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

Multiple brain regions[1] and neurotransmitters[2-4] are implicated in schizophrenia. For example, it has long been hypothesized that dopamine over-activity is related to schizophrenia[5-7], and an important brain region where neurotransmitter activity contributes to schizophrenic symptoms is the striatum[3,8,9], which is known to be involved in the control of timing[10,11]. Changes in dopamine activity also influences performance in timing tasks[9,12]; increased dopamine activity in the striatum slows subjective time-perception, making subjects over-estimate the passage of time[13,14]. 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[15]), the episodic nature of schizophrenia[16,17], and the changes in potentially-associated dopaminergic levels[6,7], 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[18-23]. 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[19,21-23]. That is, if subjective estimates of the passage of time are longer, then more time will need to pass before a response is made. Other timing tasks require a retrospective judgment of the passage of time. During temporal-bisection tasks, participants initially learn to label two stimuli as of either ‘short’ or ‘long’ duration. They are then presented with a range of stimuli of different durations, 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[18,20]. 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[14]. One factor implicated in interpreting such discrepancies[14,18,20], and the increased variability of temporal perception[14], 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[24], and effectively speed up an internal clock[25].

In overcoming such potential issues, the use of individuals scoring high on schizotypy may be useful[26]. Schizotypy refers to psychometrically-measured behavioral traits and dispositions associated with schizophrenia, but present in the non-clinical population[27-28]. The validity of schizotypy has been supported by factor analytical studies that have linked schizotypal traits to schizophrenic symptoms[29,30]. The use of this population avoids many confounds associated with schizophrenic patients, particularly in terms of medication. 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[26,31-33].

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[34,35], particularly those with high scores on the Unusual Experiences (UE) sub-scale of the O-LIFE(B) scale[36]. Moreover, high UE subjects are unable to describe the temporal nature of the RI schedule[35]. 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[37]. 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[38-40]. It is also worth noting that, in the schedule tasks used in the previous[34,35,37], 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[41], previously employed for schizophrenic patients[14,18], could forward understanding in this area..

Given the previous results noted above for schizophrenic patients[18,20,22,25], and those reported on schedules of reinforcement for high-schizotypals[34,37], 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 short 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 used as clear differences have been found in previous research using this ratio[42]. If high scorers perform in a similar manner to individuals with schizophrenia[18,20], then they should emitted 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 participants (13 males and 39 females) with an age range of 18 to 39 (Mean = 21 ± 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)[36] 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[36].

2.1.2.2 Beck's Depression Inventory (BDI)[43] 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[44].

2.1.2.3 Spielberger Trait Anxiety Inventory (STAI-T)[45] 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[46].

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[47].

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[34,35,37]. 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[48].

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 $\pm$ 1.82). For the IN subscale, 28 participants were in the low scoring group (mean = 1.86 $\pm$ 1.09), and 22 participants were in the high scoring IN group (mean = 5.05 $\pm$ 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[49]. 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 it would be useful to gain an indication of the spread of S responses, in relation to the range below the arithmetic mean where the majority of S responding would be expected. A negative bisection point difference from the arithmetic mean would indicate that the majority of S responses were made below the arithmetic mean.

Figure 1

Figure 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, $F(1,43) = 4.9$; $p < 0.05$, $d = 0.68$, 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 make more S responses for longer presentations than low UE scorers; suggesting, for any given amount of time passed, schizotypal subjects judge that actual time as shorter than it is in reality. This pattern of results is consistent with results obtained from timing studies with individuals with schizophrenia[18,20,22,25], and from predictions derived from previous studies of time-based reinforcement schedules[34,37]. 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 ± 2.22). For the CD subscale, 24 participants were in the low group (mean = 2.61 ± 1.67), and 26 participants were in the high group (mean = 7.33 ± 1.49). For the IA subscale, 30 participants were in the low group (mean = 0.44 ± 0.5), the 20 participants were in the high group (mean = 2.67 ± 0.82). For IN, 30 participants were in the low group (mean = 2.75 ± 1.22), and 20 participants were in the high scoring group (mean = 5.4 ± 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.

Figures 2 and 3

Figure 2 shows the mean bisection point difference for low and high scorers in all the subscales, for the 2:1 condition, and Figure 3 shows these data 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

High UE scorers showed a tendency to claim longer stimuli presentations as 'short' in length, than low UE scorers. This finding suggests that high UE scorers underestimate the length of time the stimuli were presented, and corroborates results from previous studies involving schizophrenic patients[22,23], and views derived from performance on various schedules of reinforcement[34,35,37]. These results are also consistent with temporal-bisection studies using schizophrenic participants that have shown when a timing bias exists, participants with schizophrenia tend place the bisection point relative to long responses at a greater temporal duration than controls[18,20].

There are a number of potential theoretical explanations of these findings. Scalar Timing Theory (SET)[10] postulates an internal clock which consists of pacemaker-accumulator, short-term and reference memory, and decision-making components[15]. 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[50] may be involved, in that comparing most the recent presentations with the standard is problematic in high UE scorers. Finally, a decision-making deficit[51] 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)[11,52] 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[11]. 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 "short" 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[53], but can also be excessive in changing their choices on reasoning tasks[54].

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. These differences, however, were prevalent only within stimuli ranges of 2:1, and above, but not below. 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.

Conflict of Interest Statement

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

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Figure Captions

Figure 1: Mean bisection point difference from the arithmetic mean in high and low scorers in each of the four O-LIFE(B) subscales (UE = unusual experiences; CD = cognitive disorganization; IA = introverted anhedonia; IN = impulsive nonconformity), for the 4:1 ratio condition in Experiment 1.

Figure 2: Mean bisection point difference from the arithmetic mean in high and low scorers in each of the four O-LIFE(B) subscales (UE = unusual experiences; CD = cognitive disorganization; IA = introverted anhedonia; IN = impulsive nonconformity)for the 2:1 ratio condition in Experiment 2.

Figure 3: Mean bisection point difference from the arithmetic mean in high and low scorers in each of the four O-LIFE(B) subscales (UE = unusual experiences; CD = cognitive disorganization; IA = introverted anhedonia; IN = impulsive nonconformity), for he 3:1 ratio condition in Experiment 2.

Figure 1

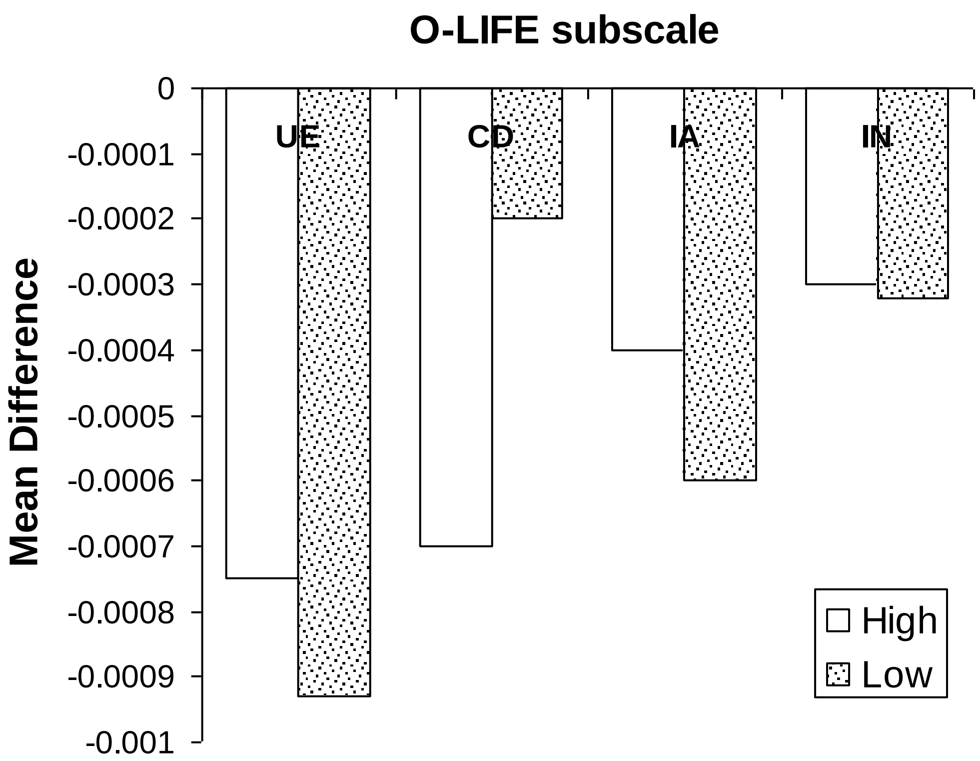

O-LIFE subscale
Mean Difference
0
-0.0001
-0.0002
-0.0003
-0.0004
-0.0005
-0.0006
-0.0007
-0.0008
-0.0009
-0.001
UE
CD
IA
IN
High
Low

Figure 2

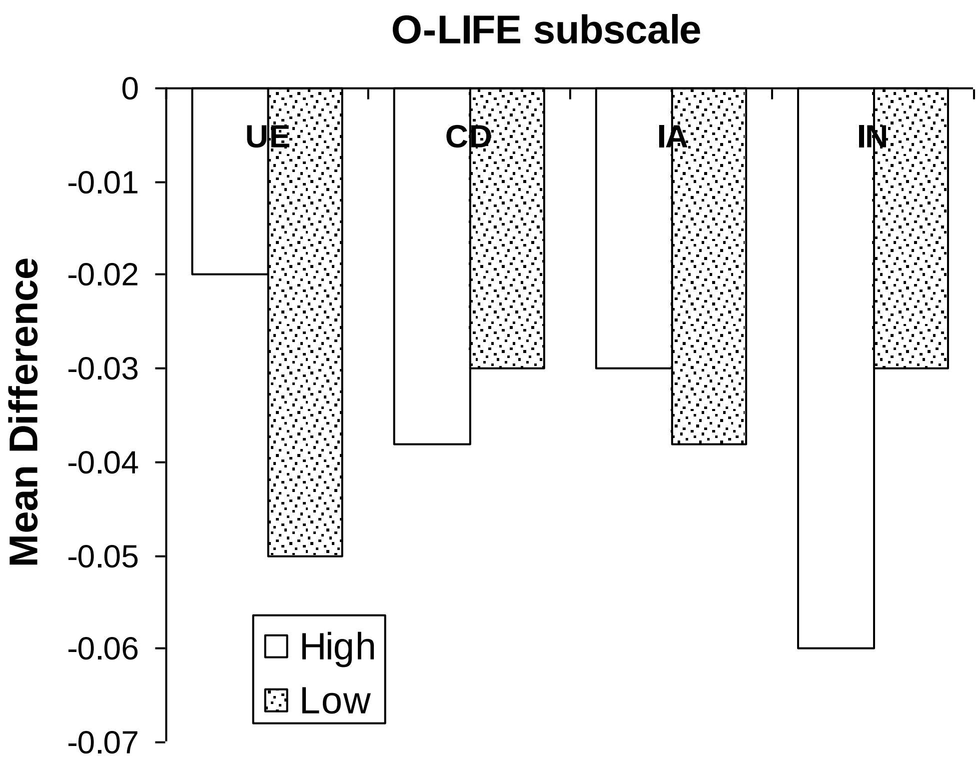
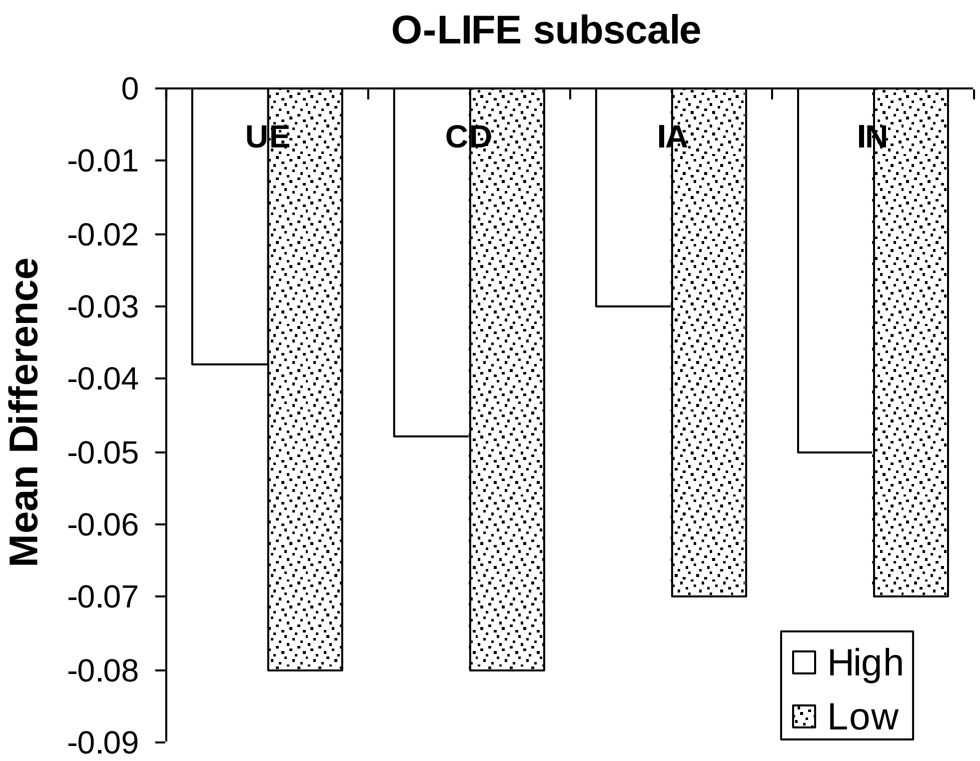

O-LIFE subscale
Mean Difference
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
UE
CD
IA
IN
High
Low

Figure 3


O-LIFE subscale
Mean Difference
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
UE
CD
IA
IN
High
Low