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Altered time-perception performance in individuals with high schizotypy levels

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Abstract

The possibility of altered time-perception in high schizotypy scorers, as postulated through previous differences shown in performance between high and low scorers in schizotypy on schedules of reinforcement with temporal elements, was examined using a series of retrospective timing tasks. Three stimuli ratio manipulations were made across two experiments, and, using an adjusted version of the bisection-point method for data analysis, results showed that high scorers on the unusual experiences subscale of the O-LIFE(B) estimated the mid point of the stimulus range to be at a significantly longer interval than low scorers. This was true when the ratio between the "short" and "long" standard stimuli were 4:1 (Experiment 1), 3:1 and 2:1 (Experiment 2). These findings are consistent with the notion of altered time-perception for high schizotypals.

Key words: time-perception; time-discrimination; retrospective evaluation; schizotypy.

1. Introduction

An important brain region where neurotransmitter activity contributes to schizophrenic symptoms is the striatum (Buhusi & Meck, 2007; Arbuthnott & Wickens, 2007; Body, Cheung, Hampson, den Boon, Bezzina, Fone, Bradshaw & Szabadi, 2009), which is known to be involved in the control of timing (Gibbon, 1977; Killeen & Feterman, 1988). Changes in dopamine activity has been shown to influence performance in timing tasks (Body et al, 2009; Cheung, Bezzina, Hampson, Body, Fone, Bradshaw & Szabadi, 2007), where increased dopamine activity in the striatum slows subjective time-perception, making subjects over-estimate the passage of time (Abi-Dargham & Moore, 2003; Carroll, O'Donnell, Shekhar & Herrick, 2009). Although multiple mechanisms may be responsible for dopamine-related disruption of time-perception in schizophrenia (e.g., impact on pacemakers and accumulators, working and reference memory, and comparator processes; see Gibbon, 1999), the episodic nature of schizophrenia (Weinberger, 1988; Zubin & Spring, 1977), and the changes in potentially-associated dopaminergic levels (Howes & Kapur, 2009; Laruelle, Abi-Dargham, Gil, Kegeles & Innis, 1999), suggest that individuals in an acute phase of the disorder, or not on medication, might be particularly prone to altered time-perception and that such time-perception effects may be variable.

In fact, those with schizophrenia show time-perception effects consistent with the above view (Carroll, Boggs, O'Donnell, Shekar & Hetrick, 2008; Densen, 1977; Elvevag, McCormack, Gilbert, Brown, Weinberger & Goldberg, 2003; Freeman & Garety, 2003; Tysk, 1983; Waters & Jablensky, 2009). In tasks that require behavior to be modulated by concurrent judgments of the passage of time, participants with schizophrenia over-estimate the passage of time (Densen, 1977; Freeman & Garety, 2003; Tysk, 1983; Waters & Jablensky, 2009). That is, if subjective estimates of the passage of time are longer, then responding occurs sooner than expected. Other timing tasks require a retrospective judgment of the passage of time. During temporal-bisection tasks, participants initially learn to label the presentation lengths of two stimuli as of either ‘short’ or ‘long’ duration in relation to each other in a training phase. They are then presented with a range of stimuli of different durations between these two extremes, and are required to judge the duration of these stimuli as ‘short’ or ‘long’. If subjective perceptions of time are slowed in schizophrenic participants, then a retrospective judgment of the same duration stimulus compared to a control would tend to be shorter. Such studies have found that schizophrenic patients are, indeed, less accurate in their timing judgments than controls, and are also more variable in these judgments (Carroll et al, 2008; Elvevag et al, 2003). However, other studies using this procedure that report results divergent to these above reports, some finding no difference in the estimation of the passage of time in schizophrenic outpatients, but an increased variability in their time judgments (Carroll et al, 2009). One factor implicated in interpreting such discrepancies (Carroll et al, 2009; Carroll et al, 2008; Elvevag et al, 2003), and the increased variability of temporal perception (Carroll et al, 2009), is the role of anti-psychotic medication. This consideration introduces a possible confound in interpreting the results, as the impact of many medications used to treat schizophrenia (e.g., risperidone) is to reduce dopamine activity in the striatum (Agid, Mamo, Ginovart, Vitcu, Wilson, Zipursky & Kapur, 2007), and effectively speed up an internal clock (Rammsayer, 1990).

In overcoming such potential issues, the use of individuals scoring high on schizotypy may be useful (Reine & Lencz, 1995). Schizotypy refers to psychometrically-measured behavioral traits and dispositions associated with schizophrenia, but present in the non-clinical population (Bentall, 1990; Meehl, 1962). The validity of schizotypy has been supported by factor analytical studies that have linked schizotypal traits to schizophrenic symptoms (Bentall, Claridge & Slade, 1989; Claridge & Beech, 1995). Moreover, research into a number of topic areas have shown both schizophrenic patients and high schizotypy scorers to show the same performance effects on the same tasks depending on the type of task and dominant trait or symptom cluster (i.e. positive, negative or cognitive disorganization), supporting the use of schizotypy as a model for research into schizophrenia (see Lubow, 2005; Dagnall & Parker 2008 for examples). The use of this population avoids many confounds associated with schizophrenic patients, such as the effects of medication, symptom severity and patient distress (Dagnall & Parker 2009; Raine & Lencz, 1995; Tsakanikos & Reed 2005), which may mask or lead to false results (see Kane, 2006) or where symptoms are so severe that patients are unresponsive. Moreover, the use of this group also allows differentiation between specific traits and symptoms associated with schizophrenia and their impacts on the ability in question (Reine & Lencz, 1995; Esterberg, Jones, Compton & Walker, 2007; Phillips & Seidman, 2008, Tsakanikos & Reed, 2005).

In terms of timing processes in high schizotypal individuals, rates of response are higher on random interval schedules in high- compared to low schizotypal subjects (Randell, Ranjith-Kumar, Gupta & Reed, 2009; Randell, Searle & Reed, 2012), particularly those with high scores on the Unusual Experiences (UE) sub-scale of the O-LIFE(B) scale (Mason, Linney & Claridge, 2005). In addition, high UE subjects are unable to describe the temporal nature of the RI schedule (Randell et al, 2012). Moreover, high scorers in UE have different performance profiles to low UE scorers on both fixed interval, and differential reinforcement of low rate, schedules of reinforcement (Randell, May, Jones & Reed, 2011). Both of these latter schedules involve concurrent timing to judge whether a certain amount of time has passed before a response will elicit reinforcement, and high UE scorers tended to respond later on the schedules than low scorers. These differences between high and low schizotypal subjects imply differences in the ability to accurately incorporate timing into schedule performance.

It would be useful to examine the performance of these groups on timing tasks outside the context of reinforcement schedules, especially as mechanisms, such as response disconfirmation, and reinforcement rates may influence response patterns over and above the various aspects of timing (Dickinson, 1989, Ferster & Skinner, 1957; Roper & Zentall, 1999). It is also worth noting that, in the schedule tasks used in the previous (Randell et al, 2009; Randell et al, 2012, Randell et al, 2011), the participants were not necessarily aware of any timing component incorporated in the task. Thus, timing was not an explicitly studied behavior on those tasks, and any potential deficits in this process are only inferred from patterns of responding, rather than being measured directly. Given these considerations, the use of temporal-bisection tasks (Church & Deluty, 1998), previously employed for schizophrenic patients (Carroll et al, 2009; Carroll et al, 2008), could forward understanding in this area.

Given the previous results noted above for schizophrenic patients (Carroll et al, 2008; Elvevag et al, 2003; Tysk, 1983; Rammsayer, 1990), and those reported on schedules of reinforcement for high-schizotypals (Randell et al, 2009; Randell et al, 2011), the expectation was that, if timing differences exist between low and high schizotypy scorers (who are free of the impact of medication), these would manifest in differences in the observed bisection point of these two groups. Specifically, it was predicted that high schizotypal subjects, when making retrospective judgments, should tend to label any given stimulus duration as shorter than low schizotypal scorers.

2. Experiment 1

Experiment 1 presented stimuli for a short (S) or long (L) standard durations during a training phase. In the subsequent experimental phase, stimuli were presented for lengths ranging between, and including, these S and L stimuli. The participants were required to press a button labeled 'SHORT' or 'LONG' for each of the stimuli in the experimental phase, and the bisection point was then calculated (the point at which the probability of making a SHORT or LONG response was equal). Differences in bisection-point location with a relatively large ratio size (4:1) of the stimulus range was used as clear differences have been found in previous research using this ratio (Allan & Gibbon, 1991), whilst a reduction in the ratio size to 3:1 and 2:1 in Experiment 2 was used to extend the generality of the findings in Experiment 1 and also because a reduction in the bisection ratio provides for some ambiguity in the bisection-point location in human performance in general (see Wearden & Ferrarra, 1996). If high scorers perform in a similar manner to individuals with schizophrenia (Carroll et al, 2008; Elvevag et al, 2003), then they should emit greater number of S responses for longer presentations than low scorers (i.e., high scorers would judge 50% of the stimuli as 'short' at a longer objective time period than low scorers).

2.1 Method

2.1.1 Participants

Fifty-two participants (13 males and 39 females) with an age range of 18 to 39 (Mean = 21 $\pm$ 3) were recruited. No participants reported psychiatric problems. Ethical approval was granted by the Psychology Ethics Committee, Swansea University, and all participants gave informed consent.

2.1.2 Measures

2.1.2.1 Oxford Liverpool Inventory of Feelings and Experiences - Brief Version (O-LIFE(B); Mason et al, 2005) is a 43-item scale comprising four subscales: Unusual Experiences (UE), Cognitive Disorganization (CD), Introvertive Anhedonia (IA), and Impulsive Nonconformity (IN), designed to measure schizotypy in the normal population. The scales have an internal reliability (Cronbach α) of 0.62 to 0.8, and a concurrent validity of between 0.9 and 0.94 (Mason et al, 2005).

2.1.2.2 Beck's Depression Inventory (BDI; Beck, Ward, Mendelson, Mock & Erbaugh, 1961) is a 21-item questionnaire assessing symptoms of depression over the past week. The internal reliability (Cronbach α) is between 0.73 and 0.92, and concurrent validity is between 0.55 and 0.73 (Beck, Steer & Garbin, 1988).

2.1.2.3 Spielberger Trait Anxiety Inventory (STAI-T; Spielberger, 1983) rates the affective, cognitive, and physiological manifestations of anxiety in terms of long-standing patterns (i.e., trait anxiety). The internal reliability (Cronbach α) of the scale is 0.93, and a concurrent validity = 0.52 to 0.8 (Spielberger, Gorsuch & Lushene, 1970).

Measures of depression and anxiety were included as a controlling measure for statistical analysis on hallucinatory reports and schizotypy scores, given that both are associated with hallucination formation (Freeman & Garety, 2003).

2.1.3 Procedure

All participants were tested individually in a quiet room, in front of a desk and computer (60cms from the monitor). Participants were required to complete the questionnaires administered in a counterbalanced fashion across participants. Participants were then presented with the instructions, before continuing with the computer task:

"*The next part of the experiment involves completing a computer task. For the first part you will see a square appear for either a "short" or "long" amount of time, your task is to watch these presentations and familiarise yourself with them. In the second part of the experiment you will be presented with more squares, but this time your task is to choose "short" or "long" in line with how long you feel each square was presented for. This process will repeat five times. Begin when you are ready*".

The experimental task was programmed in Visual Basic (version 6.0). In the training phase, participants were presented with a blank, white screen for 1s. This was followed by the presentation of either the word "Short", or the word "Long", for 1s, immediately before the presentation of a black square on the screen. The square was 86mm x 54mm in size, and was presented in the centre of the screen. The presentation lasted either for 0.2s (following the word "Short"), or 0.8s (following the word "Long"), for five presentations each. The order of the presentations of the short and long stimuli was random. Presentation lengths of less than 1s were used to avoid the effects of chronometric counting (Wearden, 1991). Visual stimuli were used as temporal bisection tasks have explored this modality previously and provide a useful approach to apply to further exploration of this task in line with a new and novel field of schizotypy. Moreover, temporal bisection tasks administered to schizophrenic patients have produced somewhat inconsistent results regarding the visual modality and further work will help to expand our understanding of the area (Carroll et al, 2008; Penney et al, 2005; Penney et al, 1998; Penney et al, 2000).

Participants were exposed to the experimental phase. Following a 1s presentation of a blank white screen, the same square as described above was presented for between 0.2s to 0.8s, at 0.1s intervals (i.e. 0.3s, 0.4s, etc.). Each of the seven lengths were presented 10 times each at random. In addition, for each presentation, the words "Short" and "Long" were presented at the bottom of the screen, beneath the letters "z" and "m", indicating the buttons to press if the participants thought the stimulus was either short or long; with "z" and "m" being counterbalanced across participants as to which corresponded to S or L choices.

This training-experimental phase process was repeated four times.

2.2 Results and Discussion

Participants were split into high and low scoring UE, CD, IA and IN groups, according to a median split of their O-LIFE(B) scores (Randell et al, 2009; Randell et al, 2012; Randell et al, 2011). A median split was used due to the sample size, and as it is unclear whether any relationship between schizotypy and bisection-point location is linear or a step-function. A regression analysis assumes the former, but a median split is theoretically neutral with respect to this assumption, and so is statistically more conservative (Osborne, McHugh, Saunders & Reed, 2008).

Twenty-six participants were in the low scoring UE group (mean = 1 $\pm$ 0.79), and 24 participants were in the high scoring UE group (mean = 5.79 $\pm$ 2.25 SD). For the CD subscale, 27 participants were in the low scoring group (mean = 2 $\pm$ 1.44), and the 23 participants were in the high scoring group (mean = 7.96 $\pm$ 1.85). For the IA subscale, 36 participants were in the low scoring group (mean = 0.89 $\pm$ 0.84), and 14 participants were in the high scoring group (mean = 4.64 ± 1.82). For the IN subscale, 28 participants were in the low scoring group (mean = 1.86 ± 1.09), and 22 participants were in the high scoring IN group (mean = 5.05 ± 1.21).

The bisection point (the point at which 50% short [‘S’] responses were made) was calculated for each individual participant by regressing the data points producing the line of steepest slope, so to provide an objective method to determine individual bisection points (Wearden & Ferrara, 1995). A bisection-point difference score was then calculated for each participant by subtracting the arithmetic mean of the range used, in this case 0.5s, from each participant’s bisection point. This method was adopted, as opposed to using the bisection point alone, as the arithmetic mean represents the point at which equal responding between “S” and “L” responses would be expected, given previous research with human participants and the ratios used here (Wearden & Ferrara, 1996). The subsequent calculation of a difference from this point provides a numerical indication of the spread of S responses in relation to the range below (or above) the arithmetic mean; a negative bisection-point difference from the arithmetic mean would indicate that the point at which “S” and “L” responses occur with equal probability is reached sooner than expected, with a bias towards “L” responses being made for shorter stimuli.

Table 1

Table 1 displays the mean bisection-point difference score for the low and high scoring groups in each of the four subscales: UE, CD, IA, and IN. An analysis of covariance (ANCOVA) was conducted on the mean bisection-point difference score for each of these subscales, with high and low scorers as the independent variable, and BDI and STAI-T scores as covariates. The ANCOVA conducted on the data from the UE subscale showed a statistically significantly lower bisection-point difference in higher UE scorers, compared to lower UE scorers, $F(1,43) = 4.90$, $p < 0.05$, $d = 0.68$, with no statistically significant effects of BDI, or STAI-T, scores, both *p*s > 0.2. The same ANCOVA analyses for each of the other three subscales: CD, IA, and IN, showed no statistically significant effect of any of these three subscales on the bisection-point difference, all *p*s > 0.30.

These results suggest that the bisection-point location for high UE scorers is closer to the arithmetic mean than in low UE scorers, suggesting that their mean bisection-point location was higher than that for low UE scorers. This pattern of results indicates that high UE scorers are less likely to give an 'L' response for a short stimulus, and make more 'S' responses for longer presentations, in comparison to low UE scorers. This pattern of results is consistent with results obtained from timing studies with individuals with schizophrenia (Carroll et al, 2008; Elvevag et al, 2003; Tysk, 1983; Rammsayer, 1990), and from predictions derived from previous studies of time-based reinforcement schedules (Randell et al, 2009; Randell et al, 2011). The fact that the other O-LIFE(B) subscales failed to show a significant effect on bisection-point difference suggests that the UE subscale may be of most importance with regard to timing deficits in high schizotypy scorers.

3. Experiment 2

Experiment 2 sought to further examine the relationship between schizotypy and timing as assessed by bisection-point location, by reducing the ratio of the stimulus range to 3:1, and further still to 2:1, across two conditions in order to extend the generality of the potentially important effect noted in Experiment 1, and to examine whether, or not, the bisection-point difference between high and low UE scorers would occur within two smaller sets of stimuli range than that used in Experiment 1, or whether the decrease in ratio would remove the difference.

3.1 Method

Fifty participants (13 males and 37 females) were recruited, with an age range of 18 to 27 (mean = 21.17 $\pm$ 2.26). No participants reported any history of psychiatric problems. The materials and stimuli were as described in Experiment 1. The procedure was the same as that described for Experiment 1, except that all participants performed under two conditions (and, hence, the received twice as many presentations of stimuli in total): one consisting of a 2:1 ratio for the presentation lengths of the stimulus range; and one consisting of a 3:1 ratio. The stimulus range was 0.4s to 0.8s for the 2:1 ratio condition, and 0.3s to 0.9s for the 3:1 ratio condition. The presentation of the 2:1 and 3:1 ratio conditions were counterbalanced across participants.

3.2 Results and Discussion

Participants were split as described in Experiment 1. For the UE subscale, there were 28 participants in the low group (mean = 1.07 $\pm$ 0.86), and 22 participants in the high group (mean = 4.82 $\pm$ 2.22). For the CD subscale, 24 participants were in the low group (mean = 2.61 $\pm$ 1.67), and 26 participants were in the high group (mean = 7.33 $\pm$ 1.49). For the IA subscale, 30 participants were in the low group (mean = 0.44 $\pm$ 0.5), the 20 participants were in the high group (mean = 2.67 $\pm$ 0.82). For IN, 30 participants were in the low group (mean = 2.75 $\pm$ 1.22), and 20 participants were in the high scoring group (mean = 5.4 $\pm$ 0.83).

The bisection point (50% S responses) for each individual participant, in both the 2:1 and 3:1 ratio conditions, was calculated using the regression method described in Experiment 1, following which a bisection-point difference was calculated for each participant, by subtracting the arithmetic mean of the range used, in this case 0.6s for both the 2:1 and 3:1 ratio conditions, from each participant's bisection point.

Table 2

Table 2 shows the mean bisection-point difference for low and high scorers in all the subscales, for the 2:1 and for the 3:1 condition. A multivariate analysis of covariance (MANCOVA), with ratio (2:1 & 3:1) as a within-subject condition, subscale group (high versus low) as a between-subject factor, and BDI and STAI-T scores as covariates, was conducted on these data for each subscale separately. This MANCOVA for the UE data revealed a statistically significant effect of UE on the mean bisection-point difference, $F(1,43) = 10.89$; $p < 0.01$, $d = 0.98$, but revealed no statistically significant effect of BDI or STAI-T scores, both *p*s > 0.1. Follow-up ANOVAs conducted separately on the bisection-point difference for the 2:1 and 3:1 conditions for the UE score (high versus low) showed a statistically significantly greater bisection-point difference in high UE scorers than in low UE scorers in both the 2:1 condition, $F(1,45) = 6.87$; $p < 0.05$, $d = 0.79$, and in the 3:1 condition, $F(1,45) = 4.91$; $p < 0.05$, $d = 0.67$. The same MANCOVA analyses conducted on each of the CD, IA, and IN subscales failed to show any statistically significant effect of any of these three subscales on the bisection-point difference, all *p*s > 0.10.

These results suggest that the bisection-point location for high UE scorers is closer to the arithmetic mean than it is for the low UE scorers, when the stimulus range produces a ratio of both 2:1 and 3:1. This implies that high UE scorers make more S responses for longer presentations than low UE scorers. Thus, Experiment 2 showed that high UE scorers demonstrated later bisection-point production than low UE scorers, and that this occurred despite the manipulation in the ratio sizes used, further confirming the generality of this effect.

4. General Discussion

The current findings suggest that participants had a bias toward responding "Long" for shorter presentation lengths. However, this bias was less pronounced in high UE scorers (although the other schizotypy sub-scales did not impact this decision). That is, high UE scorers tended to judge long stimuli as shorter, compared to low UE scorers, suggesting a greater tendency toward judging that less time had passed. This corroborates findings from previous studies involving schizophrenic patients that have suggested an underestimation of actual temporal periods (Waters & Jablensky, 2009; although see Tysk, 1983, for the opposite result). These results are also consistent with temporal-bisection studies using schizophrenic participants, regarding the judgment of long responses, that have shown participants tend to place the bisection point at a greater temporal duration than controls for visual (Elvevag et al, 2003) and auditory (e.g., see Carroll et al, 2008) stimuli. A suggested relative underestimation of the passage of time is also consistent with views derived from performance on various schedules of reinforcement (Randell et al, 2009; Randell et al, 2012; Randell et al, 2011).

There are a number of potential theoretical explanations of these findings. Scalar Timing Theory (SET; Gibbon, 1977) postulates an internal clock which consists of pacemaker-accumulator, short-term and reference memory, and decision-making components (Gibbon, 1999). High UE scorers and schizophrenic patients, during an episode, may possess a slower pacemaker than during periods of typical functioning, making longer presentations seem shorter than they are in reality. Alternatively, a memory deficit (Lenzenweger & Gold, 2000) may be involved, in that comparing most the recent presentations with the standard is problematic in high UE scorers. Finally, a decision-making deficit (Tallent & Gooding, 1999) with regard to the choices of S or L could be involved; or, of course, there could be an interaction between all three variables. In light of these possibilities, the exact nature of the underlying mechanisms and interactions between the SET components and the timing deficit in high UE scorers is clearly in need of further exploration. Alternatively, the Learning to Time theory (LeT; Killeen & Feterman, 1988; Machado & Keen, 1999) argues that timing occurs in terms of a chain of behavioral states initiated by environmental stimuli, with each state holding associative links with available responses (Killeen & Feterman, 1988). In terms of the present task, these associative links are argued to differ in strength between each behavioral state and the responses available (i.e., S and L), with earlier behavioral states in the chain more strongly linked to the S choice, whilst later behavioral states are more strongly linked to the L choice. In this context, high UE scorers show stronger associative links between the S choice and behavioral states later in the chain, suggesting interesting potential for research into the relationship between schizotypy levels and the strength of associative links between behavioral states and responding. This suggestion, again, may be useful to examine in terms of decision-making as research into delusions have shown that deluded subjects make probabilistic judgments more quickly, and with less evidence, than non-deluded subjects (Huq, Garety & Hemsley, 1988), but can also be excessive in changing their choices on reasoning tasks (Garety, Hemsley & Wessley, 1991). However, it is beyond the scope of the current paper to explore either theory of timing in line with the current data and instead to suggest that future research into timing may benefit from a model of schizptypy given some of the related features of theories of timing and characteristics of schizotypy, such as, for example, decision making (Huq et al, 1988; Garety et al, 1991; Tallent & Gooding, 1999).

Of the four OLIFE(B) subscales measured, only the UE subscale yielded significant differences between high and low scorers within that group, whilst there were no significant differences between high and low scorers in CD, IA and IN. Reasons for this could be related to the link between the features of the UE subscale; feelings, experiences and particularly the perception of the environment (Mason, Claridge & Jackson, 1995; Mason et al, 2005), and the related perceptual nature of the task (i.e. the temporal perception of visually presented stimuli), and this notion presents an interesting avenue for further exploration.

Although the study produces some interesting findings, there are also some limitations to consider. Firstly, although significant differences are present in the bisection-point difference between high and low UE scorers, these values for both groups fall close to the arithmetic mean, the bisection-point difference to the arithmetic mean for high UE scorers falling closest. This means that high UE scorers are actually more accurate than low UE scorers when the arithmetic mean is taken as the point at which 50% “Short” and “Long” responses should be expected, and therefore makes a case that high UE scorers are more accurate in estimating time within temporal bisection tasks. However, it is important to point out that the comparison between high and low UE scorers is of most concern within the current study and significant differences emerge between these two groups. Secondly, although our findings corroborate those of previous research that high UE scorers tend to overestimate time (Carroll et al, 2008; Carroll et al, 2009; Tysk, 1983; Waters & Jablensky, 2009), this is also contrary to other research reporting the opposite (e.g. Penney et al, 2005) and is explained in line with the SET model of timing elsewhere (Carroll et al, 2009; Penney et al, 2005). The objectives of the present study were not to explore any singular theory of timing, but future research could benefit from a more detailed exploration of the related characteristics of schizotypy and theories of timing on temporal perception. Thirdly, there were more female participants than males giving a gender bias for the study. This may be particularly pertinent considering female subjects have shown an increased frequency of hallucinatory experiences over males (Sharma, Dowd, & Janicak, 1999). However, exploration of an interaction between gender differences, schizotypy and timing tasks are beyond the scope of this paper. Moreover, the aim of the paper was to explore the effects of the relationship between schizotypy and timing over and above potential contributory factors, though these may provide questions for future research to answer.

In summary, the current study then showed significant differences between high and low UE scorers in timing performance as measured by a temporal-bisection task within stimuli ranges of 2:1 and above. Although the task does not allow for examination of precisely how these timing differences occur, the finding that a timing difference exists is novel, and gives scope and direction for future research with both high and low schizotypy scorers and schizophrenia patients, as a foundation to elucidate both the mechanisms of timing within these populations and the implications that these may have for the severe psychotic symptoms of schizophrenia.

Conflict of Interest Statement

"The Authors have declared that there are no conflicts of interest in relation to the subject of this study."

References

Abi-Dargham, A., Moore, H. 2003. Prefrontal DA Transmission at D1 Receptors and the Pathology of Schizophrenia, The Neuroscientist 9: 404-416.

Agid, O., Mamo, D., Ginovart, N., Vitcum I., Wilsonm A. A., Zipursky, R.B., Kapur, S. 2007. Striatal Vs extrastriatal dopamine d2 receptors in antipsychotic response – A double blind PET study in schizophrenia, Neuropsychopharmacology 32:1209-1215.

Allan L. G., Gibbon, J. 1991 Human bisection at the geometric mean. Learning and Motivation 22: 39-58.

Arbuthnott, G. W., Wickens, J. 2007. Space, time and dopamine. Trends in Neuroscience. 30: 62–69.

Beck, A.T., Steer, R.A., Garbin, M. G. 1988. Psychometric properties of the Beck Depression Inventory: Twenty-five years of evaluation. Clinical Psychology Review 8: 77-100.

Beck A. T, Ward C. H., Mendelson, M., Mock, J., Erbaugh, J. 1961. An inventory for measuring depression. Archives of General Psychiatry 4: 561–571.

Bentall R. P. 1990. The illusion of reality: A review and integration of psychological research on hallucinations. Psychological Bulletin 107: 82-95.

Bentall, R. P., Claridge, G. S., Slade, P.D. 1989. The multidimensional nature of schizotypal traits: A factor analytic study with normal subjects. British Journal of Clinical Psychology 28: 363-375.

Body, S., Cheung, T. H. C., Hampson, C. L., den Boon, F. S. , Bezzina, G., Fone, K., Bradshaw, C. M., Szabadi, E. 2009 Attenuation of the effects of *d* amphetamine on interval timing behaviour by central 5-hydroxytryptamine depletion. Psychopharmacology 203: 547-559.

Buhusi, C.V., Meck, W.H. 2007. Effect of clozapine on internal timing and working memory for time in the peak-interval procedure with gaps. Behavioral Processes 74: 159–167.

Carroll, C.A., Boggs, J., O'Donnell, B.F., Shekhar, A., Hetrick, W.P. 2008. Temporal processing dysfunction in schizophrenia. Brain and Cognition 67: 150–161.

Carroll, C. A., O'Donnell, B. F., Shekhar, A., Hetrick, W. P. 2009 Timing dysfunctions in schizophrenia span from millisecond to several-second durations. Brain and Cognition 70: 181-190.

Cheung, T. H. C., Bezzina, G., Hampson, C. L., Body, S., Fone, K. C. F., Bradshaw, C. M., Szabadi, E. 2007. Evidence for the sensitivity of operant timing behaviour to stimulation of D1 dopamine receptors. Psychopharmacology 195: 213–222.

Church, R. M. , Deluty, M. Z. 1998. Bisection of temporal intervals. Journal of Experimental Psychology: Animal Behavior Processes 3: 216-228.

Claridge, G, Beech, A. 1995. Fully and quasi-dimensional concepts of schizotypy. In A. Raine, T. Lencz, & S, Mednick (Eds.), Schizotypal Personality Disorder. Cambridge: Cambridge University Press.

Dagnall, N. & Parker, A. (2009). Schizotypy and false memory, Journal of Behaviour Therapy and Experimental Psychiatry, 40 (1), 179 – 188.

Densen, M. E. 1977. Time perception in schizophrenia. Perception and Motor Skills 44: 436-438.

Dickinson, A. M. 1989. The detrimental effects of extrinsic reinforcement on "intrinsic motivation." The Behavior Analyst 12: 1-15.

Elvevåg, B., McCormack, T., Gilbert, A., Brown, G. D. A., Weinberger, D.R., Goldberg, T. E. 2003. Duration judgments in patients with schizophrenia. Psychological Medicine 33: 1249–1261.

Esterberg, M., Jones, E. M.,Compton, M., Walker, E. 2007. Nicotine consumption and schizotypy in first-degree relatives of individuals with schizophrenia and non-psychiatric controls. Schizophrenia Research 97: 6-13.

Ferster, C. B., Skinner, B.F. 1957. Schedules of Reinforcement. New York: Appleton-Century-Crofts.

Freeman, D. & Garety, P. A. 2003. Connecting neurosis and psychosis: the direct influence of emotion on delusions and hallucinations, Behavior Research and Therapy 41: 923-947.

Garety, P. A., Hemsley, D. R., Wessley, S. 1991. Reasoning in deluded schizophrenic and paranoid patients: Biases in performance on a probabilistic inference task. The Journal of Nervous and Mental Disease 179: 194–201.

Gibbon, J. 1977 Scalar expectancy theory and Weber's law in animal timing. Psychological Review 84: 279-325.

Gibbon, J. 1999 Origins of scalar timing. Learning and Motivation; 22: 3–38.

Howes, O. D., Kapur, S. 2009. The dopamine hypothesis of Schizophrenia: Version III—The Final Common Pathway. Schizophrenia Bulleti. 35: 549–562.

Huq, S. F., Garety, P.A., Hemsley, D.R. 1988. Probabilistic judgements in deluded and nondeluded subjects. Quarterly Journal of Experimental Psychology 40A: 801-12.

Kane, J. M. (2006). Tardive Dyskinesia Circa 2006, American Journal of Psychiatry, 163, 1316 – 1318.

Killeen, P. R., Feterman, J. G. 1988 A behavioural theory of timing, Psychological Review 95: 274-295.

Laruelle, M., Abi-Dargham, A., Gil, R., Kegeles, L., Innis, R. 1999 Increased dopamine transmission in schizophrenia: relationship to illness phases. Biological Psychiatry 46: 56-72.

Lenzenweger, M.F. & Gold, J.H. 2000 Auditory working memory and verbal recall memory in schizotypy. Schizophrenia Research 42:101-110.

Lubow, R. E. (2005). Construct validity of the animal latent inhibition model of selective attention deficit in schizophrenia, Schizophrenia Bulletin, 31 (1), 139 – 153.

Machado A. & Keen R. Learning to Time (LET) or Scalar Expectancy Theory (SET)? A critical test of two models of timing. 1999 Psychological Science 10: 285-290.

Mason, O., Claridge, G. & Jackson, M. (1995). New scales for the assessment of schizotypy, Personality and Individual Differences, 53, 727-730.

Mason, O., Linney, Y. & Claridge, G. 2005. Short scales for measuring schizotypy. Schizophrenia Research 78: 293-296.

Meehl P. 1962 Schizotaxia, schizotypia, schizophrenia. American Psychologist 17: 827 – 838.

Osborne LA, McHugh L, Saunders J, Reed P. 2008. Parenting stress reduces the effectiveness of early teaching interventions for Autistic Spectrum Disorders. Journal of Autism & Developmental Disorders 38: 1092-1103.

Penney, T. B., Allan, L., Meck, W. H. & Gibbon, J. 1998. Memory mixing in duration bisection. In D. A. Rosenbaum & C. E. Collyer (Eds.) Timing of Behaviour: Neural, Computational, and Psychological Perspectives (pp. 165 – 193). Cambridge, M. A: MIT Press.

Penney, T. B., Gibbon, J., & Meck, W. H. 2000. Differential effects of auditory and visual signals on clock speed and temporal memory. Journal of Experimental Psychology, Human Perception and Performance, 26, 1770 – 1787.

Penney, T. B., Meck, W. H., Roberts, S. A., Gibbon, J. & Erlenmeyer-Kimling, L. 2005. Interval Timing Deficits in Individuals at High Risk for Schizophrenia, Brain and Cognition, 58, 109-118.

Phillips L. K., Seidman L. J. 2008. Emotion processing in persons at risk for schizophrenia. Schizophrenia Bulletin 34: 888-903.

Rammsayer, T. 1990. Temporal discrimination in schizophrenic and affective disorders: evidence for a dopamine-dependent internal clock. Int. J. Neurosci. 53: 111-120.

Randell, J., Ranjith-Kumar, A. C., Gupta, P., & Reed, P. 2009. Effect of schizotypy on responding maintained by free-operant schedules of reinforcement. Personality and Individual Differences 47: 783 – 788.

Randell, J., May, C., Jones, C., & Reed, P. 2011 High schizotypal individuals manifest differential performance on time-based schedules of reinforcement. Personality and Individual Differences 50: 735-741.

Randell, J., Searle, R., & Reed, P. 2012. Effect of schizotypy on responding and contingency awareness as maintained by free-operant schedules of reinforcement. Learning and Individual Differences 22: 425-428.

Reine, A., & Lencz, T. 1995. Conceptual and Theoretical Issues in Schizotypal Personality Research. in Reine, A., Lencz, T., & Mednick, S.A. Schizotypal Personality. PP 3-19, London: Cambridge University Press.

Roper, K. L., Zentall, T. R. 1999. Observing behavior in pigeons: The effect of reinforcement probability and response cost using a symmetrical choice procedure. Learning and Motivation 30: 201-220.

Sharma, R. P., Dowd, S. M. & Janicek, P. G. 1999. Hallucinations in the acute schizophrenic-type psychosis: effects of gender and age of illness onset. Schizophrenia Research, 37, 91 – 95.

Spielberger CD. 1983. State-Trait Anxiety Inventory STAI (Form Y). Palo Alto, CA: Consulting Psychologists Press, Inc.

Spielberger, C.D., Gorsuch, R.L., Lushene, R. 1970. Manual for the State-Trait Anxiety Inventory (STAI). 1970. Palo Alto, CA: Consulting Psychologists Press, Inc.

Tallent, K. A., Gooding, D. C. 1999 Working memory and Wisconsin Card Sorting Test performance in schizotypic individuals: a replication and extension. Psychiatry Research 89: 161-170.

Tsakanikos, E. & Reed, P. 2005. Seeing words that are not there: detection biases in psychometric schizotypy. British Journal of Clinical Psychology 44: 295-299.

Tysk, L. 1983. Time estimation by healthy subjects and schizophrenic patients: A methological study. Perceptual and Motor Skills 56: 983–988.

Waters, F. & Jablensky, A. 2009. Time discrimination deficits in schizophrenia patients with first-rank (passivity) symptoms. Psychiatry Research 167: 12-20.

Wearden, J. H. 1991. Do humans possess an internal clock with scalar timing properties? Learning and Motivation 1991; 22: 59-83.

Wearden, J.H., Ferrara, A. 1995. Stimulus spacing effects in temporal bisection by humans. Quarterly Journal of Experimental Psychology 48B: 289-310.

Wearden, J.H., Ferrara, A. 1996. Stimulus Range Effects in Temporal bisection by humans. Quarterly Journal of Experimental Psychology 49B: 24 – 44.

Weinberger, D. R. 1988 Schizophrenia and the frontal lobe. TINS 11: 367–370.

Zubin, J. & Spring, B. 1977. Vulnerability: a new view of schizophrenia, Journal of Abnormal Psychology, 86, 260–266.

Table 1: Mean bisection-point difference scores for each subscale and subgroup of the OLIFE(B) for the 4:1 ratio in Experiment 1.

Bisection-point difference (Ratio 4:1)	UE	CD	IA	IN
High	-.04 (± .08)*	-.05 (± .03)	-.03 (± .04)	-.05 (±.03)
Low	-.08 (±.04)*	-.08 (± .04)	-.07 (± .03)	-.07 (± .04)

*Significant difference between high and low scorers $p < .05$

Table 2: Mean bisection-point difference scores for each subscale and subgroup of the OLIFE(B), for the 2:1 and 3:1 ratio conditions in Experiment 2.

Bisection-point difference (Ratio 2:1 & 3:1)	UE		CD		IA		IN	
	2:1	3:1	2:1	3:1	2:1	3:1	2:1	3:1
High	-.02 * (± .06)	-.03 * (± .04)	-.04 (± .08)	-.05 (± .04)	-.03 (± .09)	-.05 (± .05)	-.03 (± .04)	-.04 (± .05)
Low	-.04 * (± .04)	-.06 * (± .04)	-.03 (± .06)	-.03 (± .07)	-.03 (± .05)	-.04 (± .04)	-.04 (± .04)	-.05 (± .04)

*Significant difference between high and low schizotypy *p <.05*