “unclear” in the *Index Test* domain due to ambiguity in diagnostic thresholds, indicating potential variability in schizotypy classification criteria. Nonetheless, the consistency of diagnostic procedures across most studies supports the reliability and applicability of findings in schizotypy research, suggesting good generalizability of findings. A summary of the assessment can be found in Fig. 2B.

3.2. Perceptual grouping

A total of 13 studies assessed perceptual grouping in individuals with SZ and schizotypal traits (Table 1). These studies examined how visual elements are combined into coherent structures based on principles such as proximity, similarity, closure, symmetry, and contextual modulation. Tasks included grouping by proximity (Kurylo et al., 2007), global form detection (Tadin et al., 2006), symmetry-based recall (Cestari et al., 2013), and visual search under grouped versus ungrouped conditions (Giersch et al., 2012; van Assche and Giersch, 2011).

Deficits in perceptual grouping were commonly reported in SZ, particularly among patients with disorganized symptoms. Uhlhaas et al. (2006) found substantial impairments across several Gestalt-based tasks in disorganized patients, which they linked to difficulties in the dynamic integration of contextually related visual information into coherent percepts. Silverstein et al. (2000) and Kéri et al. (2005) reported reduced grouping and contextual integration in chronic and unmedicated patients, respectively. Silverstein et al. (2006a, 2006b) additionally noted diminished top-down facilitation in more chronic patients, suggesting impaired higher-level modulation of grouping.

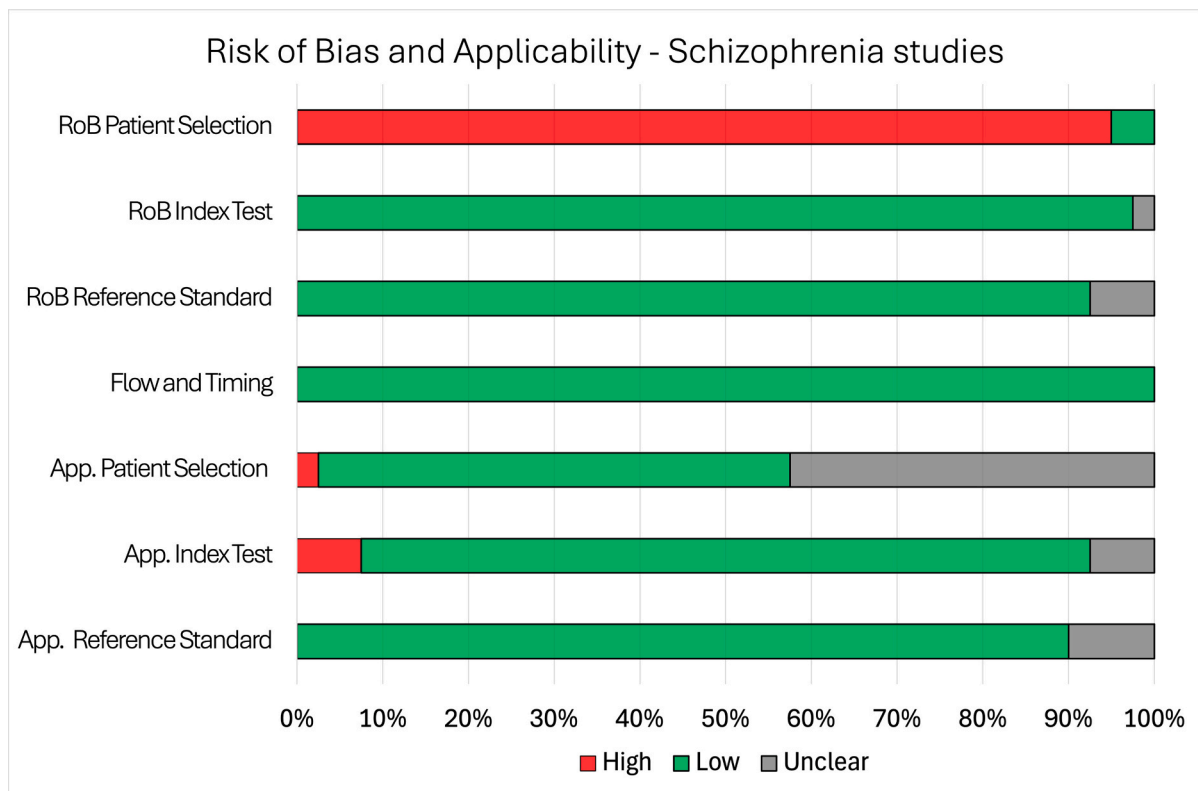
However, some studies found relatively preserved performance under specific conditions. Grouping by proximity or similarity appeared intact in certain samples, albeit with increased latencies or effort (Elahipanah et al., 2008; Giersch and Rhein, 2008). Choung et al. (2022) and van Assche and Giersch (2011) reported intact grouping when attentional load was low, but performance declined under increased demands, indicating attentional modulation of grouping abilities. Similarly, although Tadin et al. (2006) reported impaired contextual modulation in a motion-based task, performance on their static global form condition was preserved, suggesting that deficits may depend on the type and complexity of the stimulus.

No study of those included in this review directly examined perceptual grouping in schizotypy samples, leaving conclusions in this population tentative.

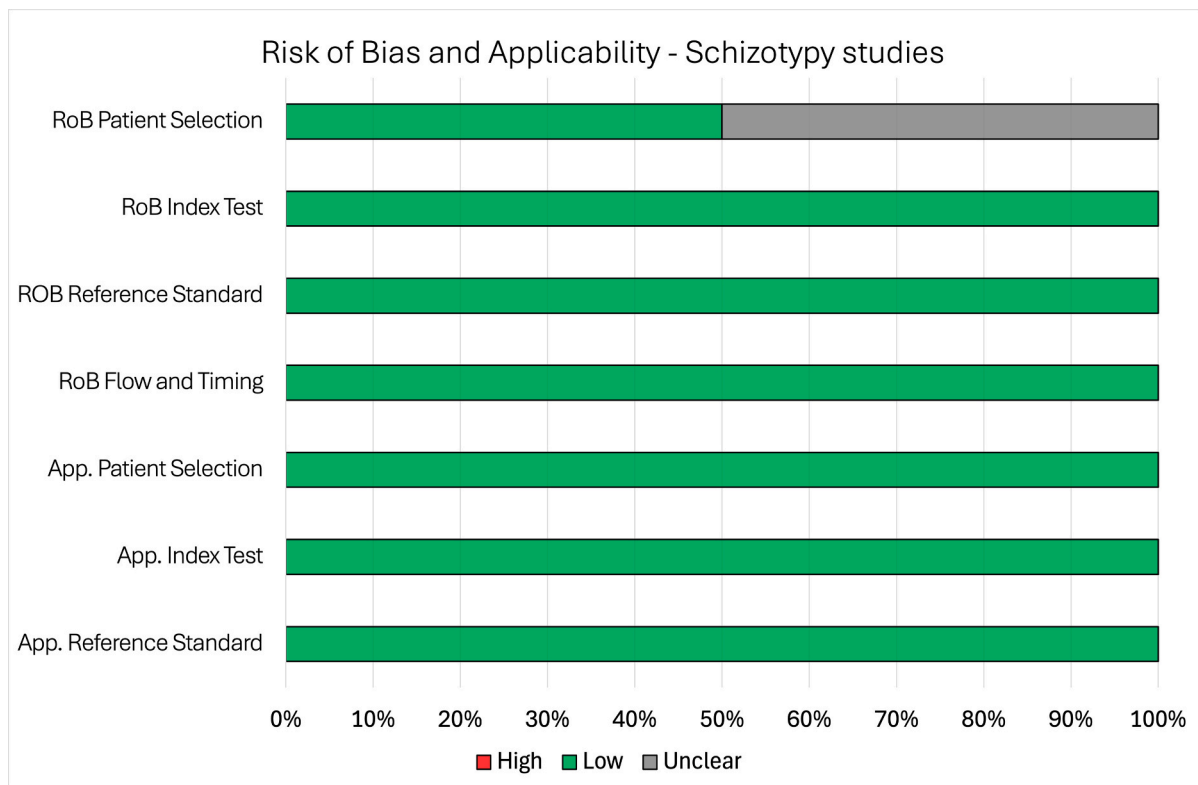
3.3. Contour integration

A total of 21 studies assessed contour integration in individuals with SZ and in schizotypy samples from the general population (see Table 1). These studies examined how fragmented visual elements are grouped into coherent contours, typically using Gabor patch arrays embedded in noise (Fig. 1A). Common paradigms included the Jittered Orientation Visual Integration (JOVI) task and contour localization methods (Feigenson et al., 2014a; Feigenson et al., 2014b; Türközer et al., 2019), while some studies manipulated spatial frequency (Keane et al., 2014a), inter-element spacing (Keane et al., 2012), or attentional demands (Giersch and Rhein, 2008) to isolate distinct stages of integration. These tasks primarily target lateral connectivity and contextual modulation mechanisms in early visual cortices (V1/V2) (Jayakumar et al., 2024; Kwon et al., 2015; Nygård et al., 2009).

Across studies, patients with SZ consistently exhibited contour integration impairments relative to healthy controls. Kozma-Wiebe et al.



(A)



(B)

Fig. 2. Risk of bias and applicability evaluation according to QUADAS 2 criteria.

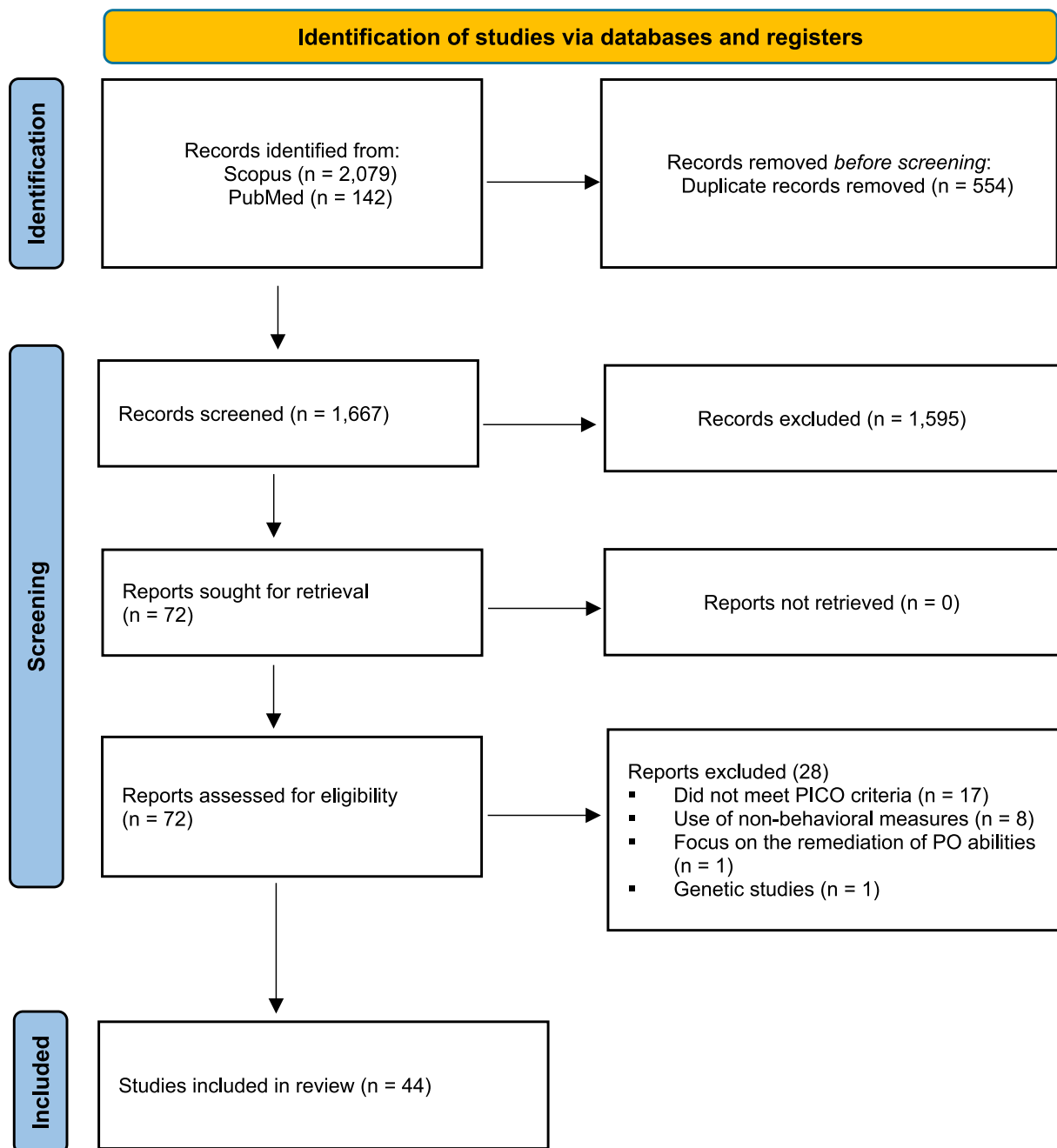


Fig. 3. PRISMA flow chart of the included studies. The diagram summarizes the identification, screening, and inclusion phases of the review. A total of 2221 records were retrieved. After duplicate removal and manual screening, 1667 records remained. Titles and abstracts were screened according to predefined inclusion criteria yielding 71 potentially eligible studies. Full-text assessment excluded papers that did not meet these criteria (e.g., studies focusing exclusively on treatment effects, complex ecological stimuli, or neuroimaging without behavioral measures), resulting in 44 studies included in the final review.

(2006) and Silverstein et al. (2009, 2012) reported reduced accuracy and elevated thresholds, indicating greater difficulty in integrating fragmented contour elements under increasing levels of orientation noise. Keane et al. (2012, 2019) linked these deficits to weakened lateral interactions and reduced sensitivity to spatial context. Kurylo et al. (2007) found that patients required more salient collinearity cues for contour detection, consistent with bottom-up dysfunction. Similarly, Robol et al. (2013) observed that more configural information was needed to support adequate performance in SZ. Schallmo et al. (2013) further showed that patients display abnormal contextual modulation during contour detection, with weaker orientation-dependent surround suppression, suggesting broader orientation tuning in early visual

cortex.

Contour integration performance was also related to symptom clusters. Joseph et al. (2013) and Silverstein et al. (2015a, 2015b) both reported that disorganization symptoms were strongly associated with poorer contour integration. Tso et al. (2014) found that lower contour integration performance was linked to reduced accuracy in gaze perception and emotional intelligence, suggesting a connection between visual integration deficits and social cognition impairments. However, task characteristics moderated outcomes: Herzog et al. (2004) and Silverstein et al. (2006a, 2006b) found that patients performed comparably to controls when strong collinearity or symmetry cues facilitated grouping, but deficits emerged when contextual support was reduced,

Table 1

Behavioral studies examining visual perceptual organization processes in individuals with schizophrenia, including perceptual grouping, contour integration, and figure-ground segmentation.

Authors (year)	Participants (number)	Control group (number)	Symptoms assessment scale	Investigated components	Task	Summary of findings
Perceptual grouping						
Kéri et al. (2005)	Unmedicated SZ patients (35)	Healthy individuals (20)	SANS SAPS BSABS	Perceptual grouping, PO and rapid visual processing	Flanker task with Gabor patches, Vernier thresholds task, Natural scene categorization task	Deficits in PO and M pathway functioning in SZ patients. The deficits correlate with negative symptoms
Kim et al. (2005)	SZ outpatients (14)	Healthy individuals (15)	BPRS SANS SAPS	Perceptual grouping through global form perception, biological motion processing	Biological motion task Global-form task	Significant impairments in biological motion perception in SZ patients, reflecting deficits in processing socially relevant visual information. These impairments were associated with reduced social functioning
Silverstein et al. (2006a, 2006b)	First-episode SZ (54) High-risk group (70) Psychotic individuals under 30 years of age (27) Mood or anxiety disorders (13)	Healthy individuals (24)	–	PO, perceptual grouping and early visual processing	Target detection task with grouped vs. ungrouped elements (modified Banks & Prinzmetal, 1976)	High-risk individuals showed perceptual organization deficits tied to progression toward psychosis
Tadin et al. (2006)	SZ patients (16)	Healthy individuals (14)	BPRS SANS SAPS	Center-surround interactions in visual motion processing vs static perceptual grouping	Motion discrimination task Global form task	Impaired static visual grouping
Uhlhaas et al. (2006)	SZ disorganized (11) SZ non-disorganized (24) Psychotic patients (27) Non-psychotic psychiatric patients (35)	–	PANSS	Visual perceptual grouping	Contour integration task Visual size perception task Visual closure task	Impaired perceptual grouping in disorganized SZ patients
Kurylo et al. (2007)	SZ and SA in- and outpatients (19)	Healthy individuals (20)	BPRS SANS	PO and perceptual grouping by proximity and similarity	Grouping by proximity task Color similarity task	Impaired PO for perceptual grouping in both tasks
Giersch and Rhein (2008)	SZ outpatients (30)	Healthy individuals (30)	PANSS	Perceptual grouping	Group-based visual matching task	Preserved grouping for proximal elements, but impaired segmentation of distant regions in SZ patients
Elahipanah et al. (2008)	SZ and SA patients (23)	Healthy individuals (22)	PANSS	Search efficiency and perceptual grouping	Visual search task with varying distractor ratio	Spared search efficiency and grouping but longer RTs in SZ patients
van Assche and Giersch (2011)	SZ outpatients (23)	Healthy individuals (23)	PANSS	Perceptual grouping	Repetition discrimination task, Stroop task	Preserved grouping by proximity but impaired between-group target detection in SZ, suggesting deficits in top-down processes
Giersch et al. (2012)	SZ outpatients (16)	Healthy individuals (15)	PANSS	Perceptual grouping and re-grouping	Visual search task with connected and unconnected figure pairs	Impaired re-grouping of unconnected items and loss of automatic grouping under attentional demands in SZ patients
Cestari et al. (2013)	SZ inpatients (10)	Healthy individuals (20)	PANSS	Perceptual grouping by recall of symmetrical and asymmetrical patterns	WM visuospatial task	Reduced overall pattern recall accuracy in SZ patients, but spared symmetry advantage
Roinishvili et al. (2015)	SZ patients (16)	Healthy individuals (15)	SANS SAPS	Contextual modulation and perceptual grouping	Vernier offset discrimination task	Intact contextual modulation in SZ patients
Choung et al. (2022)	SZ patients (15)	Healthy individuals (15)	SANS SAPS	Perceptual grouping, crowding and contextual processing	Vernier visual acuity task	Intact complex grouping and Gestalt processing in SZ patients. Intact uncrowding but longer stimulus duration needed from SZ patients
Contour integration						
Silverstein et al. (2000)	Chronic SZ inpatients (23)	Non schizophrenic psychiatric inpatients (19) Healthy individuals (17)	PANSS	PO, perceptual grouping and Contour integration	Contour integration task with Gabor patches	Impaired perceptual grouping and Contour integration in SZ patients

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Table 1 (continued)

Authors (year)	Participants (number)	Control group (number)	Symptoms assessment scale	Investigated components	Task	Summary of findings
Uhlhaas et al. (2005)	Disorganized SZ and SA patients (14) Non-disorganized SZ and SA patients (33) Non-SZ psychotic patients (19) Non-psychotic psychiatric patients (25)	–	PANSS	Contour integration and perceptual closure	Contour integration task Visual closure task	PO deficit evident only in disorganized group; disappears after partial remission
Kozma-Wiebe et al. (2006)	SZ patients (12)	Healthy individuals (11)	–	Contour integration	Computer-based Contour integration task	SZ patients' performance deteriorates at lower jitter levels compared to controls
Silverstein et al. (2006a, 2006b)	SZ patients (38) SA patients (32)	Healthy individuals (17)	–	Effects of top-down processes on Contour integration	Contour integration task	Intact Contour integration but reduced sensitivity to top-down effects
Silverstein et al. (2009)	SZ outpatients (14)	Healthy individuals (14)	PANSS	PO and Contour integration	Contour integration task with Gabor patches	Impaired Contour integration in SZ with reduced accuracy at intermediate difficulty levels
Keane et al. (2012)	SZ patients (36)	Healthy individuals (25)	BPRS	Contour integration	Contour integration task with Gabor patches (small vs. large element spacing)	Impaired contour integration in SZ but deficits did not increase with larger spacing, suggesting no specific impairment in longer-range connectivity
Silverstein et al. (2012)	SZ patients (148)	Healthy individuals (136)	–	Contour integration	Contour integration-JOVI task	Impaired contour integration and lower thresholds in SZ patients
Robol et al. (2013)	SZ patients	Healthy individuals (18)	PANSS	Contour detection and integration	Contour Localization Task Orientation Discrimination Task	Impaired contour detection and reduced contextual disruption in SZ
Joseph et al. (2013)	SZ in- and outpatients (87)	–	PANSS	Perceptual organization and Contour integration	Contour integration-JOVI task, Ebbinghaus illusion task	Poor premorbid functioning and disorganization associated with stronger PO deficits
Schallmo et al. (2013)	SZ patients (25) SA patients (3)	First-degree relatives (15) Healthy individuals (29)	BPRS	Contour integration	Gabor-based contour detection task	Impaired contour detection and abnormal contextual modulation in SZ. Comparable performance in controls and relatives
Feigenson et al. (2014a, 2014b)	FEP patients (18) SZ inpatients (24)	Healthy individuals (36)	PANSS	Contour integration impairment across clinical states	Contour integration-JOVI task	Impaired Contour integration in SZ, intermediate performance in FEP; no improvement over time
Keane et al. (2014a, 2014b)	SZ patients (15) SA patients (10)	Healthy individuals (25)	PANSS	Spatial frequencies and Contour integration deficits	Collinear facilitation task Contour integration task Kanizsa shape perception	Contour integration deficits not dependent on spatial frequency variations
Tso et al. (2014)	SZ patients (21), SA patients (8)	Healthy individuals (23)	SANS SAPS	Visual integration and social cognition	Contour integration task Coherent motion task Eye-contact perception task	Impaired Contour integration in SZ correlates with social processing deficits
Silverstein et al. (2015a)	SZ inpatients (24) BD patients (20) OCD patients (20)	Healthy individuals (20)	PANSS	PO and Contour integration	Ebbinghaus illusion Contour integration task	Disrupted Contour integration performance in SZ, other groups similar to controls
Silverstein et al. (2015b)	SZ patients (47)	Healthy individuals (56)	BPRS	Contour integration	Contour integration-JOVI task	Impaired Contour integration across difficulty levels in SZ patients
Grove et al. (2018)	SZ patients (25) SA patients (22) BD patients (31)	Healthy individuals (38)	BDI-IA SAPS SANS YMRS	Contour integration	Contour integration task	Visual integration deficits specific to psychotic disorders
Keane et al. (2019)	SZ patients (38)	Healthy individuals (50)	PANSS PAS	Contour integration and collinear facilitation	Contour integration task	Impaired integration of spatially scaled stimuli linked to lateral connectivity deficits
Pokorny et al. (2021)	SZ patients (27) BD patients (23) SZ relatives (23)	Healthy individuals (37)	BPRS	Context modulation in Contour integration	Collinear Gabor Contour Task	Impaired contour detection and reduced context modulation in SZ
Türközer et al. (2019)	SZ and SA patients (28)	Healthy individuals (31)	PANSS	Contour integration and visual context processing	JOVI task (7° jitter) Size illusion task	Impaired Contour integration but preserved context processing in SZ and SA
Frattaroli et al. (2022)	SZ patients (13) High/low schizotypy (102 online) Psychotic patients (11)	Healthy individuals (20)	PANSS CAPE	Contour integration	JOVI RiSE DPX	Contour integration impairment in psychotic patients but not in high schizotypy

(continued on next page)

Table 1 (continued)

Authors (year)	Participants (number)	Control group (number)	Symptoms assessment scale	Investigated components	Task	Summary of findings
Keane et al. (2022)	Non-psychotic patients (8) SZ patients (22) BD patients (24)	Healthy individuals (21)	PANSS	Illusory contour detection and integration	Shape completion task	Shape completion deficits decrease from SZ to BD to controls
Jayakumar et al. (2024)	SZ patients (23)	Healthy individuals (15)	–	Contour integration	Contour integration training task	Contour integration deficits in SZ, particularly with complex shapes
Figure-ground segmentation						
Herzog et al. (2004)	SZ patients (16)	Healthy individuals (14)	SAPS SANS	Figure-ground segmentation	Shine through backward masking	Intact figure-ground segmentation and grouping in SZ patients
Loas (2004)	SZ patients (62)	–	BPRS	Figure-ground segmentation	EFT	Negative correlation between EFT and negative/disorganization subscales
Hancock et al. (2008)	Chronic SZ or SA inpatients (9)	Healthy students (63)	–	Figure-ground segregation by onset asynchrony	Contour integration 2AFC paradigm variants	Reduced sensitivity to onset asynchrony in SZ
Favrod et al. (2022)	SZ patients (47) Depressed patients (28) Patients' relatives (25)	Healthy individuals (55)	BPRS SANS SAPS HDRS	Figure-ground segmentation	L-EFT	No specific Gestalt deficit, but general processing delays in SZ

2AFC = Two-Alternative Forced Choice; BD = Bipolar Disorder; BDD = Body Dysmorphic Disorder; BDI-IA = Beck Depression Inventory revised; BPRS = Brief Psychiatric Rating Scale; BSABS = Bonn Scale for the Assessment of Basic Symptoms; CAPE = Community Assessment of Psychic Experiences; Contour integration = Contour Integration; DPX = Dot Pattern Expectancy; EFT = Embedded Figure Task; FEP = First Episode Psychosis; HDRS = Hamilton Depression Rating Scale; JOVI = Jittered Orientation Visual Integration; L-EFT = Leuven Embedded Figure Test; OCD = Obsessive Compulsive Disorder; PANSS = Positive and Negative Symptoms Scale; PAS = Premorbid Adjustment Scale; PO = Perceptual Organization; RiSE = Relational and item-Specific Encoding; RT = Reaction Time; SA = Schizoaffective; SANS = Scale for the Assessment of Negative Symptoms; SAPS = Scale for the Assessment of Positive Symptoms; SZ = Schizophrenic; WM = Working Memory; YMRS = Young Mania Rating Scale.

requiring flexible integration and greater top-down involvement. This suggests that some deficits may emerge only under demanding conditions, specifically when bottom-up grouping cues are weak and successful performance depends on top-down coordination. This pattern is consistent with models proposing that early sensory instabilities in SZ are exacerbated by impaired top-down modulation (Silverstein and

Keane, 2011; Uhlhaas and Mishara, 2007), leading to intact performance when stimuli provide robust bottom-up information, but failures when compensation from higher-order processes is required.

In schizotypal traits, 3 papers were included, and their results appeared more variable (Table 2). Uhlhaas et al. (2004) found impaired contextual facilitation in contour integration tasks in schizotypal

Table 2

Behavioral studies examining visual perceptual organization processes in individuals with schizotypal traits, including perceptual grouping, contour integration, and figure-ground segmentation.

Authors (year)	Participants (number)	Control group (number)	Symptoms assessment scale	Investigated components	Task	Summary of findings
Uhlhaas et al. (2004)	High SPQ scores undergraduate psychology students (32) Thought-disordered schizotypal individuals (24)	Low SPQ scores undergraduate psychology students (37)	SPQ TDI	Contour integration and context processing	Visual size perception task Contour integration task	Impaired context processing in thought-disordered schizotypal individuals
Panton et al. (2018)	High PAb students (55)	Low PAb students (77)	Wisconsin Schizotypy Scales (PAb and Social Anhedonia subscales) O-LIFFE (Cognitive Disorganization subscale)	Contour integration	RFJOT	Poorer local processing but intact global processing in High PAb students compared to Low PAb controls
Laycock et al. (2019)	High schizotypy (20)	Low schizotypy (20)	SPQ	Contour integration, contrast and motion sensitivity	Flicker-defined form task Motion coherence task Form coherence task Change detection task	Impaired change detection performance in high schizotypy individuals
Tsakanikos and Reed (2003)	Undergraduate psychology students (100)	–	O-LIFE	Figure-ground segregation	Hidden Figures Test	Impaired figure-ground segregation associated with negative schizotypy

BDI = Beck Depression Inventory; EFT = Embedded Figure Task; O-LIFE = Oxford-Liverpool Inventory of Feelings and Experiences; PAb = Perceptual Aberration Scale; RFJOT = Radial Frequency Jittered Orientation Task; RFST = Radial Frequency Search Task; SPQ = Schizotypal Personality Questionnaire; TDI = Thought Disorder Index.

individuals with thought disorder. [Panton et al. \(2018\)](#) reported reduced tolerance to orientation noise in high positive schizotypy, while [Laycock et al. \(2019\)](#) found slowed change detection, possibly reflecting dorsal stream dysfunction. By contrast, [Frattaroli et al. \(2022\)](#) observed no contour integration impairments in high schizotypy, despite clear deficits in psychotic patients, pointing to differences across schizotypy dimensions and tasks.

Overall, contour integration deficits are robust in SZ, particularly in disorganized subtypes, but findings in schizotypy remain mixed. Task design and symptom profiles appear to modulate outcomes, underscoring the need for methodological standardization in future research.

3.4. Figure-ground segmentation

A total of 4 studies examined figure-ground segmentation in individuals with SZ or schizotypal traits ([Table 1](#)). These studies assessed participants' ability to differentiate objects from their background, a core process for interpreting complex visual scenes. A range of paradigms was employed, including the Embedded Figures Test ([Loas, 2004](#)), the shine-through backward masking task ([Herzog et al., 2004](#)), onset asynchrony manipulations ([Hancock et al., 2008](#)), and a lateralized variant of the EFT ([Favrod et al., 2022](#)).

Findings were mixed. [Loas \(2004\)](#) and [Hancock et al. \(2008\)](#) reported impaired figure-ground segregation in SZ, particularly when contrast or temporal separation between figure and background was reduced. In contrast, [Herzog et al. \(2004\)](#) found that despite elevated susceptibility to visual masking, patients retained intact temporal resolution and figure-ground segmentation, as evidenced by their sensitivity to subtle spatiotemporal variations in the shine-through task. Similarly, [Favrod et al. \(2022\)](#) observed no Gestalt-based impairment in SZ; while patients responded more slowly, their accuracy did not differ from controls, suggesting a broader slowing of visual processing rather than a disruption of organizational mechanisms. Associations with symptom clusters were explored in [Loas \(2004\)](#), who found that lower performance on a figure-ground task was significantly associated with higher levels of disorganization and negative symptoms, consistent with a dimensional rather than categorical interpretation of the impairment.

In non-clinical samples, [Tsakanikos and Reed \(2003\)](#) reported that high negative schizotypy was associated with reduced performance on the Hidden Figures Test, whereas other schizotypy dimensions showed no significant relationship, highlighting a specific relation between negative traits and perceptual vulnerabilities in figure-ground segmentation ([Table 2](#)).

In sum, figure-ground segmentation appears only mildly impaired in SZ and more strongly modulated by task difficulty and symptom profile. While low-level mechanisms may remain intact under simple conditions, segmentation performance deteriorates under increased perceptual or cognitive load, especially in individuals with disorganized or negative traits. However, it is important to note that these conclusions are based on only four studies, which limits the strength and generalizability of the evidence.

4. Discussion

4.1. Perceptual organization deficits in schizophrenia

This systematic review investigated three main aspects of PO in SZ: contour integration, perceptual grouping, and figure-ground segmentation. Earlier reviews often considered PO as a uniform process, with emphasis on disrupted coordination between early sensory processing and higher-order modulation (e.g., [Panton et al., 2018](#); [Silverstein and Keane, 2011](#); [Uhlhaas and Silverstein, 2005](#)). Our review extends this work by explicitly considering PO as composed of distinct sub-components and synthesizing how evidence converges or diverges across them. This approach highlights both commonalities and differences in impairment patterns, providing a more differentiated picture of

PO deficits across the SZ spectrum.

Contour integration emerges as the most consistently impaired process. It depends heavily on bottom-up lateral interactions in early visual areas (V1/V2), which detect local edges and orientations and link them into continuous contours ([Neumann and Sepp, 1999](#); [Qiu et al., 2016](#)). These areas are critical for functions like lateral connectivity and contextual modulation ([Silverstein et al., 2015a, 2015b](#)), which support contour integration processes ([Grossberg et al., 1997](#); [Piëch et al., 2013](#); [Tang et al., 2007](#)). These areas are often compromised in SZ due to abnormalities in GABAergic inhibition and NMDA receptor function ([Ettinger et al., 2015](#); [Hardingham and Do, 2016](#); [Nakazawa et al., 2012](#)). Reduced GABA in the visual cortex is associated with impaired cortical inhibition ([Aksenov et al., 2022](#)), which is needed for contour integration as it regulates suppression of irrelevant information and integration of relevant visual elements ([Katzner et al., 2011](#)). Therefore, GABAergic dysfunction may contribute to the contour integration deficits observed in SZ ([Marín, 2012](#)). Yet performance is not only determined by feedforward signals: when contours are sparse or noisy, higher-order influences, such as attentional biasing and propagation of activity along contours, are necessary to stabilize perception, and failures of top-down reinforcement amplify differences with the control group ([Keane et al., 2014a, 2014b](#); [Richter et al., 2018](#); [Silverstein et al., 2006a, 2006b](#)). However, two important aspects need to be taken into consideration. Contour integration has indeed been more intensively studied than grouping or figure-ground, which likely increases the visibility and reliability of effects. Second, contour integration tasks are often designed to minimize strong grouping cues (e.g., sparse, jittered contours in noise), making them especially sensitive to failures of lateral/contextual integration and to the need for stabilizing top-down input. From this perspective, the consistent impairments observed in CI may not only reflect bottom-up dysfunction in early visual circuits but also the inability of higher-order mechanisms to compensate when stimulus-driven support is weak.

Perceptual grouping shows a more mixed profile. In SZ it does not present a uniform deficit but instead reveals how the balance between bottom-up and top-down processes determines performance. As Gestalt theory and empirical work highlight, proximity, similarity, and symmetry are among the strongest grouping cues, with proximity generally emerging as the most robust ([Elder and Goldberg, 2002](#); [Huang, 2015](#); [Wagemans et al., 2012](#)). This helps explain why preserved performance is often observed when such cues are salient: strong bottom-up regularities provide sufficient support for grouping, even in the presence of perceptual deficits. However, our review shows that when stimulus support is weak or task demands increase, patients struggle, revealing a critical reliance on top-down modulation. Impairments reported in disorganized patients ([Uhlhaas et al., 2006](#)) and in chronic or unmedicated samples ([Kéri et al., 2005](#); [Silverstein et al., 2006a, 2006b](#); [Silverstein et al., 2000](#)) align with the idea that cognitive coordination and attentional control are necessary to stabilize PO under ambiguous conditions.

These patterns suggest that grouping deficits in SZ are not simply failures of Gestalt principles themselves, but of the dynamic interaction between bottom-up processing and the higher-level mechanisms that modulate and sustain them. From this perspective, preserved performance under proximity or similarity reflects the importance of early perceptual mechanisms, while deficits under load or ambiguity indicate failures of flexible top-down recruitment. Importantly, not all grouping principles appear equally affected. A process like symmetry-based grouping remains relatively underexplored in SZ and schizotypy research, despite its central role in PO ([Bertamini et al., 2018](#)).

Figure-ground segmentation similarly relies on early boundary and contrast computations, which often remain intact with simple or high-salience stimuli ([Herzog et al., 2004](#); [Favrod et al., 2022](#)). Impairments emerge when segmentation requires resolving competition between alternatives, implicating the role of top-down attention and contextual guidance in organizing visual scenes ([Hancock et al., 2008](#);

Loas, 2004).

4.2. High- vs. low-level perceptual deficits in schizophrenia

A central debate in SZ research concerns whether PO deficits primarily reflect disruptions in early sensory processing or arise from impairments in higher-order cognitive functions (Silverstein and Keane, 2011). Some models emphasize bottom-up failures in the basic binding of perceptual features, suggesting that disruptions in early visual areas lead to fragmented representations (Adámek et al., 2022). These low-level processes encompass early visual feature extraction, Gestalt principles of grouping (such as proximity and similarity), and lateral interactions within local cortical circuits (Kurylo et al., 2007). Deficits at this level can lead to unstable and fragmented representations (Smid et al., 2013). However, others argue that deficits in contextual modulation, cognitive organization, and top-down influences play a more prominent role (Silverstein et al., 2000). Rather than being mutually exclusive, these perspectives likely describe different stages of a cascading failure across the visual processing hierarchy, which is consistent with the theory suggesting that SZ can be characterized as a disorder of higher order hierarchical processing. Taken together, these findings suggest that PO deficits in SZ are best understood as the outcome of a cascade: early sensory instabilities compromise contour integration, and insufficient top-down control prevents compensation during grouping and segmentation, especially when stimulus cues are weak or cognitive demands are high. This subcomponent perspective thus extends earlier accounts, specifying how disruptions in bottom-up and top-down processes map onto distinct facets of PO. This is particularly evident in contour integration tasks, where patients struggle to form coherent percepts from fragmented inputs (Silverstein et al., 2000).

Impairments in contour integration have often been cited as evidence of early-stage dysfunction, as they rely on lateral interactions in early visual areas such as V1 and V2 (Silverstein et al., 2000; Kozma-Wiebe et al., 2006). Deficits at this level suggest that perceptual fragmentation begins at the initial stages of visual processing. However, if the impairment was purely sensory, one would expect uniformly poor performance across all PO tasks involving fragmented stimuli. Instead, performance varies depending on task parameters, with relatively preserved processing when grouping is driven by strong stimulus cues and minimal cognitive demand (Uhlhaas et al., 2006). This variability suggests that while bottom-up deficits contribute, they do not fully account for the inconsistencies observed across paradigms, and impairments may be most pronounced when weakly grouped elements require additional top-down modulation.

Several studies support the role of top-down deficits, particularly in patients with disorganized symptoms, who show broader impairments in cognitive coordination (Uhlhaas et al., 2005; Keane et al., 2014a, 2014b). Attentional control and contextual modulation are essential for PO (Barbot et al., 2018) and deficits in these domains may underlie poorer performance in cognitively demanding PO tasks (Silverstein et al., 2015a, 2015b). Rather than being strictly sensory or cognitive, we propose that PO deficits likely emerge from an interaction between these levels. Early sensory disruptions produce unstable representations, which are not adequately resolved by impaired top-down modulation (Adámek et al., 2022; Kok et al., 2013) resulting in the characteristic perceptual disturbances of SZ. This breakdown is especially evident in contour integration tasks, where the need to integrate weakly grouped local elements without strong external cues exposes vulnerabilities in both early processing and top-down stabilization.

This interaction between bottom-up and top-down contributions aligns with broader evidence on contextual processing in SZ. For example, reduced surround suppression in contrast and motion perception tasks has been consistently reported (Pokorný et al., 2023; Tadin et al., 2006; Yang et al., 2013; Yoon et al., 2009). These center-surround abnormalities are thought to reflect impaired inhibitory mechanisms in early visual cortex, which normally sharpen orientation

tuning and stabilize perceptual integration. Their disruption may contribute to the instability observed in contour integration and grouping tasks when strong bottom-up information is absent and greater top-down coordination is required.

4.3. Perceptual organization deficits in schizotypy

PO deficits in schizotypal traits are consistent with neurophysiological vulnerabilities associated with SZ risk (Uhlhaas and Mishara, 2007; Uhlhaas and Silverstein, 2005). Previous reviews document early visual and organizational abnormalities that resemble but are milder than those seen in SZ (Silverstein and Keane, 2011), supporting continuity between traits and disorder at the level of mechanisms, rather than distinct categories (Nelson et al., 2013). However, findings remain limited and mixed, which arise from variability in task design, schizotypy assessment, and the influence of compensatory mechanisms in schizotypy, as shown by the present review. For example, evidence suggests that individuals with high schizotypy can employ compensatory mechanisms to offset early sensory instabilities. ERP studies show reduced early visual P1 responses in high schizotypy, linked to working memory impairments, but performance normalizes when stimuli are presented for longer durations (Koychev et al., 2010). This indicates that intact performance in some tasks may reflect compensation rather than absence of deficits. Consistent with this, Ettinger et al. (2015) emphasize that while schizotypy is associated with early-stage perceptual abnormalities across modalities, many tasks reveal preserved or even enhanced performance under supportive conditions, likely due to attentional recruitment or reliance on alternative cognitive strategies. These mechanisms allow high-schizotypy individuals to achieve task accuracy despite underlying inefficiencies, helping to explain why deficits appear selectively in paradigms with weak bottom-up support or high cognitive demand. Furthermore, different schizotypy subtypes (e.g., positive, negative, disorganized) may also relate to specific PO tasks; for example, negative schizotypy is associated with poorer performance on figure-ground segmentation tasks (Uhlhaas et al., 2006), suggesting that not all grouping/segmentation paradigms will be equally sensitive. Finally, the heterogeneity in experimental tasks, which complicates direct comparisons across studies (Uhlhaas et al., 2006), might also play a role. In paradigms that increase perceptual load, higher schizotypy shows worse performance, consistent with limited perceptual resources and greater reliance on top-down regulation under demand (Cappe et al., 2012). These moderators align with the broader PO literature in SZ: deficits are most evident when bottom-up support is weak and top-down stabilization is required (e.g., fragmented contours, ambiguous figure-ground), while strong stimulus anchors allow near-normal performance. While there is tentative evidence of PO impairments associated to schizotypal traits, findings are inconsistent and often constrained by methodological variability. A dimensional view of PO dysfunction is more appropriate, where targeting symptom clusters, rather than broad categories, helps to better understand how perceptual impairments contribute to cognitive and functional variability (Feigenson et al., 2014a, 2014b; Uhlhaas et al., 2006) and may be an index of illness progression (Silverstein et al., 2006a, 2006b). As the following section will illustrate, the association between disorganization symptoms and PO deficits is more robust in clinical populations, suggesting that symptom dimensions may be a more meaningful framework for identifying perceptual vulnerabilities than diagnosis alone.

4.4. Symptom-specific deficits in perceptual organization

A key finding from this review is the confirmation that PO deficits are not uniformly present across all SZ patients but appear to be specifically associated with disorganization symptoms. In particular, studies consistently report that higher levels of disorganization are associated with more severe deficits in contour integration and perceptual grouping (Joseph et al., 2013; Keane et al., 2014a, 2014b; Keane et al.,

2019; Silverstein et al., 2006a, 2006b; Silverstein et al., 2000).

This symptom-specificity helps explain why PO deficits are not always observed at the group level and why some studies that did not analyze subgroups by symptom dimensions found intact performance (e.g., Kim et al., 2005). Rather than reflecting a unitary diagnostic effect, PO deficits appear to map onto cognitive disorganization, characterized by fragmentation of thought and instability of attentional control (Uhlhaas et al., 2004, 2006). It also suggests that PO tasks, particularly those requiring flexible integration of fragmented input, may act as sensitive functional markers of cognitive disorganization in SZ. These tasks depend on both bottom-up grouping and top-down modulation, making them vulnerable to attentional instability and coordination failures in disorganized subtypes (Silverstein and Keane, 2011). In contrast, associations between PO and other symptom dimensions, such as negative or positive symptoms, appear less robust. For example, while some studies report figure-ground segmentation impairments in patients with pronounced negative symptoms, these effects are more variable and often task-dependent (Joseph et al., 2013; Panton et al., 2018). Moreover, PO deficits appear more pronounced in patients with poorer premorbid functioning (Silverstein and Keane, 2011; Keane et al., 2019), suggesting that early developmental or cognitive vulnerabilities may set the stage for later perceptual disorganization. There is also evidence for broader associations between PO performance and other symptom domains. For instance, contour integration and Mooney face detection deficits have been linked to negative symptoms, reflecting reduced perceptual sensitivity and diminished integration efficiency (Türközer et al., 2019).

In schizotypy, the picture is further complicated by compensatory mechanisms and less severe cognitive disruption. While some studies suggest trait-level associations between disorganization and PO, these links are generally weaker and more inconsistent than in SZ. Notably, one of the few studies to distinguish schizotypy subtypes reported contour integration impairments specifically in individuals with disorganized traits (Uhlhaas et al., 2004). However, such findings remain isolated, and further investigation is needed to determine whether symptom-specific PO deficits extend reliably into non-clinical populations.

Altogether, these findings further support a dimensional view of PO dysfunction, where disorganization, rather than diagnosis per se, is the key predictor (Feigenson et al., 2014a, 2014b).

4.5. Methodological considerations and future directions

A key limitation in the current literature on PO deficits in SZ is the heterogeneity in experimental tasks, which complicates direct comparisons across studies. Differences in stimulus type (e.g., Gabor elements vs. line contours), response format (e.g., forced choice vs. adjustment paradigms), and task complexity may contribute to variability in findings. For instance, tasks requiring flexible integration under noise tend to reveal stronger deficits than tasks relying on salient grouping cues, even when targeting the same PO process (Kim et al., 2005; Herzog et al., 2004). While both forced choice and adjustment methods offer valid insights, they measure different aspects of perception (i.e., susceptibility versus magnitude) and their inconsistent use reduces comparability across studies.

Further, several studies fail to report key methodological parameters, such as number of trials, stimulus timing, or dispersion measures (e.g., standard deviations), which are essential for evaluating effect size and replicability. Even subtle variations in visual features, such as contrast, spacing, or stimulus duration, can influence PO task performance (Choung et al., 2022), yet such parameters are often underreported or inconsistently defined. Symmetry-based grouping has received limited attention in SZ and schizotypy research yet may be differentially affected across symptom dimensions or task demands, warranting more systematic investigation.

Another limitation relates to spectrum bias in case-control designs.

Outpatient convenience samples likely underestimate PO deficits, while inpatient or acutely ill cohorts may exaggerate them. Because PO performance varies systematically with disorganization symptoms, illness phase, and premorbid functioning (Uhlhaas and Silverstein, 2005; Silverstein and Keane, 2011), spectrum bias can pull estimates in both directions, contributing to inconsistent findings across the literature. To reduce this problem, future studies should use broader recruitment strategies and model symptom dimensions explicitly, rather than relying only on categorical patient-control contrasts (Rutjes et al., 2006; Whiting et al., 2011).

Another factor that needs to be considered is basic visual acuity. Even when all groups meet the common inclusion criterion of “normal or corrected-to-normal vision” (20/20), subtle differences in refractive error may still impact performance on contour integration tasks, particularly those involving small or high spatial frequency stimuli. Recent evidence shows that correcting acuity beyond 20/20 can significantly improve contour detection and integration (Keane et al., 2024). This suggests that residual refractive blur, even within the normal range, could contribute to inter-individual variability or apparent group differences in special populations. Future studies should therefore carefully assess and report refractive error and best-corrected acuity, to ensure that observed PO deficits reflect perceptual rather than optical limitations.

Finally, we did not focus on CHR/UHR groups. These cohorts are more closely tied to early clinical phases of psychosis, whereas our intent was to examine schizotypy as a non-clinical expression of liability. Future reviews could focus more directly on CHR/UHR samples, to further explore the dimensional continuum between symptom severity and perceptual deficits.

To advance the field, future research should prioritize task standardization, detailed reporting of experimental parameters, and greater use of dimensional designs that capture individual differences across symptom clusters or schizotypy dimensions. Open science practices, shared protocols, and multi-lab collaborations would enhance comparability and support more robust synthesis of findings across research groups. The potential translational value of PO tasks also deserves consideration. Because PO impairments are most consistently linked to disorganization, they may provide a symptom-specific marker that complements established neurocognitive assessments. However, unlike domains prioritized in initiatives such as MATRICS (Nuechterlein et al., 2008; Kern et al., 2004), PO has not yet been incorporated into standard clinical batteries, largely due to the absence of task standardization, limited psychometric validation, and uncertainty about incremental validity (Green et al., 2009, 2019). As emphasized in recent work, clinical cognitive measures must be reliable, scalable, brief, and culturally adaptable to be usable in practice (Nuechterlein et al., 2025). Addressing these barriers through psychometric validation, standardization of task protocols, and demonstration of predictive value for functional outcomes will be critical if PO measures are to transition from experimental tools into clinically informative instruments for early detection and intervention.

CRediT authorship contribution statement

Roberta Cessa: Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Andrea Ghiani:** Writing – review & editing, Writing – original draft, Methodology. **Ezgi Cenik:** Writing – review & editing, Writing – original draft, Visualization, Methodology. **Marco Bertamini:** Writing – review & editing, Writing – original draft, Conceptualization.

Declaration of competing interest

The authors declare no conflict of interest.

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