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SUPPLEMENT ARTICLE

The Relationship Between Schizotypal Personality Traits and Temporal Discounting: The Role of the Date/Delay Effect

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***Background and Hypothesis*: Many patients with psychiatric disorders show increased temporal discounting (TD), ie, they discount future rewards more steeply than healthy controls. However, findings for schizophrenia and schizotypy, a personality constellation considered to be on the schizophrenia spectcrum, are less clear. Moreover, the role of future time representation in TD in the schizophrenia spectrum has not been examined. We hypothesized positive associations between schizotypal personality traits and TD and reduced TD when the timepoint of future rewards is represented in dates rather than delay units (the date/delay effect). Further, we explored associations between schizotypy and the magnitude of the date/delay effect. *Study Design*: We conducted a large-scale, general-population online study (N = 1000) assessing TD with the Monetary Choice Questionnaire (MCQ) and schizotypal traits with the Short Oxford-Liverpool Inventory of Feelings and Experiences (sO-LIFE). Time representation in the MCQ (dates vs delays) was manipulated within subject. *Study Results*: Associations between TD and sO-LIFE subscales were not significant after Bonferroni correction (all $r \leq .06$). The date/delay effect was successfully replicated ($P < .001$, $g_{av} = 0.22$). Interestingly, higher values in the sO-LIFE Unusual Experiences subscale predicted the magnitude of the date/delay effect when controlling for influences of other sO-LIFE subscales, age, education, and drug use. *Conclusions*: TD was not associated with schizotypy, but individuals with higher levels of positive schizotypy were more sensitive to manipulations of the representation of future timepoints. Future studies should focus on these processes as potential mechanisms in the development and treatment of cognitive-perceptual deficits in the schizophrenia spectrum.**

Key words: future time perception/intertemporal choices/MCQ/schizotypy/sO-LIFE

Introduction

Schizotypy refers to a personality constellation resembling schizophrenia symptoms on a subclinical level and reflecting vulnerability for schizophrenia.[1] Schizotypy comprises positive, negative, and disorganized dimensions,[2] although some conceptualizations include impulsive nonconformity as a fourth dimension.[3] The fully dimensional approach, conceptualizing schizotypy as personality dimensions within the general population,[4] has gained support by studies revealing a continuum between schizotypal traits and psychotic disorders like schizophrenia.[5–10] Therefore, studies examining schizotypy in the general population do not only allow conclusions to be drawn about this multifaceted construct itself but also about the etiology and mechanisms underlying schizophrenia[5,9,11] whilst excluding confounds such as medication.[9] For instance, higher levels of schizotypy are, like schizophrenia, associated with deficits in cognitive functions such as attention, working memory, and language,[7,11,12] albeit with less pronounced effect sizes.[9] Parallels between schizotypy and schizophrenia can also be found in maladaptive behaviors such as increased nicotine[13–16] and cannabis consumption,[14,17,18] or decreased physical activity,[19,20] pointing to more impulsive decision making and deficits in pursuing long-term goals in individuals on the schizophrenia spectrum.

Impulsive decision making can be assessed with intertemporal choice tasks, in which participants choose between smaller rewards available sooner and larger

rewards available later. This phenomenon of subjectively devaluing future rewards is known as delay discounting or temporal discounting (TD).[21] Steeper TD is related to individual differences in impulsivity[22–24] and to a broad range of mental disorders,[25] including schizophrenia.[26–33] Steeper TD has also been found in high schizotypy.[34–36] However, for both schizophrenia and schizotypy, findings are not entirely consistent.[31,36–40] Given that only few studies have examined associations between schizotypy and TD, with most applying an extreme group approach,[34,35] further research is warranted to explore the entire continuum.

Beyond establishing the association between schizophrenia spectrum phenotypes and TD, its potential origins remain unclear. Hypotheses[33,34] include roles of cognitive deficits, genetics, smoking (given that smoking is both highly prevalent in schizophrenia[13,15] and related to TD[41]) and disease symptoms and medication. Importantly, studies in schizophrenia patients revealed that cognitive deficits at least partly play a role,[26–30,32,33] as patients represent future rewards differently than controls. In intertemporal choice tasks, divergent representations of future rewards may have three causes: aberrant valuation of *rewards*,[42–44] aberrant valuation of (future) *time*,[44–47] and aberrant cognitive mechanisms or strategies in the *integration* of reward and time information.[48,49]

All of these can potentially be observed in schizophrenia. First, schizophrenia patients show deviations in reward processing and valuation.[50–52] Particularly, they show reduced motivational drive and anticipatory pleasure than healthy controls[51,53–55] and use less—or biased—information on reward, probability, and effort to make decisions.[31,55–58] As a result, they are less sensitive to changes in these environmental variables, ultimately leading to potentially maladaptive and impulsive behaviors.[57] Second, schizophrenia patients show altered time processing and perception,[59–61] resulting in decreased precision (ie, higher variability) and, in some tasks, aberrant accuracy of time estimates. A recent meta-analysis[60] showed that schizophrenia patients perceive durations, depending on the task, as either longer or shorter than objective time, reflecting altered internal clock mechanisms[62] and/or cognitive deficiencies relating to working memory.[63] Third, in agreement with working memory deficits in schizophrenia, schizophrenia patients show impairments in integrating affective and cognitive decision features, such as reward and time information of two options.[50,64]

Importantly, altered time estimation in schizophrenia not only concerns present time[60] but also future time,[30,65] ie, estimating time periods that individuals have not yet experienced.[46] Since the latter is essential in intertemporal choices,[46,66,67] it may be that schizophrenia spectrum individuals subjectively overestimate reward delays in intertemporal choice tasks.[66,68,69] In combination with above-mentioned differences in reward processing, which, incidentally, also lead to less anticipatory pleasure for more distal rather than proximal rewards,[34,70,71] overestimation of delay would ultimately lead to increased impatience and more impulsive behaviors.

The same argumentation may apply to schizotypy, where deviations in reward[35,54,72] and time processing[73,74] have also been found. However, it should be mentioned that for schizotypy, studies of the complete continuum are scarce and results are less consistent than for schizophrenia, particularly with regards to time perception where findings mostly refer to retrospective time bisection tasks[73–75] that generally revealed evidence of a decelerated internal clock.[60]

Thus, increased TD in the schizophrenia spectrum might be caused by alterations in reward or time processing or their integration. While previous studies have emphasized the role of reward processing,[27,34] here we wished to determine whether TD differences are partly due to altered time processing. Given that intertemporal choice tasks involve both reward- and time-related information, measuring the influence of either in isolation is difficult. However, differences in choice due to time perception may be examined using a framing that specifically manipulates sensitivity to time: Usually, time in intertemporal choice tasks is presented in delay units (ie, days) from the present. However, when time is framed in dates, TD is reduced compared to the standard delay condition, an effect known as the date/delay effect.[76–79] While the exact cognitive mechanisms underlying the effect are not entirely clear, time sensitivity likely plays a major role. Specifically, time periods represented by dates are perceived as shorter than those represented by time units.[80] Thus, this manipulation of time attributes can be drawn upon to offer novel insights into the mechanisms that may underlie altered intertemporal choice in schizotypy.

In this preregistered study, we assessed schizotypal personality traits in a large, general-population sample (N = 1000) to investigate two primary research goals: First, given inconsistent associations between TD and schizotypy,[34–36,40] we aimed to examine, for the first time, the association of TD with the four dimensions of schizotypy assessed by the Short Oxford-Liverpool Inventory of Feelings and Experiences (sO-LIFE).[81] Second, we attempted to replicate the date/delay effect and relate it to schizotypy in order to draw conclusions about the mechanisms of decision making impairments in the schizophrenia spectrum. We hypothesized that (1) TD is positively associated with schizotypy[81] in the original delay condition and that (2) the date/delay effect[76,77] is replicated, and we planned to investigate whether the magnitude of the date/delay effect is associated with schizotypy.

Methods

Participants

Based on an *a priori* power analysis with G*Power,[82] we aimed for 1000 participants (≥18 years), providing

88.68% power to reveal a correlation of $r = 0.1$ between schizotypy and TD (two-tailed alpha level of 0.05; see preregistration: https://osf.io/7jxf9). To exclude careless responders, we used 10 items adapted from Jackson's Infrequency Scale[83] (eg, "Have you ever kept a pet monkey for years?") embedded within the sO-LIFE. All participants who gave at least one "infrequent" answer were excluded before data analysis. Additionally, we followed recommendations[84] to exclude participants with low consistency in their response patterns in the Monetary Choice Questionnaire (MCQ).[85] Specifically, we excluded participants with consistency of <0.80 within any of the different magnitudes (small, medium, large) of either MCQ version (delay/date).

The study was advertised via social media and student mailing lists and data were collected online via Unipark (Tivian XI GmbH, Cologne, Germany). As incentives, participants were given the opportunity to take part in a lottery to win one of five Amazon vouchers (€25 each) and psychology students could additionally receive course credit (which was erroneously not mentioned in our preregistration). Study procedures were approved by the ethics committee of the Department of Psychology of the University of Bonn. In total, 1338 participants completed the study, 338 of whom had to be excluded due to infrequency or consistency criteria, leaving a final sample of $N = 1000$. All participants provided written consent. Participants (25.6% male, 73.9% female, 0.5% diverse) were on average 29.93 years old (SD = 11.88; range 18–81) and had relatively high educational levels (Supplementary Material A: 9.7% low, 50.5% medium, 38.8% high education; no response: 1.0%).

Measures

Monetary Choice Questionnaire (MCQ) To assess TD, we used the MCQ[85] in a German version. The MCQ comprises 27 decisions between smaller-immediate (SIR) and larger-later rewards (LLR). Items can be divided into three different levels of reward magnitudes, with 9 items at each magnitude level: small (LLR range: €25–€35), medium (LLR range: €50–€60), and large (LLR range: €75–€85). The MCQ has been validated in clinical and nonclinical populations[24,85] and shows high test–retest reliability.[86] As we wanted to examine the date/delay effect,[76,77] two different MCQ versions were used: the time interval until receipt of the LLR was presented either as number of days (eg, "in 117 days") or as dates (eg, "on 30th November 2023"). Participants completed both versions. Choices were hypothetical; however, participants were instructed to answer as if they would actually receive the rewards. The presentation order of items was as in Kirby et al.,[85] but the presentation order of the two versions was randomized. Choice consistency and hyperbolic discount rates were estimated based on previous procedures[85] and syntax.[84] After checking for sufficiently consistent choices, discount rates for each of the 3 magnitude levels in each version were combined into a single index (k) for each version by calculating their geometric mean. Subsequently, discount rates were log-transformed due to skewness (delay: skew = 5.62, SE = 0.08; date: skew = 6.93, SE = 0.08).

Short Oxford-Liverpool Inventory of Feelings and Experiences (sO-LIFE) The sO-LIFE[81] comprises 43 items covering four schizotypy dimensions: (1) unusual experiences (UE), reflecting positive schizotypy (eg, odd perceptual experiences, magical thinking); (2) cognitive disorganization (CD), reflecting disorganized schizotypy (eg, difficulties in attention and decision making, social anxiety); (3) introvertive anhedonia (IA), reflecting negative schizotypy (eg, lack of pleasure, avoidance of intimacy); and (iv) impulsive nonconformity (IN), reflecting impulsive and eccentric behaviors (eg, lack of self-control, antisociality). sO-LIFE subscales show high test–retest-reliabilities (0.69–0.87 for a 1-month interval) and acceptable-to-high internal consistencies (0.62–0.80).[87] Here, a German version was administered.[88] Participants provided dichotomous responses ("no" or "yes") and a sum score was computed for each subscale.

Alcohol, Smoking and Substance Involvement Screening Test (ASSIST) The ASSIST (version 3.1)[89,90] is a measure developed by the World Health Organization (WHO) to screen for problematic substance use, resulting in risk scores for a range of psychoactive substances (such as tobacco products, alcohol, cannabis, etc.). For each substance, up to 8 questions are asked, referring to amount, craving and negative consequences of drug use and failed abstinence attempts. Given that our study was conducted online, we used the ASSIST as self-report measure. Alcohol items were omitted since we also used the Alcohol Use Disorders Identification Test (AUDIT).[91] Scoring was done according to the manual,[89] with a potential sum score range from 0 to 33 (due to a programming error, question number 3 of the ASSIST was not displayed for any drug, which is why the sum score does not go up to 39 and is not comparable to other studies; given that we only use a small part of the ASSIST as control variable, the missing item is unlikely to influence the results). If a participant indicated that they never had consumed any of the substances (item 1) nor any of them in the last three months (item 2), all subsequent questions were skipped, resulting in a score of 0. In our statistical analysis, we solely used the tobacco data, due to the large number of nonconsumers of the other drugs.

Alcohol Use Disorders Identification Test (AUDIT) The AUDIT[91] is a measure developed by the WHO to identify problematic alcohol use and to screen for excessive drinking. It contains 10 items on hazardous alcohol use, dependence symptoms, and harmful alcohol use.

Questions from the German version[92] were answered on 3- or 5-point Likert scales assessing the existence and frequency of harmful alcohol behaviors. Scoring was done according to the manual,[91] with a potential sum score range from 0 to 40. Questions 2 to 10 were skipped if a participant indicated they never had drinks containing alcohol (item 1), resulting in a score of 0.

Statistical Analysis

Data analysis was conducted in R (version 4.2.2) using RStudio (version 2022.12.0). All statistical tests were done using a 2-tailed alpha level of .05, unless specified otherwise.

To investigate associations between schizotypy and TD, in a preregistered analysis we calculated Pearson correlations between sum scores of the four subscales and ln(k) in the standard delay version (Bonferroni-corrected alpha level of .05/4 = .0125). Furthermore, following a reviewer comment, we calculated nonpreregistered t-tests to compare schizotypy low- and high-scorers (with grouping based on the lower and upper 10% of the respective subscale score[35]). In additional nonpreregistered exploratory analyses, we examined Pearson correlations between ln(k) in the date version and subscale scores, and used multiple linear regressions to explore associations while controlling for influences of (1) the other subscales and (2) age, dummy-coded education (low/medium/high), alcohol, and tobacco consumption as well as the other subscales (hierarchical linear regression).

To determine whether the date/delay effect was replicated, we conducted a preregistered paired sample t-test with MCQ version (date vs delay) as independent variable and ln(k) as dependent variable. Hedges g_{av} was computed as measure of effect size.[93] For explorative purposes, we conducted a nonpreregistered 2 × 3 (version × magnitude) within-subject ANOVA to analyze whether the date/delay effect interacted with reward magnitude (small, medium, large). Also, we tested the effect of MCQ presentation order (delay first vs date first) on TD and the date/delay effect in a nonpreregistered 2 × 2 (version × order) mixed ANOVA.

We then examined whether the magnitude of the date/delay effect was associated with schizotypy. First, in a preregistered explorative analysis, we considered correlations between ln(k) in the two versions and schizotypy scores and compared them using Williams t-test[94] (Bonferroni-corrected alpha level of 0.05/4 = 0.0125). Next, using the previously created groups, we calculated nonpreregistered t-tests comparing schizotypy low- and high-scorers on the date/delay effect. Finally, in a nonpreregistered exploratory analysis, we used multiple linear regressions to examine whether the difference in ln(k) between the two versions (delay minus date) was predicted by any of the four sO-LIFE subscale scores, controlling for influences of age, dummy-coded education, alcohol and tobacco consumption as well as the other subscales (hierarchical linear regression).

Results

Descriptive statistics, Cronbach's alphas and Pearson correlations are shown in table 1. The association between schizotypy and TD in the delay condition was significant for UE, $r(998) = .06$, $P = .04$, but only at the nonadjusted alpha level. When adjusting for multiple comparisons, none of the associations between schizotypal traits and TD were significant, neither in the delay nor in the date condition (all $P > .0125$). Similarly, comparing TD in schizotypy high- and low-scorers using a nonpreregistered extreme group approach did not reveal any significant differences (Supplementary Material B1–B2). Nonpreregistered multiple linear regressions in which sO-LIFE subscale scores were added as predictors for discount rates as well as hierarchical linear regressions in which age, dummy-coded education, alcohol and tobacco consumption were entered in the first and subscale scores in the second step only

Table 1. Descriptive Statistics, Cronbach's Alphas, and Pearson Correlations

Variable	M	SD	Sk	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) ln(k) Delay	−5.73	1.70	−0.05	(0.93)								
(2) ln(k) Date	−6.10	1.65	0.19	0.91***	(0.93)							
(3) Date/Delay Effect	0.37	0.71	0.81	0.27***	−0.15***	(0.25)						
(4) Unusual Experiences	3.77	2.57	0.50	0.06*	0.04	0.06	(0.71)					
(5) Cognitive Disorganization	4.89	2.96	0.22	0.02	0.03	−0.04	0.40***	(0.77)				
(6) Introvertive Anhedonia	2.07	1.80	1.02	0.02	0.04	−0.05	0.09**	0.32***	(0.56)			
(7) Impulsive Nonconformity	3.14	1.94	0.57	0.04	0.06	−0.04	0.40***	0.39***	0.10**	(0.52)		
(8) Alcohol (AUDIT)	5.14	4.87	1.41	<0.01	0.03	−0.05	0.02	0.11***	−0.07*	0.25***	(0.77)	
(9) Tobacco (ASSIST)	2.84	4.86	1.81	0.11***	0.10**	0.04	0.22***	0.16***	0.02	0.30***	0.23***	(0.58)

Note. Values in the correlation diagonal represent Cronbach's alphas, except for the date/delay effect (computed as ln(k) Delay minus ln(k) Date), for which the reliability was estimated using formula 4 from Trafimow.[95] Correlations: $df = 998$. $N = 1000$. M = mean; SD = standard deviation; Sk = skewness; ln(k) = log-transformed discount rate based on the Monetary Choice Questionnaire.[85]
*$P < .05$, **$P < .01$, ***$P < .001$ (unadjusted).

yielded significant effects of age, education, and nicotine. Associations between subscale scores and discount rates were nonsignificant (Supplementary Material B3–B6).

Comparisons of discount rates in the two versions showed that participants discounted future rewards significantly more steeply in the delay than in the date condition, $t(999) = 16.25$, $P < .001$, $g_{av} = 0.22$, replicating the date/delay effect (Supplementary Material B7). An exploratory, nonpreregistered within-subject ANOVA examining the interaction between the date/delay effect and the magnitude effect (Supplementary Material B8) revealed main effects of time framing, $F(1,999) = 263.89$, $P < .001$, $\eta_p^2 = 0.21$, and magnitude, $F(1.81,1811.58) = 1030.00$, $P < .001$, $\eta_p^2 = 0.51$, but no interaction, $F(1.99,1985.02) = 0.77$, $P = .46$, $\eta_p^2 < 0.01$. Furthermore, a nonpreregistered mixed ANOVA examining the effect of MCQ presentation order (Supplementary Material B9) revealed that, while the date/delay effect was still highly significant, $F(1,998) = 264.89$, $P < .001$, $\eta_p^2 = 0.21$, TD was generally lower in participants who first completed the date and then the delay version (than vice versa), $F(1,998) = 12.91$, $P < .001$, $\eta_p^2 = 0.01$. Additionally, a significant version × order interaction indicated that the date/delay effect was higher in participants who first completed the date version, $F(1,998) = 33.61$, $P < .001$, $\eta_p^2 = 0.03$.

Next, we explored whether the date/delay effect was related to schizotypy. Preregistered Williams tests did not yield significant differences between the correlations across the date and delay conditions for any of the subscales (UE: $t(997) = 1.70$, $P = .09$; CD: $t(997) = -1.24$, $P = .22$; IA: $t(997) = -1.60$, $P = .11$; IN: $t(997) = -1.51$, $P = .13$). Similarly, in a nonpreregistered extreme group approach comparing the date/delay effect between schizotypy high- and low-scorers, we did not find any significant differences (Supplementary Material B10). However, a nonpreregistered multiple linear regression in which all four subscale scores were used to predict the difference between ln(k) values of the two versions revealed that UE was significantly associated with the magnitude of the date/delay effect while the other subscales were not (Supplementary Material B11). Specifically, higher UE scores were associated with a greater date/delay effect. This effect persisted when controlling for age, education, alcohol, and tobacco consumption in hierarchical linear regression (table 2).

Discussion

The current study is the first to use the sO-LIFE to examine associations between TD and four dimensions of schizotypy. Furthermore, it is the first to replicate the date/delay effect in a large-scale study and to examine its relation to schizotypy. Results are as follows: First, none of the schizotypy traits were significantly related to TD, neither in the delay nor in the date condition. While a significant positive correlation between UE and discount rate occurred in the standard delay version, it did not persist after correcting for multiple comparisons. Second, as expected, the date/delay effect was replicated. The effect was independent of the magnitude effect. Third, when controlling for influences of the other sO-LIFE subscales

Table 2. Hierarchical Linear Regression Predicting the Magnitude of the Date/Delay Effect

Variable	*B*	95% CI for *B*		SE *B*	β	R^2	ΔR^2
		LL	*UL*				
Step 1						0.010	0.010
Constant	0.270***	0.135	0.404	0.069	—		
Age	0.004*	0.000	0.008	0.002	.07		
Education (low)	−0.067	−0.234	0.100	0.085	−.03		
Education (high)	−0.002	−0.103	0.099	0.052	.00		
Alcohol (AUDIT)	−0.009	−0.018	0.001	0.005	−.06		
Tobacco (ASSIST)	0.008	−0.001	0.018	0.005	.06		
Step 2						0.019	0.010*
Constant	0.323	0.145	0.501	0.091	—		
Age	0.004	−0.001	0.008	0.002	.06		
Education (low)	−0.052	−0.220	0.116	0.086	−.02		
Education (high)	0.007	−0.095	0.109	0.052	.00		
Alcohol (AUDIT)	−0.007	−0.017	0.003	0.005	-.05		
Tobacco (ASSIST)	0.008	−0.002	0.018	0.005	.06		
Unusual Experiences	0.024*	0.004	0.044	0.010	.09		
Cognitive Disorganization	−0.007	−0.025	0.011	0.009	−.03		
Introvertive Anhedonia	−0.019	−0.045	0.007	0.013	−.05		
Impulsive Nonconformity	−0.021	−0.048	0.007	0.014	−.06		

Note. Education was entered as two dummy variables (reference category: medium). CI = confidence interval; *LL* = lower limit; *UL* = upper limit. $N = 990$.
*$P < .05$, ***$P < .001$

(and age, education as well as alcohol and tobacco consumption), the UE subscale predicted the magnitude of the date/delay effect. That is, higher values in UE were associated with a higher reduction of TD in the date compared to the delay condition.

The null findings regarding relations between schizotypy and TD are consistent with the only other study examining these relations across the entire schizotypy continuum. Indeed, Weatherly[40] found only few subscales of the Schizotypal Personality Questionnaire (SPQ)[2] to be related to TD in undergraduates, with low effect sizes. Our study extends this finding to a larger sample using the sO-LIFE – a measure that is based on the fully dimensional approach rather than on clinically derived symptom descriptions.[1] So far, studies that have found considerable effect sizes of relations between schizotypal traits and TD are usually based on extreme group designs, often with a particular focus on negative schizotypy, be it in studies comparing schizotypy high- and low-scorers[34,35] or in those comparing schizophrenia patients and healthy controls.[27,29] In our study, however, we did not find TD differences in analyses comparing schizotypy high- and low-scorers. Given the inconsistent findings outlined above, our results could therefore either indicate that deviations in TD are nonexistent (or very low in effect size) across the entire schizophrenia spectrum or that a certain limit of symptomatology has to be exceeded to show significant aberrations, which would better accord with quasi-dimensional than fully dimensional approaches of schizotypy.[1] The latter could additionally suggest that deviations in TD in schizophrenia are due to disease processes or medication effects, as previously suggested,[33,34] rather than to vulnerability in highly schizotypal individuals. Alternatively (or additionally), combinations of specific trait profiles, for example interactions between higher positive and negative schizotypy, could be necessary to reveal TD differences as both reward and time processing could be altered in such individuals. Given the overall inconsistent findings, however, more work is needed to clarify the magnitude of effect sizes of TD differences across the schizophrenia spectrum.

A more refined approach to this question is to examine the cognitive mechanisms suspected to lead to increased TD and to explore whether these are altered in schizophrenia spectrum individuals. Here, we focused on future time perception by using a date/delay manipulation. Importantly, we replicated the date/delay effect and found it to be robust against the well-known magnitude effect in TD (ie, larger rewards being discounted less steeply than smaller ones[96,97]) and against order of MCQ presentation (although it was greater when the date version was presented first). The date/delay effect has been found previously,[76,77,80,98–101] with a meta-analysis revealing a slightly larger effect size than our study.[78] However, this difference could be partly due to our effect size calculation in which we corrected for the correlation of measurements (ie, our uncorrected effect size is $d_z = 0.51$). Importantly, our study was one of the few using a within-subject design[99,100] and had by far the largest sample to date.

Importantly, the association of the date/delay effect with schizotypy had not previously been investigated. Here, we observed that higher positive schizotypy (UE) scores were associated with a stronger date/delay effect after controlling for the other subscales. This intriguing finding may indicate that not only reward but also time processing and/or their integration are aberrant in high schizotypy. Interestingly, previous studies have shown that negative symptoms and anhedonia are mainly responsible for deviations in reward valuation[50–52] and some studies found high levels in positive symptoms to be associated with aberrant time perception and internal clock mechanisms.[61,74] Thus, one may speculate that the distinction between positive and negative symptoms is important for differential influences on time and reward processing, respectively. Furthermore, the finding suggests that simple manipulations such as the date/delay framing could help particularly vulnerable populations to reduce impulsive decision making. This idea is in line with the finding that in schizotypy high-scorers, episodic future thinking (EFT),[102] ie, presenting future rewards in combination with positive future (rather than recent) events, helped to reduce TD.[103] While that study lacked a control group (thus not revealing whether the manipulation might be particularly effective within schizotypy high-scorers), it is the only other study showing that manipulations of future time perspective can help to reduce TD in a sample with high schizotypy levels. It is of considerable interest to further investigate whether the date/delay and EFT manipulations have particularly beneficial impacts on people high in schizotypal traits and schizophrenia patients, especially considering that schizophrenia patients have been shown to have altered EFT.[104] This, of course, would not only provide insights into time processing mechanisms in schizotypy and schizophrenia but also a potential way to reduce impulsive decision making.[103]

There are some limitations to consider. First, the online setting prevented us from collecting comprehensive clinical data. Thus, diagnostics of mental disorders was not possible, although this may be desirable given the influences of different disorders on TD.[25] Similarly, our attempts to control for risky substance consumption must be interpreted with care because they were not validated independently. The possibility that our findings are driven by any one disorder is unlikely, however, given the large sample size. Second, we used a hypothetical intertemporal choice task because previous general population studies showed that they result in similar discount rates as incentive-compatible ones where participants are paid out one or more of their decisions.[105,106] However, a study comparing schizophrenia patients and healthy controls only found a difference in TD when using an experiential rather than a hypothetical task, thus raising the question whether the association depends on realization

of rewards.[31] Whilst other studies, in part, found significant effects with hypothetical tasks,[26,27,29,30,32] this is important to consider in future studies. Third, our analysis revealing the association between positive schizotypy and the date/delay effect was largely explorative, included a difference score with potentially limited reliability[95] (however, see Thomas and Zumbo[107]), and yielded only a small effect size, thus warranting replication. Fourth, while we accounted for educational status in our analyses, future studies might also consider assessing further control variables, such as working-memory capacity, IQ or socio-economic status as these are known to be associated with TD.[22] Fifth, a more representative sample regarding distributions of education and gender would be desirable, especially since the latter is associated with differences in O-LIFE subscale scores.[3]

Overall, our large-scale study revealed that schizotypal personality traits are not (or only very weakly) associated with TD. However, positive schizotypy was associated with the magnitude of the date/delay effect, suggesting deviations in future time perception in people with high levels of positive schizotypy and potential reductions of those through the simple date manipulation. Future studies are needed to determine whether this effect is robust in nonclinical and clinical samples to draw conclusions on cognitive mechanisms of altered decision making in schizophrenia.

Supplementary Material

Supplementary material is available at https://academic.oup.com/schizophreniabulletin/. Study materials, data and analysis scripts as well as supplementary material can be accessed at https://osf.io/xdn7c/.

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