Schizotypy Correlates with Poor Event Segmentation:

Insights for Schizophrenia Spectrum

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Abstract

Schizophrenia is a spectrum of mental disorders that impair individuals' ability to perceive and understand their environment. A critical aspect of understanding our environment is our ability to parse continuous experiences into discrete events in our minds, a process termed 'event segmentation.' Understanding segmentation along the spectrum of schizophrenia severity (i.e., schizotypy) and symptoms can facilitate our understanding of the mechanisms underlying disorganized perception in schizophrenia. To that end, online participants (N=483) completed a task in which they segmented short movie clips into discrete units by indicating when in their mind one unit ends and another begins. Participants with higher levels of schizotypy (based on self-report) indicated segments in less typical time points, as reflected by less agreement with the group's segmentation norm. That is even though they had the same number of segments. These results reflect a disorganized and less structured perception of events in schizotypy. Additionally, symptoms of perceptual dysregulation specifically, more so than eccentricity and unusual beliefs, correlated with poorer segmentation. This study contributes to our understanding of the relationship between schizotypy and perceptual organization, shedding light on potential cognitive mechanisms underlying psychotic experiences.

Keywords: Event segmentation, schizophrenia, schizotypy, psychotic symptoms, perceptual dysregulation, context

Introduction

The Role of Event Segmentation in Perceptual Processing.

Human thinking happens within a constant flow of sensory information (i.e. what we see, hear, taste, smell). Despite this constant flow, our brains parse continuous experiences into distinct clusters or episodes, a process termed 'event segmentation' (Zacks et al., 2007). This breaking-up of events is triggered by event boundaries, which are shifts in situational context (Clewett et al., 2019; Zacks, 2020; Zacks et al., 2007). For example, when I'm walking my dog, walking out of the door to the street is a change of context from my home to the street, which signals a clear beginning of a new event – that of walking the dog. Likewise, walking through the door when coming back home signals an ending. By breaking down continuous experiences into discrete events, individuals can organize complex information into manageable parts and comprehend their surroundings effectively to make context-appropriate decisions and actions (Zacks & Sargent, 2010). Segmentation also allows for the extraction of meaningful information by enabling individuals to focus attention on specific aspects of each segment, discern patterns, and understand the significance of events within their context (Zacks, 2020). Moreover, segmentation facilitates memory encoding by creating distinct memory traces (Clewett et al., 2019). Thus, event segmentation serves as a fundamental mechanism for navigating and making sense of our dynamic environment.

Neurotypical individuals tend to agree about where event boundaries occur (Baldwin & Baird, 2001). This shared agreement depends on using similar sensory cues and shared semantic knowledge that represents previously learned information about event parts and the perception of boundaries, which arises from ongoing perceptual processing and regulates attention and memory (Zacks et al., 2007). Sensory cues, such as changes in visual or auditory stimuli, serve as perceptual anchors that signal transitions between events. Additionally, semantic knowledge, acquired through shared experiences and cultural norms, shapes individuals' understanding of how events are structured and organized; therefore, they can agree about where event boundaries occur. This shared understanding of event boundaries is essential for effective social interaction, as it enables individuals to interpret others' actions and intentions accurately (Baldwin & Baird, 2001). For instance, recognizing the end of a conversation segment might signal that it's appropriate to respond with empathy or offer support to a friend who has just shared a personal experience. By aligning their perceptions of events, individuals can engage in effective communication, fostering social cohesion and mutual understanding between individuals (Boggia & Ristic, 2015).

In addition, event segmentation theory (EST) and empirical findings suggest that events are segmented hierarchically (Baldassano et al., 2017; Kurby & Zacks, 2008; Zacks et al., 2001). Events are segmented at multiple levels, encompassing small, fine-grained events that are nested within larger, more abstract events. Fine segmentation (i.e., into small events), is thought to be based on sensory information like changes in sound, color, or shape, and might be mediated by early visual and auditory processing areas in the brain (Baldassano et al., 2017; Zacks, 2020). Coarse segmentation of large, high-order events is thought to be driven by a combination of bottom-up processing of sensory features and top-down processing of conceptual features and is potentially mediated by the ventromedial prefrontal cortex (vmPFC) as lesions to this region have been shown to selectively impair coarse segmentation (Zacks et al., 2016). For example, walking my dog would be a large event containing smaller events such as grabbing my house key, putting on my dog’s leash, and locking the door on my way out. Small events help me to complete the larger goal of walking my dog. In this way, the integration of various levels of abstraction allows humans to analyze and understand their experiences as meaningful events.

A Spectrum of Schizophrenia Disorders

Schizophrenia encompasses a spectrum of disorders characterized by disturbances in thought, perception, and behavior. Central to the experience of schizophrenia is the disruption of cognitive processes, including perception, attention, memory, and executive function (Green, 2006) as well as difficulty in understanding others' behavior and intentions (Eisenberg & Berman, 2009; Orellana & Slachevsky, 2013). Individuals with schizophrenia often struggle to maintain coherence in their thoughts and may experience hallucinations (false perceptions, i.e., seeing, hearing, or feeling things that are not grounded in reality), delusions, or confabulations (false memories or stories that individuals believe to be true), which further exacerbate their difficulties in distinguishing reality from internal experiences (Marder & Freedman, 2014). The neurobiological underpinnings of schizophrenia involve dysregulation in various neurotransmitter systems as well as structural and functional abnormalities in brain regions implicated in executive function, such as the prefrontal cortex (Howes & Kapur, 2009; Lewis & Lieberman, 2000; Orellana & Slachevsky, 2013). Importantly, these same prefrontal regions are also implicated in event segmentation (DuBrow & Davachi, 2016; Ezzyat & Davachi, 2011; Zacks, 2020).

Impairments in executive function, here defined as the ability to organize a sequence of actions in time to achieve a goal, are common in both schizophrenia and individuals with prefrontal cortex lesions (Zacks & Sargent, 2010). These deficits may contribute to challenges in event segmentation, particularly coarse segmentation, in schizophrenia (Zalla et al., 2006). Individuals with poor executive function find it difficult to stay focused and motivated when working towards their goals, which could lead to the disorganization of sequences toward the goal. This would predict that schizophrenic participants could still segment small events, for which goal maintenance might be less important, but have particular difficulties identifying larger event boundaries and events. Indeed, in a study that asked schizophrenia patients to identify fine or coarse event boundaries, schizophrenia patients identified coarse boundaries less accurately but showed no impairments in fine segmentation (Zalla et al., 2004).

In addition, a lack of integration of bottom-up (sensory-driven) and top-down (concept-driven) information processing in individuals with schizophrenia (de Boer et al., 2019; Karbakhsh et al., 2023) can exacerbate segmentation impairments. One possibility is that in schizophrenia, the brain fails to chunk sensory information into events and potentially interprets a large event as multiple smaller events, but with no cohesive conceptual organization of the small events, and this could lead to disorganized thinking and confusion. For example, picking up my toothbrush, wetting my toothbrush, and putting toothpaste on my toothbrush are all small events, but some individuals with dysfunctional segmentation may fail to construct these small events under one larger event. When such a disconnect occurs, individuals may struggle to segment actions into larger, coarse-grained events, which could lead to difficulty in comprehending the purpose behind their actions.

While the past research above focused on schizophrenia patients, schizophrenia exists along a spectrum. It includes a wide range of symptoms, severity levels, and functional impairments. Schizotypy often refers to a personality organization characterized by behaviors, thoughts, and emotions that resemble those seen in schizophrenia but appear to a lesser extent. Thus, schizotypy reflects a susceptibility to schizophrenia spectrum disorders (Barrantes-Vidal et al., 2015; Ettinger et al., 2014; Lenzenweger, 2018), and research highlights significant overlap between the two across behavioral, brain structural, and functional, as well as molecular levels

(Fanous et al., 2007). Like schizophrenia patients, individuals with schizotypy may exhibit deficits in recognizing contextual changes and forming coherent mental representations crucial for daily functioning (Phillips et al., 2016). While event segmentation has been studied to some extent in schizophrenic patients (Zalla et al., 2004; 2006), no study has specifically investigated how schizotypal traits influence event segmentation. Addressing this gap can help our understanding of the cognitive mechanisms underlying schizotypy and schizophrenia and potentially identify early markers of vulnerability to psychosis. Further, by looking at symptoms of schizotypy continuously, we can potentially discern nuanced effects like how different symptoms are associated with event segmentation. That might be obscured in patients because of the high severity of all symptoms.

To that end, in this study, we ask, 1) What is the relationship between event segmentation and schizotypy? and 2) How does this relationship relate to specific schizotypal symptoms? To address these questions, participants viewed and segmented movie clips into discrete events based on their subjective perception of meaningful boundaries, a paradigm that has been extensively used before to study event segmentation (Newtson, 1973; Swallow et al., 2009; Zacks et al., 2007). They also completed a validated self-report questionnaire that assessed the severity of schizotypal symptoms along a continuum (PID-5: Personality Inventory of the DSM-5; Krueger et al., 2012). We hypothesize that schizotypy will correlate with less appropriate segmentation of coarse events, i.e., indicating boundaries in uncommon time points, reflected in lower segmentation agreement. We will further test specifically which symptoms of schizotypy correlate with altered segmentation.

Methods

Participants.

Recruitment and Compensation: We enlisted participants through Prolific (www.prolific.co), specifically including native English speakers aged 18 and above from the United States. Participants received $15.00 for each 75-minute session dedicated to the segmentation task, equivalent to a rate of $12.00 per hour. Incentives included $1 upon completion of both the segmentation and RT tasks (see below), and an additional $0.50 for achieving good performance criteria, defined as surpassing 75% accuracy in memory questions about movie clips, completion of all cognitive tasks, and scoring above 85% accuracy in the symmetry span task (as per Kane et al., 2004; Unsworth et al., 2005). A $3.00 compensation was provided for an additional questionnaire session taking approximately 10 minutes, with a bonus of 30 cents for completing the entire session. Informed consent was obtained in accordance with procedures approved by the Princeton University Institutional Review Board.

Invitations and Eligibility Criteria: We extended invitations to the initial session of the experiment to individuals who had successfully completed and passed quality control in a mental health symptoms questionnaires section of another lab study that was ongoing approximately at the same time. Quality control measures for the questionnaires included screening for no zigzag response patterns, avoidance of consistent straight-line responses, and making no more than two errors in attention check questions (Zorowitz et al., 2023). Attention check questions were designed to be straightforward and embedded within the questionnaires, mirroring the phrasing of the questionnaire questions but having an obvious and highly probable answer (e.g., endorsing "I avoid walking in front of a speeding car" with 'definitely agree'). Regarding the main segmentation task, exclusion criteria for the current experiment were (1) achieving below 75% accuracy in attention checks during the movie segmentation, and (2) having less fine segments compared to coarse segments, indicating poor compliance with the task (see below).

A total of 660 participants initiated the initial movie segmentation session. Among them, 10 did not complete the session, and an additional 3 repeated at least a portion of it due to technical issues. Out of the remaining 647 participants, 640 surpassed the 75% attention-check accuracy threshold, qualifying them for an invitation to the second segmentation session and an additional questionnaire session (data from this session was not analyzed here and will not be further discussed).

Invitations for the first session simply informed participants that they were invited based on their performance in a previous lab study, without specifying the study name. Invitations for the second session explicitly mentioned it was the second part of the same study, acknowledging the similarity in tasks between the two sessions and participants' general awareness that repeating the same experiment is discouraged. Five days after the first session, invitations were extended for the second session of the movie segmentation task, allowing completion within eight days after the initial session.

Participant and Sample Size Characteristics: We based our sample size on a power analysis using the effect size obtained in a similar online study, Experiment 2 from Gillan et al. (2016), which tested correlations between a cognitive task and mental health symptoms, and controlling for several nuisance covariates. The effect size for the coefficient of partial determination was $f^2 = 0.018$ (a “small” effect; Cohen, 1988; Lakens, 2013). For $p < .05$, testing schizotypy (see below) as a predictor of interest and including age and gender as additional covariates, implies 80% power at N=438 and 90% at N=586 (G*Power a-priori power analyses for an F-test, multiple regression: Fixed model, R^2 increase). This study was run in parallel to an additional study in the lab.

We aimed to reach a sample size that would give us at least 80% power. Of the 530 participants who initiated the second session after the first session (82% retention), 5 did not complete it, and an additional 1 participant did not meet the attention check threshold. An additional 22 participants (4%) were excluded for having fewer fine segments compared to coarse segments, indicating poor compliance with the task (see below). One additional participant did not complete the RT task both before and after the task in the second session and was excluded from the analysis. Among the remaining 501 participants, 17 participants were removed due to outlier segmentation behavior (> 3 SD of the mean). Another participant was removed for not providing demographic information due to a technical error; complete data for age and gender are necessary to ensure accurate analysis when controlling for these variables. In sum, a total of 483 participants were included in the main analysis (190 women, 9 non-binary, 284 men; ages 18-73, M = 37.9, SD = 13.1) that had all tasks and questionnaires data, passed all quality control thresholds, and had demographic data. This gives us 84% power to discover an effect of $f^2 = 0.018$.

Materials.

Self-report instruments for assessing mental health symptoms in online participants:

Participants completed a subset of the PID-5 (Krueger et al., 2012) questionnaire, a tool previously employed in studies investigating latent cause inference in the Niv lab. This questionnaire, which usually consists of 220 items, required participants to rate the extent to which they identified with each statement on a Likert scale, indicating the degree of agreement with the statements (Krueger et al., 2012). In the current study, this assessment was conducted on a reduced subset of items, and the data from subscales addressing schizotypal symptoms - unusual beliefs, perceptual dysregulation, and eccentricity - was used. This self-report questionnaire was administered using the NivTurk software in JsPsych (Zorowitz & Bennett, 2022).

Movie clips for movie segmentation: During the task, participants viewed eight movie clips that were, on average, 144 seconds long, ranging from 90 to 179 seconds each, with a total duration of 1152 seconds. The audiovisual stimuli consisted of eight movie clips taken from a previous segmentation study (Baldassano et al., 2018) and from the internet. All eight movies showed scenes representing goal-directed events that follow a natural chronological order on a color screen with matching audio. These movies have already been piloted to achieve a range of prior knowledge regarding the typical unfolding of events in that context. For example, a date in a restaurant (high knowledge) vs. astronaut training (low knowledge). The 8 movies were: a fishing scene (A River Runs Through, 90 s), a supermarket scene (Home Alone, 146 s), a heist scene (Ocean's Eight, 168 s), a scene including breaking of code (The Imitation Game, 121 s), a laundry scene (Friends, 179 s), a law lecture (How to Get Away from Murder, 178 s), a date in a restaurant (Derek, 157 s), and an astronaut training scene (First Man, 113 s). An additional two short clips were included for practice. They have different plots and narratives that vary in content. Five of the clips were cut from longer full-length movies (A River Runs Through It, Home Alone, Ocean's Eight, The Imitation Game, First Man). Three of the clips were cut from episodes from television shows (Friends, How to Get Away with Murder, Derek). Each movie clip was preceded by a 5-second countdown (Baldassano et al., 2018) in which black numbers appeared at the center of the screen and decreased in numeral order.

Experimental procedure.

For each of the eight clips, participants were tasked with indicating the points where one meaningful unit concluded and another commenced by clicking the space bar. This task was performed twice, with a 5-8 day interval (Sargent et al., 2013). Participants initially focused on the identification of larger meaningful units (coarse segmentation) and subsequently on smaller meaningful units (fine segmentation; Sargent et al., 2013). The sequencing and timing were determined based on a prior study examining segmentation in PTSD patients (Eisenberg et al., 2016).

Prior to engaging in the segmentation task, participants received instructions and had the opportunity to practice to ensure a clear understanding of the task. Participants were instructed to “press the space bar when, in your judgment, one meaningful and natural unit ends, and another begins. There are no right or wrong answers, we want to know how you do it” (Michelmann et al., 2021; Newtson, 1973; Sargent et al., 2013). Participants were informed that they could segment the movies based on either small or large events and were given practice in both types of segmentation. They were then directed, "Today, you will indicate the largest units that seem meaningful to you" (with the word 'largest' replaced by 'smallest' in the second session). To ensure the attentiveness and comprehension of online participants regarding the level of segmentation in each session, they were prompted to type whether they intended to segment based on the largest or smallest units in the current session. Task progression was contingent on providing the correct response. Subsequently, participants practiced the segmentation task once more, focusing on the granularity specified for that particular session. This final practice round also encompassed knowledge and emotion questions (see below). The segmentation tasks were coded using Inquisit 6.6.1 (2021; www.millisecond.com) and were run on participants’ desktops using Inquisit 6.

Figure 1: Procedure for Movie Event Segmentation Task

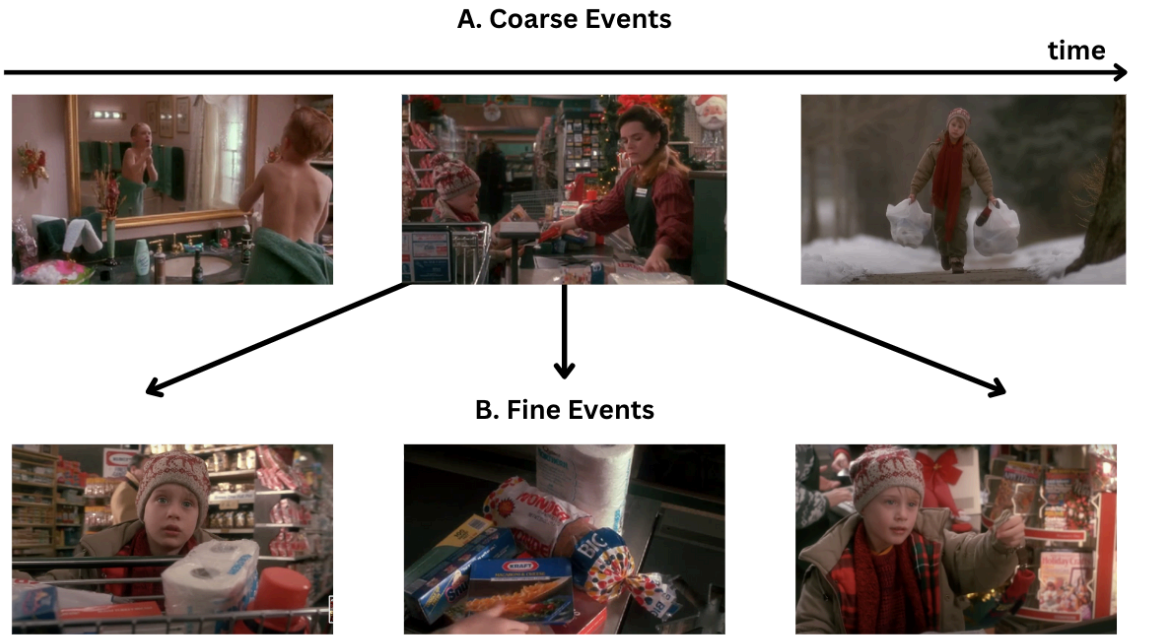

Figure 1: Procedure for Movie Event Segmentation Task in the Online Study. Participants were asked to watch the eight movie clips twice, with a 5-8 day interval between viewings. They were prompted to press the space bar when they perceived a transition between meaningful units, first for coarse segmentation (identifying larger meaningful units), and then again, in a separate viewing, for fine segmentation (identifying smaller meaningful units). Screenshots depict an example of potential key moments from one of the movies, 'Home Alone,' as part of the segmentation task. A. Coarse events in chronological order, e.g.: 1) getting ready for the day, 2) checking out at the supermarket, and 3) walking home from the supermarket. B. Fine events within the large event of checking out at the supermarket also in chronological sequence, e.g.,: 1) waiting in line at the register, 2) placing your items on the register, and 3) paying for your items. This is an illustrative example, in the task, participants were asked to segment events based on their *own* judgment.

Attention checks, Emotional Response, and Knowledge: Following each movie clip, participants responded to two straightforward questions related to the clip, serving as attention checks (refer to exclusion criteria above). Additionally, participants rated valence and arousal on a 9-point scale (Bradley & Lang, 2017) to assess their emotional responses to the movies, allowing for subsequent control in the analysis. Recognizing that knowledge can impact event segmentation (Hard et al., 2006; Zacks, 2020; Zacks et al., 2001), participants were also prompted to indicate their familiarity with the general situations presented in the clips (e.g., grocery shopping in a supermarket; not specifically “Home Alone”), how frequently they encounter such situations, and the most recent occasion on which they experienced them. The knowledge and emotion ratings were used as control (see Analysis).

Reaction Time Task Procedure: In each session, both before and after the segmentation task, participants engaged in a short reaction-time task. In this task, they were presented with a black fixation cross in the center of the screen, changing to a black circle (Zalla et al., 2004). Their task was to press the spacebar as soon as possible once the circle changed from the fixation cross to the circle. Participants were asked to press the spacebar as quickly and as accurately as possible once they saw the circle. They were also instructed to use the same finger they planned to use throughout all the tasks, including the segmentation task, and not to switch hands or fingers throughout the rest of the study. This task served to measure and adjust for individual differences in response times, ensuring accurate segmentation results and correcting for baseline reaction-time differences across participants (see Analysis).

Cognitive Tasks: In addition to the tasks above, participants engaged in short, established, and well-validated cognitive assessments, including a vocabulary test (Hartshorne & Germine, 2015), an executive function task (Bilker et al., 2012), and a working memory task (Kane et al., 2004; Unsworth et al., 2005). These supplementary tasks were conducted after the second RT task and provided a comprehensive evaluation of participants' cognitive abilities in conjunction with the primary movie segmentation task. The cognitive tasks were coded using Inquisit 6.6.1 (2021; www.millisecond.com) and were run on participants' desktops using Inquisit 6.

Analysis

We assessed five segmentation measures: the number of fine segments, the number of coarse segments, fine segmentation agreement, coarse segmentation agreement, and hierarchical segmentation. These 5 measures were assessed for each participant and for every movie clip they viewed. We then input these data into a mixed-level linear model and derived an estimate for each participant while controlling for confounds (i.e. movie order and identity of the movies). Then, this data was input into a multiple regression model to correlate segmentation with schizotypy while controlling for age and gender. The number of segments reflects how many times participants identified a boundary, computed independently for both fine and coarse segmentation. Different processes are required to generate segmentation agreement and hierarchical segmentation. These are described below.

Segmentation agreement.

Segmentation agreement quantifies how closely a participant's segmentation aligns with the group's segmentation profile (Eisenberg et al., 2016; Sargent et al., 2013; Zacks et al., 2001). Initially, to adjust for inter-participant variations in reaction times, segmentation times were modified for each participant by offsetting them based on the average reaction time obtained from the pre- and post-movie reaction time tasks (Zalla et al., 2004). Subsequently, each movie clip was subdivided into 1-second intervals, and the proportion of participants identifying each interval as a boundary was computed, generating the group segmentation profile. For every participant and each movie, agreement with the group segmentation profile was determined by correlating the participant's time series for that movie (assigning a value of 1 to time bins identified as boundaries by the participant, and 0 to all other time bins) with the group segmentation profile of the respective movie. To correct for the number of segments, these agreement values were normalized by the minimum and maximum possible correlation, given the number of segments of each participant in each movie. The maximum possible correlation was computed by aligning the time bins the participant indicated as boundaries with the time bins with the highest proportions in the group profile and computing a correlation. The minimal correlation was the inverse – aligning the participant's boundaries with the lowest proportions. Afterward, the agreement score underwent normalization to a feasible range using the formula: $r_{adjusted} = (r_{observed} - r_{min})/(r_{max} - r_{min})$. Agreement was calculated separately for fine and coarse segmentation. As these values are between 0 and 1, they were Fisher transformed (Eisenberg et al., 2016; Sargent et al., 2013; Zacks et al., 2001).

To achieve the segmentation profile of the non-schizotypy population we used values for PID-5 facets and domains that represent values 1.5 SDs above the mean for each of the schizotypy symptoms (Miller et al., 2022; unusual beliefs < 1.59; eccentricity < 1.96; perceptual dysregulation < 1.16). To make the norm independent of each participant's agreement score, for the participants included in the non-schizotypy group, we calculated, for each participant, the norm without that participant, and compared the participant to that norm. To complement this analysis, we also verified that the results did not change when calculating the group profile using all participants. The non-schizotypy data included 391 participants, while the total data used to compute agreement, encompassing both non-schizotypy and schizotypy participants, consisted of 501 participants.

Hierarchical segmentation.

In a well-organized perceptual system, where events are segmented hierarchically, one would anticipate a certain degree of alignment between different levels of segmentation. This alignment reflects a systematic organization of perceptual information, where higher-level event boundaries contain lower-level segmentation cues. To test this, we measured the distance between coarse boundaries and their nearest fine boundary and compared it to the distance expected by chance for the number of fine and coarse boundaries a participant indicated (Hard et al., 2006; Kurby & Zacks, 2008; Zacks et al., 2001).[1] Movies in which participants did not segment at least once for fine or coarse were excluded from the analysis, as hierarchical segmentation analysis requires segmented events. Of the 501 participants who completed both sessions, 14 (3%) participants who did not have data from at least 75% of the movie clips (i.e., less than 6 movie clips) were excluded from the analysis involving hierarchical segmentation, leaving participants with hierarchical segmentation data. First, segmentation times were adjusted as described earlier for segmentation agreement. Then, for each participant and movie clip, the average distance between each coarse boundary and its nearest fine boundaries was calculated. The actual distance was compared to the distance expected by chance, which was computed by averaging the distances between every two fine boundaries and dividing by the total number of fine boundaries (Zacks et al., 2001). To address right skewness, both the actual distance and the chance distance were log-transformed. The difference between these log-transformed distances was then taken as the measure of hierarchical segmentation (Kurby & Zacks, 2008). At the group level, we investigated the presence of hierarchical segmentation. We calculated the average hierarchical segmentation for each participant across all movies. Subsequently, we conducted a one-sample t-test to ascertain if this average differed significantly from zero, which represents the chance level.

Preliminary analyses.

Segmentation measures: Each of the five segmentation measures was included separately in a mixed-level model (implemented using the "lme4" package in R), with movies and movie order

[1] Previous research utilized a discrete measure, which bins the data into 1-second intervals, assessing the presence of both fine and coarse boundaries within each bin. However, it's acknowledged in prior studies that this binning process is arbitrary and can heavily influence the analysis. Consequently, we opted to exclusively incorporate the continuous measure previously employed, which does not encounter the same critique.

treated as fixed effects, alongside an intercept per participant and a slope per participant for movie order. Data points deviating by more than three standard deviations from the mean were excluded. As the number of fine and coarse segments are inherently non-negative and right-skewed, we addressed this non-normality by adding 1 to each count and applying a log transformation to them to mitigate the potential influence of movie order by reducing the magnitude of extreme values while accounting for individual differences in responsiveness to movie order. Consequently, the participant-specific intercepts were derived, representing each participant's segmentation score while controlling for movie order effects and individual movie variations. These intercepts for each measure were subsequently utilized in group-level analyses, as outlined below.

Main analysis.

We performed multiple linear regressions for each of the 5 segmentation measures. We incorporated an average of the schizotypy symptom scores from the PID-5 as predictors, along with age and gender, which were controlled for as confounding variables. A two-tailed t-test was performed on the coefficient estimate of the schizotypy score to test whether there is a significant association between schizotypy and segmentation. To correct for multiple comparisons for the 5 segmentation measures, we applied Bonferroni correction (i.e., the threshold for significance is $p < .01$). When the average schizotypy score yielded significant results, we conducted further analyses to investigate the specificity of the correlation with the three schizotypy symptoms. We did this by implementing an additional linear regression that included each of the sum scores from the schizotypy symptom subscales (unusual beliefs, perceptual dysregulation, and eccentricity). We also followed up with additional control analyses, explained below.

Control analyses.

1. To investigate segmentation measures in schizotypy while controlling for the influence of emotional responses and prior knowledge, participants rated their emotional responses to the movies (i.e. valence and arousal) on a 9-point scale (Bradley & Lang, 2017) for each movie clip. Participants were also asked how familiar they were with the situation presented in the movies, how often they experienced it, and when was the last time they did so to assess their knowledge and familiarity with the movie clips and the situations shown in the movies. We did not design the study to examine how emotional content and prior knowledge might influence segmentation in schizotypy, we used these ratings as controls. These ratings and their interaction (z-scored within participants) were added as fixed effects and slopes per participant to the linear regression model described in the preliminary analysis. That means that the intercept per participant in this control model reflects the segmentation measure for the average emotion rating, accounting for within-participant variance due to emotion. Then, the group-level analyses (a linear regression correlating average schizotypy with segmentation while controlling for age and gender, as above) were repeated with these intercepts.

2. To control for general cognitive function, the main multiple regressions above were repeated including participants' accuracy in each of the three cognitive tasks (see Methods) as covariates. Of note, although participants are required to keep their accuracy above 85% in the additional 'processing' task in the symmetry span (namely, the indication of symmetrical pattern or not; Kane et al., 2004; Unsworth et al., 2005), we did not omit participants that did not reach that score, to be conservative with exclusion, and following research showing that exclusion based on this score does not impact the

reliability of the working memory score from the main task (i.e., remembering the order and location of a sequence of squares on the screen; Đokić et al., 2018).

Results

At the group level, with 501 participants, segmentation agreement was comparable to previous studies (fine: *M* = .55, *SD* = .11; coarse: *M* = .43, *SD* = .12). Also consistent with prior studies, we obtained robust hierarchical segmentation, significantly different from zero which reflects chance-level segmentation (*M* = .44, *SD* = .44; $t_{(486)} = 21.98$, $p < .0001$; Cohen's *d* = 1.00).

Schizotypy Correlates with Poor Event Segmentation

In our primary analyses, coarse agreement, fine agreement, and hierarchical segmentation significantly correlated with schizotypy (p's < .025; Table 1). Specifically, participants who reported higher scores of schizotypy symptoms differed more from the neurotypical group segmentation profile (Table 1; Figure 2) and also showed less hierarchical segmentation. This suggests a less structured organization of perception. Of these, only coarse segmentation agreement survived Bonferroni correction for 5 comparisons ($p < .01$). Thus, follow-up analyses were conducted only on coarse segmentation agreement. Coarse segmentation agreement also correlated with schizotypy when controlling for cognitive functions, the knowledge participants had about the situations in the clips, and emotional response to the movies and remained significant when calculating agreement with the entire group's profile rather than just non-schizotypy (see Methods; *p's* < .006). There was no significant relationship between schizotypy and the number of either coarse or fine segments (*p*'s > .28; Table 1).

We were further interested in which specific schizotypy symptoms — unusual beliefs, perceptual dysregulation, and eccentricity — correlate with coarse agreement. When testing together in one regression the scores from these three schizotypy symptom subscales, only perceptual dysregulation showed a robust significant correlation with the coarse segmentation agreement (standardized $\beta = -0.130$, $t_{(476)} = 2.15$, $p = 0.032$; controlling for cognitive function, knowledge and emotion, as above, $p = 0.037$). Unusual beliefs did initially correlate with coarse segmentation agreement ($p < 0.039$), but not after controlling for cognitive function ($p < 0.129$). Eccentricity did not correlate with coarse segmentation agreement ($p < 0.175$).

Table 1: Main Analysis Statistical Results

Segmentation	**Standardized *β***	***t***	***p***
Number of Fine Segments	-0.051700	1.063	0.288
Number of Coarse Segments	0.004640	0.095	0.925
Fine Agreement	-0.108448	2.259	0.02430 *
Coarse Agreement	-0.135481	2.808	0.00519 **
Hierarchical Agreement	-0.115357	2.331	0.0202 *

Table 1: Main Analysis Statistical Results showing the correlation between segmentation measures and schizotypy. The table presents standardized β, t, and p values for each segmentation measure, including the number of fine segments, number of coarse segments, fine agreement, coarse agreement, and hierarchical agreement. Results demonstrate significant correlations between schizotypy and coarse agreement, fine agreement, and hierarchical segmentation, while controlling for age and gender as demographic factors. Note: $p < .01$ is considered significant after applying Bonferroni correction for multiple comparisons.

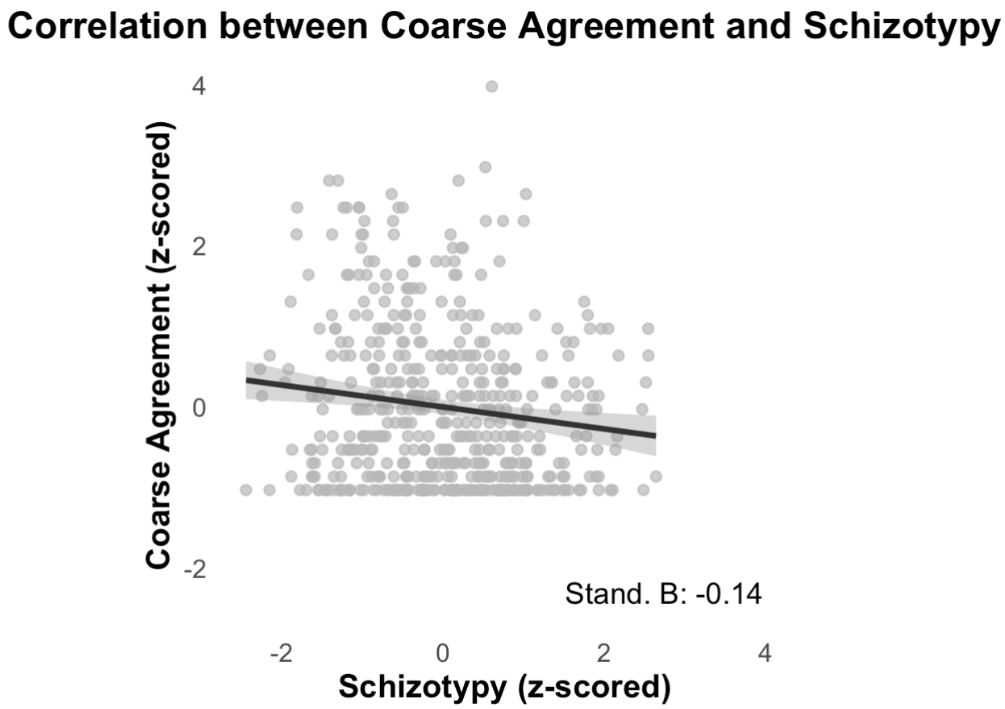

Figure 2: Scatter plot depicting the relationship between Coarse Agreement (z-scored) on the y-axis and Schizotypy (z-scored) on the x-axis in the participant population. Gray points represent individual data points and the black line indicates the linear regression fit to the data, with error bars denoting the confidence interval. The correlation coefficient, calculated as -0.14, is provided in the plot. The analysis controlled for potential confounding variables including gender and age.

Discussion

Humans parse continuous streams of perceptual information and actions into distinct clusters or episodes when the situation changes, a process termed 'event segmentation' (Zacks et al., 2007). In this study, we show that individuals who reported higher levels of schizotypy symptoms exhibited poor segmentation. Specifically, they showed less typical segmentation, namely, decreased agreement with the group segmentation. This was most robust for coarse segmentation, potentially reflecting pronounced difficulties in organizing perceptual experiences into meaningful high-order events.

This study extends previous work in schizophrenia patients (Zalla et al., 2004) to a community (online) sample including individuals with schizotypy. In that previous study, schizophrenia patients identified coarse boundaries less accurately (Zalla et al., 2004). Our results are consistent with Zalla et al.'s (2004) findings, showing an impairment in coarse boundary typicality. Zalla et al. (2004) measured typicality using the percentage of correct boundaries detected, where correct was defined based on the judgment of an independent group of raters indicating boundaries. Only boundaries on which the consensus among them was equal or superior to 80% were considered as prototypical. We measured segmentation agreement by correlating our boundary identifications with a group profile as was prevalent in other studies (e.g., Zacks et al., 2001) (see Methods). Nevertheless, our results converge with Zalla et al.'s (2004) results contributing to the robustness of the findings across the studies. Our findings also parallel Zalla et al.'s (2004) findings, showing no differences in the number of segments for coarse and fine boundaries or impairments in fine segmentation. Importantly, we extend previous results to the schizotypy spectrum by examining symptom strength continuously. Taken together, the results highlight the prevalence of segmentation impairments across the schizophrenia spectrum, extending beyond clinically diagnosed patients.

One conceptual framework for interpreting these findings and their relationship with hallucinations in schizophrenia could be understanding event segmentation in the context of our prior knowledge and beliefs (shortly 'priors,' in Bayesian theory), and the updating of these priors given evidence (Corlett et al., 2019; Kube & Rozenkrantz, 2021). Priors lead us to make predictions or hypotheses about the source of perceived sensory information. For example, in that framework, I 'hypothesize' that my dog is the collection of lines and brown colors reaching the early visual cortex of my brain. Then, this prediction is compared to incoming information (i.e., is it my dog, or maybe another dog?). If there is a mismatch between our prediction and perceptual input, this is a prediction error. This prediction error can, in turn, lead to updating of our prior beliefs, so that the next time our predictions will be more accurate (Corlett et al., 2019; Kube & Rozenkrantz, 2021).

Event models can be conceptualized as priors because they provide structured representations and expectations of potential outcomes based on past data or knowledge (Franklin et al., 2020). Like priors, event models need to be updated when surprising experience is encountered, as well as replaced at boundaries, in which perceptual information is inconsistent with the event model (Zacks, 2007; 2020). However, if the priors are very strong, they might remain unchanged, despite contradictory sensory evidence, leading to inappropriate event models.

In schizophrenia and schizotypy, it has been suggested that strong priors that remain unchanged can cause hallucinations (Corlett et al., 2019). Indeed, empirical studies have shown that strong priors can induce hallucinations in both healthy individuals and those prone to hallucinations (Powers et al., 2017). Powers and colleagues (2017) trained four different groups of participants, each with varying levels of voice-hearing to associate a tone with visual stimuli. Using functional neuroimaging and computational modeling of perception modeling, they found that participants who typically heard voices (i.e., prone to hallucinations) held strong prior beliefs about voice existence which led them to not viewing the induced auditory hallucinations as contradictory evidence. Therefore, those prone to hallucinations did not update their models. This rigidity in updating priors may explain the challenges with event segmentation observed in schizophrenia spectrum disorders if event models are not updated appropriately. Conversely, impaired event segmentation can contribute to the formation and strengthening of overly strong priors. If individuals with schizotypy have difficulty segmenting and organizing observed perceptual information into meaningful events, they may rely more heavily on their existing priors to make sense of their surroundings. This over-reliance on strong and inflexible priors could, in turn, further hinder their ability to update their event models in response to new sensory information, creating a feedback loop that reinforces their susceptibility to hallucinations and other psychotic symptoms.

Consistent with this suggestion, in our study, we found that symptoms of perceptual dysregulation specifically correlated with impaired coarse segmentation agreement (more than eccentricity and unusual beliefs). This dysregulation includes experiences like altered object perceptions, feelings of an unreal environment, and thoughts of being controlled by others, which correspond to hallucinations and confabulations. Therefore, impaired segmentation can either lead to or result from these false perceptions, disrupting normal sensory processing and perception of reality.

Limitations.

Everyday life situations oftentimes involve many sensory modalities that extend beyond visual and auditory information such as touch, smell, and motion that interact to create complex and cohesive experiences. Multisensory integration (MSI), the ability to blend information from different sensory modalities, is necessary to form a coherent and comprehensive perception of our environments (Talsma et al., 2010). Individuals with schizophrenia suffer from impairments in MSI, particularly in visual, auditory, and tactile modalities (de Jong et al., 2009; Gelder et al., 2003; Liu et al., 2020). Our study focused on the visual and auditory senses. While we see no reason that these impairments would not persist across all sensory modalities, this should be empirically tested. In future studies, researchers could employ virtual reality technology to explore the impact of MSI impairments on the segmentation of events including various sensory modalities.

Here, as in previous studies (Sargent et al., 2013; Zacks et al., 2001; Zalla et al, 2004), we used rich movie stimuli. While these movies aim to capture the complexity of everyday life events, their structured narratives may not capture life's unpredictability and complexity, where outcomes are less predictable and open to varied interpretations. This is especially relevant for individuals with schizophrenia because previous research has found that they have a difficult time forming a conceptual framework to understand ambiguous stimuli (Haut et al., 1996). Our movie clips didn't directly test this aspect, suggesting that future work could explore more unpredictable and complex stimuli to better reflect the uncertainty of everyday life

Future Directions.

Emotion has been shown to alter event segmentation (Clewett et al., 2020; McClay et al., 2023; Riegel et al., 2023). Individuals with schizophrenia exhibit abnormalities in emotion perception, experience, regulation, and expression (Kring, 1999). For example, they report fewer positive experiences and exhibit less outward emotion. Also, people with disorganized symptoms exhibit a bias towards attending and remembering more negative information (Phillips et al., 2005; Hall et al., 2007; Horan et al., 2006), and in interpreting events (Phillips et al., 2000). This suggests that emotion can influence how individuals with schizotypy segment complex events. Considering this possibility, we controlled for emotional response in our analysis, and the relationship between coarse segmentation agreement and schizotypy remained significant. However, we did not measure emotion as participants watched the movie clips (only collected a rating after each clip) because we did not want it to interfere with the segmentation task.

To assess emotional response continuously without interrupting segmentation, a future study could measure pupil dilation during movie watching, as a marker of arousal signals. Salient environmental changes, such as hearing an unexpected sound, can activate central arousal systems that regulate ongoing attention and memory processes across the brain (Berridge & Waterhouse, 2003; Bouret & Sara, 2005; Sara, 2009). Furthermore, arousal signals mediate some of the same cognitive processes that are thought to be triggered by event boundaries, including cognitive control, prediction errors, and attention re-orienting (Rouhani et al., 2020; Sara, 2009; Zacks et al., 2011; Zacks et al., 2007). Emerging evidence also suggests that arousal responses are sensitive to the structure of temporally extended experiences (Bianco et al., 2020; Zhao et al., 2019). For instance, pupil dilation occurs when a highly organized and repeated sequence of auditory tones suddenly transitions to a randomized sequence of tones (Zhao et al., 2019). Specifically for event segmentation, one study showed that indeed pupils dilate at event boundaries, and suggested that characteristics of pupillary reflect both the stability and changes in ongoing mental context representations (Clewett et al., 2020). Together, these findings suggest that arousal dysregulation, a proposed feature of schizophrenia (Williams et al., 2004), may contribute to the segmentation deficits observed in schizophrenia spectrum disorders.

Conclusion

Our study investigated the relationship between event segmentation and schizotypy. Individuals reporting higher schizotypal symptoms showed less typical segmentation, as measured by lower agreement with the group segmentation profile. Furthermore, our analysis revealed that perceptual dysregulation, a specific schizotypy symptom, significantly correlated with coarse segmentation agreement, highlighting its relevance in event perception abnormalities. Our study highlights deficits in event segmentation among individuals with schizotypy and emphasizes the importance of considering perceptual organization deficits in schizophrenia spectrum disorders. More broadly, our study identifies a relationship between event segmentation research and mental health. Future research could further specify this relationship, understand its underlying mechanisms, and explore its significance to clinical interventions and outcomes.

I pledge my honor that this paper represents my work in accordance with University regulations.

/s/ Cara Suliman Khalifeh

References

Baldassano, C., Chen, J., Zadbood, A., Pillow, J. W., Hasson, U., & Norman, K. A. (2017). Discovering Event Structure in Continuous Narrative Perception and Memory. *Neuron*, *95*(3), 709-721. 10.1016/j.neuron.2017.06.041

Baldassano, C., Hasson, U., & Norman, K. A. (2018). Representation of Real-World Event Schemas during Narrative Perception. *The Journal of Neuroscience*, *38*(45), 9689-9699. 10.1523/JNEUROSCI.0251-18.2018

Baldwin, D. A., & Baird, J. A. (2001). Discerning intentions in dynamic human action. *Trends in Cognitive Sciences*, *5*(4), 171-178. 10.1016/s1364-6613(00)01615-6

Barrantes-Vidal, N., Grant, P., & Kwapil, T. R. (2015). The Role of Schizotypy in the Study of the Etiology of Schizophrenia Spectrum Disorders. *Schizophrenia Bulletin*, *41*(Suppl 2), S408–S416. 10.1093/schbul/sbu191

Berridge, C. W., & Waterhouse, B. D. (2003). The locus coeruleus-noradrenergic system: modulation of behavioral state and state-dependent cognitive processes. *Brain Research*, *42*(1), 33-84. 10.1016/s0165-0173(03)00143-7

Bianco, R., Ptasczynski, L. E., & Omigie, D. (2020). Pupil responses to pitch deviants reflect predictability of melodic sequences. *Brain and Cognition*, *138*. https://doi.org/10.1016/j.bandc.2019.103621

Bilker, W. B., Hansen, J. A., Brensinger, C. M., Richard, J., Gur, R. E., & Gur, R. C. (2012). Development of Abbreviated Nine-item Forms of the Raven's Standard Progressive Matrices Test. *Assessment*, *19*(3), 354–369. 10.1177/1073191112446655

Boggia, J., & Ristic, J. (2015). Social event segmentation. *Quarterly Journal of Experimental Psychology*, *68*(4), 731-744. https://doi.org/10.1080/17470218.2014.964738

Bouret, S., & Sara, S. J. (2005). Network reset: a simplified overarching theory of locus coeruleus noradrenaline function. *Trends in Neurosciences*, *28*(11), 574-582. 10.1016/j.tins.2005.09.002

Bradley, M. M., & Lang, P. L. (2017). International Affective Picture System In: Zeigler-Hill, V., Shackelford, T. (eds). *Encyclopedia of Personality and Individual Differences*, 1-4. https://doi.org/10.1007/978-3-319-28099-8_42-1

Clewett, D., DuBrow, S., & Davachi, L. (2019). Transcending time in the brain: How event memories are constructed from experience. *Hippocampus*, *29*(3), 162-183. https://doi.org/10.1002/hipo.23074

Clewett, D., Gasser, C., & Davachi, L. (2020). Pupil-linked arousal signals track the temporal organization of events in memory. *Nature Communications*, *11*, 4007. https://doi.org/10.1038/s41467-020-17851-9

Corlett, P. R., Horga, G., Fletcher, P. C., Alderson-Day, B., Schmack, K., & Powers III, A. R. (2019). Hallucinations and Strong Priors. *Trends in Cognitive Sciences*, *23*(2), 114-127. https://doi.org/10.1016/j.tics.2018.12.001

de Boer, J. N., Linszen, M. M. J., de Vries, J., Schutte, M. J. L., Begemann, M. J. H., Heringa, S. M., Bohlken, M. M., Hugdahl, K., Aleman, A., Wijnen, F. N. K., & Sommer, I. E. C. (2019). Auditory hallucinations, top-down processing and language perception: a general population study. *Psychological Medicine*, *49*(16), 2772–2780. https://doi.org/10.1017/S003329171800380X

de Jong, J.J., Hodiamont, P.P.G., Van den Stock, J., & de Gelder, B. (2009). Audiovisual emotion recognition in schizophrenia: Reduced integration of facial and vocal affect. *Schizophrenia Research*, *107*(2-3), 286-293. https://doi.org/10.1016/j.schres.2008.10.001

Đokić, R., Koso-Drljević, M., & Đapo, N. (2018). Working memory span tasks: Group administration and omitting accuracy criterion do not change metric characteristics. *PLoS ONE*, *13*(10). https://doi.org/10.1371/journal.pone.0205169

DuBrow, S., & Davachi, L. (2016). Temporal binding within and across events. *Neurobiology of Learning and Memory*, *134*(Pt. A), 107-114. 10.1016/j.nlm.2016.07.011

Eisenberg, D. P., & Berman, K. F. (2009). Executive Function, Neural Circuitry, and Genetic Mechanisms in Schizophrenia. *Neuropsychopharmacology Reviews*, *35*, 258–277. https://doi.org/10.1038/npp.2009.111

Eisenberg, M. L., Sargent, J. Q., & Zacks, J. M. (2016). Posttraumatic Stress and the Comprehension of Everyday Activity. *Collabra: Psychology*, *2*(1), 11. 10.1525/collabra.43

Ettinger, U., Meyhöfer, I., Steffens, M., Wagner, M., & Koutsouleris, N. (2014). Genetics, Cognition, and Neurobiology of Schizotypal Personality: A Review of the Overlap with Schizophrenia. *Frontiers in Psychiatry*, *5*. https://doi.org/10.3389/fpsyt.2014.00018

Ezzyat, Y., & Davachi, L. (2011). What constitutes an episode in episodic memory? *Psychological Science*, *22*(2), 243-252. 10.1177/0956797610393742

Fanous, A. H., Neale, M. C., Gardner, C. O., Webb, B. T., Straub, R. E., O'Neill, F. A., Walsh, D., Riley, B. P., & Kendler, K. S. (2007). Significant correlation in linkage signals from genome-wide scans of schizophrenia and schizotypy. *Molecular Psychiatry*, *12*, 958–965. https://doi.org/10.1038/sj.mp.4001996

Franklin, N. T., Norman, K. A., Ranganath, C., Zacks, J. M., & Gershman, S. J. (2020). Structured Event Memory: A neuro-symbolic model of event cognition. *Psychological Review*, *127*(3), 327–361. https://doi.org/10.1037/rev0000177

Gelder, B. d., Vroomen, J., Annen, L., Masthof, E., & Hodiamont, P. (2003). Audio-visual integration in schizophrenia. *Schizophrenia Research*, *59*(2-3), 211-218. https://doi.org/10.1016/S0920-9964(01)00344-9

Gillan, C. M., Kosinski, M., Whelan, R., Phelps, E. A., & Daw, N. D. (2016). Characterizing a psychiatric symptom dimension related to deficits in goal-directed control. *Elife*, *5*, e11305. https://doi.org/10.7554/eLife.11305

Green, M. F. (2006). Cognitive impairment and functional outcome in schizophrenia and bipolar disorder. *The Journal of Clinical Psychiatry*, *67*(Suppl 9), 3-8. https://pubmed.ncbi.nlm.nih.gov/16965182/

Hall, J., Harris, J. M., McKirdy, J. W., Johnstone, E. C., & Lawrie, S. M. (2007). Emotional memory in schizophrenia. *Neuropsychologia*, *45*(6), 1152-1159. https://doi.org/10.1016/j.neuropsychologia.2006.10.012

Hard, B. M., Tversky, B., & Lang, D. S. (2006). Making Sense of Abstract Events: Building Event Schemas. *Memory & Cognition*, *34*(6), 1221–1235. https://doi.org/10.3758/BF03193267

Hartshorne, J. K., & Germine, L. T. (2015). When does cognitive functioning peak? The asynchronous rise and fall of different cognitive abilities across the lifespan. *Psychological Science*, *26*(4), 433–443. 10.1177/0956797614567339

Haut, M. W., Cahill, J., Cutlip, W. D., Stevenson, J. M., Makela, E. H., & Bloomfield, S. M. (1996). On the nature of Wisconsin Card Sorting Test performance in schizophrenia. *Psychiatry Research*, *65*(1), 15-22. https://doi.org/10.1016/0165-1781(96)02940-X

Horan, W. P., Kring, A. M., & Blanchard, J. J. (2006). Anhedonia in Schizophrenia: A Review of Assessment Strategies. *Schizophrenia Bulletin*, *32*(2), 259–273. https://doi.org/10.1093/schbul/sbj009

Howes, O. D., & Kapur, S. (2009). The Dopamine Hypothesis of Schizophrenia: Version III—The Final Common Pathway. *Schizophrenia Bulletin*, *35*(3), 549–562. https://doi.org/10.1093/schbul/sbp006

Kane, M. J., Hambrick, D. Z., Tuholski, S. W., Wilhelm, O., Payne, T. W., & Engle, R. W. (2004). The generality of working memory capacity: a latent-variable approach to verbal and visuospatial memory span and reasoning. *Journal of Experimental Psychology: General*, *133*(2), 189-217. 10.1037/0096-3445.133.2.189

Karbakhsh, H., Kouchakzadeh, A., & Gharibzadeh, S. (2023). The Conflict between Top-down and Bottom-up Impairments in Consciousness Disorder in Schizophrenia. *Current Psychiatry Research and Reviews*. 10.2174/2666082219666230907093951

Kring, A. M. (1999). Emotion in Schizophrenia: Old Mystery, New Understanding. *Current Directions in Psychological Science*, *8*(5), 160-163. https://doi.org/10.1111/1467-8721.00

Krueger, R. F., Derringer, J., Markon, K. E., Watson, D., & Skodol, A. E. (2012). Initial Construction of a Maladaptive Personality Trait Model and Inventory for DSM-5. *Psychological Medicine*, *42*(9), 1879–1890. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3413381/

Kurby, C. A., & Zacks, J. M. (2008). Segmentation in the perception and memory of events. *Trends in Cognitive Sciences*, *12*(2), 72-79. 10.1016/j.tics.2007.11.004

Lenzenweger, M. F. (2018). Schizotypy, schizotypic psychopathology and schizophrenia. *World Psychiatry*, *17*(1), 25–26. 10.1002/wps.20479

Lewis, D. A., & Lieberman, J. A. (2000). Catching Up on Schizophrenia: Natural History and Neurobiology. *Neuron*, *28*(2), 325-334. https://doi.org/10.1016/S0896-6273(00)00111-2

Liu, D., Fan, H. Z., Zhao, W. X., Wang, Y. H., Li, D., Wu, J. L., Yan, T. Y., & Tan, S. P. (2020). Deficits of Tactile Passive Perception Acuity in Patients With Schizophrenia. *Front Psychiatry*, *11*, 519248. 10.3389/fpsyt.2020.519248

Marder, S. R., & Freedman, R. (2014). Learning From People With Schizophrenia. *Schizophrenia Bulletin*, *40*(6), 1185–1186. https://doi.org/10.1093/schbul/sbu096

McClay, M., Sachs, M. E., & Clewett, D. (2023). Dynamic emotional states shape the episodic structure of memory. *Nature Communications*, *14*, 6533. https://doi.org/10.1038/s41467-023-42241-2

Michelmann, S., Price, A. R., Aubrey, B., Strauss, C. K., Doyle, W. K., Friedman, D., Dugan, P. C., Devinsky, O., Devore, S., Flinker, A., Hasson, U., & Norman, K. A. (2021). Moment-by-moment tracking of naturalistic learning and its underlying hippocampo-cortical interactions. *Nature Communications*, *12*(1), 5394. 10.1038/s41467-021-25376-y

Miller, J. D., Bagby, R. M., Hopwood, C. J., Simms, L. J., & Lynam, D. R. (2022). Normative data for PID-5 domains, facets, and personality disorder composites from a representative sample and comparison to community and clinical samples. *Personality Disorders: Theory, Research, and Treatment*, *13*(5), 536–541. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10052968/

Newtson, D. (1973). Attribution and the unit of perception of ongoing behavior. *Journal of Personality and Social Psychology*, *28*(1), 28–38. https://doi.org/10.1037/h0035584

Orellana, G., & Slachevsky, A. (2013). Executive Functioning in Schizophrenia. *Front Psychiatry*, *4*, 35. 10.3389/fpsyt.2013.00035

Phillips, L. K., Deldin, P. J., Voglmaier, M. M., & Rabbitt, S. (2005). Emotional Stroop performance predicts disorganization in schizophrenia. *Schizophrenia Research*, *77*(2-3), 141-149. https://doi.org/10.1016/j.schres.2005.02.009

Phillips, M. L., Senior, C., & David, A. S. (2000). Perception of threat in schizophrenics with persecutory delusions: an investigation using visual scan paths. *Psychological Medicine*, *30*(1), 157-167. doi:10.1017/S0033291799001397

Powers, A. R., Mathys, C., & Corlett, P. R. (2017). Pavlovian conditioning–induced hallucinations result from overweighting of perceptual priors. *Science*, *357*(6351), 596-600. 10.1126/science.aan3458

Riegel, M., Granja, D., Amer, T., Vuilleumier, P., & Rimmele, U. (2023). Opposite effects of emotion and event segmentation on temporal order memory and object-context binding. *Cognition and Emotion*, 1–19. https://doi.org/10.1080/02699931.2023.2270195

Rouhani, N., Norman, K. A., Niv, Y., & Bornstein, A. M. (2020). Reward prediction errors create event boundaries in memory. *Cognition*, *203*. https://doi.org/10.1016/j.cognition.2020.104269

Sara, S. J. (2009). The locus coeruleus and noradrenergic modulation of cognition. *Nature Reviews Neuroscience*, *10*, 211–223. https://doi.org/10.1038/nrn2573

Sargent, J. Q., Zacks, J. M., Hambrick, D. Z., Zacks, R. T., Kurby, C. A., Bailey, H. R., Eisenberg, M. L., & Beck, T. M. (2013). Event segmentation ability uniquely predicts event memory. *Cognition*, *129*(2), 241-255. 10.1016/j.cognition.2013.07.002

Swallow, K. M., Zacks, J. M., & Abrams, R. A. (2009). Event boundaries in perception affect memory encoding and updating. *Journal of Experimental Psychology: General*, *138*(2), 236–257. https://doi.org/10.1037/a0015631

Talsma, D., Senkowski, D., Soto-Faraco, S., & Woldorff, M. G. (2010). The multifaceted interplay between attention and multisensory integration. *Trends in Cognitive Sciences*, *14*(9), 400-410. https://doi.org/10.1016/j.tics.2010.06.008

Unsworth, N., Heitz, R. P., Schrock, J. C., & Engle, R. W. (2005). An automated version of the operation span task. *Behavior Research Methods*, *37*(3), 498-505. 10.3758/bf03192720

Vuilleumier, P. (2005). How brains beware: neural mechanisms of emotional attention. *Trends in Cognitive Science*, *9*(12), 585-594. https://doi.org/10.1016/j.tics.2005.10.011

Williams, L. M., Das, P., Harris, A. W. F., Liddell, B. B., Brammer, M. J., Olivieri, G., Skerrett, D., Phillips, M. L., David, A. S., Peduto, A., & Gordon, E. (2004). Dysregulation of Arousal and Amygdala-Prefrontal Systems in Paranoid Schizophrenia. *American Journal of Psychiatry*, *161*(3), 480-489. https://doi.org/10.1176/appi.ajp.161.3.480

Zacks, J. M. (2020). Event Perception and Memory. *Annual Review of Psychology*, *4*(71), 165-191. 10.1146/annurev-psych-010419-051101

Zacks, J. M., Kurby, C. A., Eisenberg, M. L., & Haroutunian, N. (2011). Prediction error associated with the perceptual segmentation of naturalistic events. *Journal of Cognitive Neuroscience*, *23*(12), 4057-4066. 10.1162/jocn_a_00078

Zacks, J. M., Kurby, C. A., Landazabal, C. S., Krueger, F., & Grafman, J. (2016). Effects of Penetrating Traumatic Brain Injury on Event Segmentation and Memory. *Cortex*, *74*, 233-46. 10.1016/j.cortex.2015.11.002

Zacks, J. M., & Sargent, J. Q. (2010). Chapter 7—Event Perception: A Theory and Its Application to Clinical Neuroscience. In *Psychology of Learning and Motivation* (B. H. Ross (Ed.) ed., Vol. 53, pp. 253–299). Elsevier. https://doi.org/10.1016/S0079-7421(10)53007-X

Zacks, J. M., Speer, N. K., Swallow, K. M., Braver, T. S., & Reynolds, J. R. (2007). Event Perception: A Mind/Brain Perspective. *Psychological Bulletin*, *133*(2), 273-293. 10.1037/0033-2909.133.2.273

Zacks, J. M., Tversky, B., & Gowri, I. (2001). Perceiving, remembering, and communicating structure in events. *Journal of Experimental Psychology*, *130*(1), 29–58. https://doi.org/10.1037/0096-3445.130.1.29

Zalla, T., Bouchilloux, N., Labruyere, N., Georgieff, N., Bougerol, T., & Franck, N. (2006). Impairment in event sequencing in disorganised and non-disorganised patients with schizophrenia. *Brain Research Bulletin*, *68*(4), 95-202. 10.1016/j.brainresbull.2005.04.020

Zalla, T., Verlut, I., Franck, N., Puzenat, D., & Angela, S. (2004). Perception of dynamic action in patients with schizophrenia. *Psychiatry Research*, *128*(1), 39–51. https://doi.org/10.1016/j.psychres.2003.12.026

Zhao, S., Chait, M., Dick, F., Dayan, P., Furukawa, S., & Liao, H.-I. (2019). Pupil-linked phasic arousal evoked by violation but not emergence of regularity within rapid sound sequences. *Nature Communications*, *10*. https://doi.org/10.1038/s41467-019-12048-1

Zorowitz, S., & Bennett, D. (2022). *NivTurk*, (v1.2-Prolific) [Zenodo]. https://doi.org/10.5281/zenodo.6609218

Zorowitz, S., Solis, J., Niv, Y., & Bennett, D. (2023). Inattentive responding can induce spurious associations between task behaviour and symptom measures. *Nature Human Behaviour*, *7*(10), 1667–1681. https://doi.org/10.1038/s41562-023-01640-7