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Highlights

- The circles drawn by participants could be indicative of their time perspectives.
- The novel Circle Test measurement results differed among groups.
- Depressed patients with brain tumors may experience changes in time perspective.
- Changes in the time perspective may be related to treatment adherence.

Depression and time perspectives in patients with brain tumors: Novel measurements in the Circle Test

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Abstract

Background: Tumors trigger both depression and anxiety about death because they can be terminal. However, the relationship between depression and time perspective in patients with life-threatening diseases remains unclear. In this study, we examined the effects of depression on time perspective in patients with brain tumors using a projective method, i.e., the Circle Test.

Methods: Participants (40 depressed patients, Dp; 35 non-depressed patients, NDp; and 40 healthy non-depressed controls, NDc) were administered the Circle Test of time perspectives and self-rating depression scales before and after surgery. The Circle Test data were analyzed using traditional indices, i.e., time dominance and relatedness, and novel measurements, i.e., time area and proportion.

Results: Although the traditional indices showed no differences, the results for the novel measurements differed among the Dp, NDp, and NDc groups. The overall time perspective was smaller in the Dp group than in the NDc group; furthermore, the proportions of the future and past perspectives were higher and lower, respectively, in the Dp group compared to the NDp group.

Limitations: Patients with brain tumors and depressed controls could not be compared, because no healthy control was depressed. Differences in depression-related changes in time perspective between patients with brain tumors and healthy controls should be examined in future studies.

Conclusions: Depressed patients with brain tumors may experience changes in time perspectives according to the results for our novel measurements, and this might play an important role in treatment adherence.

Keywords

Brain tumor, Cancer, Circle test, Depression, Time perspective

1. Introduction

Depression has a negative effect on patients' welfare and health outcomes. Previous studies have suggested that depression has a negative influence on treatment adherence (Gonzalez et al., 2011; Grenard et al., 2011) and that the mortality rate of depressed patients, including those with tumors, is higher than that of non-depressed patients (Freedland et al., 2016; Polsky et al., 2005; Satin et al., 2009). Such findings are particularly relevant when seeking to manage patients with cancer because such patients are confronted with life-threatening illnesses and fears about death ("death anxiety") (Sharpe et al., 2018). The rate of depression is high in patients with tumors, including brain tumors (Fann et al., 2008; Huang et al., 2017; Massie, 2004). Previous studies found that patients who felt that their lives were threatened were less likely to consider the future (Chao et al., 2009; Lahav et al., 2011). Time perspectives are defined as the subjective view of the temporal extents of the past, present, and future (Frank, 1939; Lewin, 1942). Future time perspective was decreased in depressed patients (Foulks and Webb, 1970) and was associated with treatment adherence in patients with head and neck cancer (Baldensperger et al., 2018). Therefore, the relationship between depression and time perspective, especially future time perspective, is of great importance in patients with potentially cancerous tumors that constitute life crises. However, the issue may be much more complicated in patients with brain tumors because brain damage itself causes depression (e.g.,

post-stroke depression) (Villa et al., 2018) and may change one's time perspective (Fellows and Farah, 2005). When considering associations between depression and time perspectives in patients with brain tumors, the affected brain regions should be considered. We investigated whether time perspectives were affected by depression in patients with brain tumors after we confirmed that these patients were indeed more depressed than healthy controls. In addition, we explored whether the associations between depression and time perspectives according to the brain region affected.

Time perspectives can be measured in several ways. However, such measurements may be particularly complex in patients living with cancer diagnoses and facing the existential distress associated with possible early death. To avoid awareness of possible early death by the patients, we used the Circle Test, a projective method in which participants express their past, present, and future time perspectives by arranging and sizing three circles representing the past, present, and future (Cottle, 1967). In the Circle Test, two indices, namely time dominance and time relatedness, have traditionally been used. Time dominance refers to the relative sizes of the circles, and time relatedness relates to whether circles are separate, in contact with one another, or overlapping. Recent progress in computer technology has made it possible to measure the area of the circles, which was difficulty when the Circle Test was first proposed (Cottle, 1967). Therefore, in this study, we analyzed the areas and proportions of the circles, in addition to calculating the traditional indices.

2. Methods

2.1. Participants

One hundred and nine patients (mean age: 60.4 years; range: 21–85 years; 59 men and 50 women) who were scheduled to undergo awake craniotomy for brain and spinal cord tumors from 2016 to 2019 at Tokyo Metropolitan Cancer and Infectious Diseases Center, Komagome Hospital, participated in this study. Inclusion criteria included a diagnosis of brain and neck tumor, an age of 20 years or older, and sufficient language ability to complete a cognitive screening test, the Cognistat, including orientation to time and place, attention, language, construction, memory, calculation, and reasoning (Kiernan et al., 1987; Matsuda and Nakatani, 2009). Patients who lacked data because of withdrawing consent or who were unable to participate because of deteriorating health were excluded from data analyses. Patients who had tumors in multiple regions and regions for which there were fewer than five patients (e.g., fornix, occipital cortex, spinal cord, and ventricle) were also excluded from data analyses. Therefore, the data from 75 patients who had brain tumors in the medial prefrontal cortex (mPFC), lateral prefrontal cortex (lPFC), temporal lobe (TL), parietal lobe (PL), auditory nerve, and cerebellum (mean age: 61.3 years; range: 21–85 years; 38 men and 37 women) were analyzed. The control data were obtained from 40 healthy participants (mean age: 58.4 years; range: 30–77 years; 18 men and 22 women) recruited from a job placement center for elderly people and a volunteer center in the local community, with payment. The control participants had no medical history of mental or neurological disease. To evaluate depression, we used the self-rating depression scale (SDS) (Fukuda and Kobayashi, 1973; Zung, 1965) or the World Health Organization-Five Well-being Index (WHO-5) (Inagaki et al., 2013; World Health

Organization, 1998). The SDS was replaced by the WHO-5 early in the study because some patients appeared to become distressed when answering sensitive questions posed by the SDS. A previous study that tested the reliability and validity of the Japanese version of the WHO-5 indicated that a cut-off score of <13 was appropriate for screening depression (Awata et al., 2007). Patients and healthy controls who scored ≥40 on the SDS or <13 on the WHO-5 were categorized as depressed based on the cutoff scores of the SDS and WHO-5. Both SDS and WHO-5 showed sufficient validity in screening depression (Awata et al., 2007; Biggs et al., 1978; Bonsignore et al., 2001; Jokelainen et al., 2019). The patients with a tumor comprised 40 depressed patients (Dp group) and 35 non-depressed patients (NDp group), and all healthy controls were categorized into non-depressed controls (NDc group) because all scored >13 on the WHO-5. All participants gave written informed consent under a protocol that was approved by the Institutional Review Board of Tokyo Metropolitan Cancer and Infectious Diseases Center, Komagome Hospital, and the Research Ethics Committee of the Institute of Cultural Science at Chuo University.

(Table 1 near here)

2.2. Procedures

An examination battery that included the SDS (Fukuda and Kobayashi, 1973; Zung, 1965) or the WHO-5 (Inagaki et al., 2013; World Health Organization, 1998), the Circle Test (Cottle, 1967), and the Cognistat (Kiernan et al., 1987; Matsuda and Nakatani, 2009) was administered

twice. The first session for the patients was conducted 3–5 days before the surgery and the second session was conducted 4–18 days after the surgery. The healthy controls received the same sessions at an interval of 1–3 weeks. In the Circle Test, the participants were asked to imagine "past," "present," and "future" as circle shapes and were told to draw these circles on a blank sheet of A4 paper in landscape mode in the manner that best represented their relationships. The Cognistat was administered to explore whether the Dp, NDp, and NDc groups differed in terms of general cognitive ability.

2.3. Data analyses.

Two traditional indices and two newly adopted measures were used to evaluate subjective time perspectives on the Circle Test. The two indices were time dominance and time relatedness. Time dominance was defined as the largest circle among the three circles representing past, present, and future. Time relatedness consisted of three types: temporal atomicity, temporal continuity, and temporal integration depending on the relationships between every two in each circle (Cottle, 1967). Two independent circles scored 0 points, one circle touching another circle scored 2 points, two overlapping circles scored 4 points, and one circle including another circle scored 6 points. The time-relatedness category was defined based on the score: temporal atomicity was 0 points, temporal continuity was 2–6 points, and temporal integration was 8–18 points. Temporal atomicity refers to the absence of area relatedness and corresponds to atemporal interstitial areas lying between circumscribed areas. Temporal continuity is present when areas are touching but not overlapping and depicts time as an ineluctable flow. Finally,

temporal integration refers to partial or totally overlapping areas and represents the past and future as inherent in the present (Cottle, 1967). To investigate whether time dominance and time relatedness could be modulated by depression, chi-square tests comparing the Dp, NDp, and NDc groups were performed with the data of the first and second sessions. The two newly adopted measures were the sizes of the circles reflecting the past, present, and future and the proportion of the total area represented by each circle. The area of each circle was obtained with ImageJ (National Institutes of Health, Bethesda, MD, USA; https://imagej.nih.gov/ij/). The areas were analyzed via a three-way analysis of variance (ANOVA) with group (Dp, NDp, and NDc) serving as a between-subjects factor, and time points (past, present, and future) and sessions (first and second) serving as within-subject factors when investigating the effects of depression on time perspectives. In addition, because the individual differences in each area were large, the percentages of the past, present, and future circles relative to the sum of the three circles were calculated as the proportions of each time perspective, and two-way ANOVAs of the proportions by group (Dp, NDp, and NDc) were performed for the past, present, and future circles. We assessed the validity of the newly adopted measures by determining whether future time perspective was negatively correlated with age, as in previous studies (Brothers et al., 2014; Kooij et al., 2014; Weiss et al., 2016). Thus, correlation analyses between age and the area of each circle during the first session were performed in the Dp, NDp, and NDc groups. In addition, to determine whether the area of each circle was affected by tumor location, a three-way analysis of variance (ANOVA; region of tumor × time point × session) for area and two-way ANOVA (region of tumor × session) for proportion were performed. IBM SPSS

Statistics ver. 22 was used for all analyses (IBM, USA). P-values were corrected using the Bonferroni procedure for multiple comparisons.

3. Results

3.1. Prevalence of depression

A chi-square test revealed a significant difference in the rate of depression between the patients and healthy controls ($\chi^2 = 32.7$, $p < 0.01$, V = 0.53). However, a further chi-square test revealed no significant difference in brain tumor locations between the Dp and NDp groups ($\chi^2 = 3.30$, $p = 0.65$, V = 0.21). The demographic data of the Dp, NDp, and NDc groups are shown in Table 1. No significant difference was observed among the Dp, NDp, and NDc groups in age ($F(2, 112) = 0.82$, $p = 0.44$, $\eta p^2 = 0.01$), Cognistat score ($F(2, 112) = 2.72$, $p = 0.07$, $\eta p^2 = 0.05$), or sex ($\chi^2 = 0.35$, $p = 0.84$, V = 0.06).

3.2. Time dominance and time relatedness

The time-dominance and time-relatedness results of the Circle Test are shown in Table 2. No significant differences in time dominance or time relatedness were observed among the groups (Dp, NDp, and NDc) according to the first session (time dominance: $\chi^2 = 3.64$, $p = 0.46$, V = 0.13; time relatedness: $\chi^2 = 7.53$, $p = 0.11$, V = 0.18) or second session (time dominance: $\chi^2 = 8.45$, $p = 0.08$, V = 0.19; time relatedness: $\chi^2 = 6.19$, $p = 0.19$, V = 0.16).

(Table 2 near here)

3.3. Area comparison between groups and sessions

In the analysis of area, a three-way ANOVA with group (Dp, NDp, and NDc), time point (past, present, and future), and session (first session and second session) as factors showed significant main effects of group ($F(2,112) = 3.79$, $p < 0.05$, $\eta p^2 = 0.06$), time point ($F(2,111) = 5.75$, $p < 0.01$, $\eta p^2 = 0.09$), and session ($F(1,112) = 4.09$, $p < 0.05$, $\eta p^2 = 0.04$) (Figure 1). Post hoc analyses indicated that the total area of the Dp group was significantly smaller than that of the NDc group ($p < 0.05$), the area of the past was significantly smaller than those of the present and future (versus present: $p < 0.01$; versus future: $p < 0.05$), and the area of the first session was significantly smaller than that of the second session ($p < 0.05$). The interactions were not significant ($p > 0.1$ for all comparisons).

(Figure 1 near here)

3.4. Proportions of areas by groups and sessions

A two-way ANOVA with group and session as factors showed a significant main effect of group on the proportions of the past and future perspectives (past: $F(2,112) = 4.23$, $p < 0.05$, $\eta p^2 = 0.07$; future: $F(2,112) = 3.45$, $p < 0.05$, $\eta p^2 = 0.06$) but no significant effect on the present ($F(2,112) = 0.17$, $p = 0.85$, $\eta p^2 = 0.00$) (Figure 2). Post hoc analyses revealed that the proportion of the past was greater in the Dp group than in the NDp group ($p < 0.05$) and that the proportion of the future perspective was smaller in the Dp group than in the NDp ($p < 0.05$) group. No

other main effects or interactions were significant in the past, present, or future perspectives ($p > 0.1$ for all comparisons).

(Figure 2 near here)

3.5. Correlations between area and age

Correlation analyses between the area of the future circle and age revealed significant negative correlations in the NDc ($r = -0.39$, $p < 0.05$) and NDp groups ($r = -0.37$, $p < 0.05$), and a marginally significant correlation in the Dp group ($r = -0.29$, $p = 0.07$). The correlation between the area of the present circle and age was also significant in the NDc group ($r = -0.33$, $p < 0.05$). No significant correlation was detected between the area of the past circle (Dp: $r = 0.07$, $p = 0.67$; NDp: $r = 0.11$, $p = 0.53$; NDc: $r = -0.15$, $p = 0.37$) or present circle and age (Dp: $r = -0.10$, $p = 0.52$; NDp: $r = 0.02$, $p = 0.91$).

3.6. Areas and proportions: Comparison among regions

In a three-way ANOVA of area with location (mPFC, lPFC, TL, PL, auditory nerve, cerebellum, and NDC), time point (past, present and future), and session as factors, there were no significant main effects or interactions ($p > 0.1$ for all comparisons). In two-way ANOVAs of the proportions of the three time perspectives with region and session as factors, there was a significant main effect of region ($F(6,108) = 2.41$, $p < 0.05$, $\eta p^2 = 0.12$) in the proportion of the past time perspective (post hoc: PL > lPFC, $p < 0.05$) but there were no other main effects or

interactions for past, present, or future perspective ($p > 0.1$ for all comparisons).

Discussion

Prior to investigating whether time perspective was affected by depression in patients with brain tumors, we explored whether patients with brain tumors were more depressed than healthy controls. We confirmed that patients with brain tumors were more depressed than controls (Table 1), as previously observed in patients with other tumors (Fann et al., 2008; Massie, 2004), and in those with brain tumors (Huang et al., 2017). No control subject was depressed (0%, 0/40), but the incidence of depression was high among the patients with brain tumors (53%, 40/75).

To investigate the relationship between depression and time perspective, we used novel measures, namely the areas and proportions of circles, in addition to the traditional indices of the Circle Test (time dominance and time relatedness). There were two notable findings. First, the traditional indices of time dominance and time relatedness did not differ among the groups (Dp, NDp, and NDc) (Table 2). Second, in terms of the novel indices of the Circle Test, the areas of the Dp group were smaller than those of the NDc group (Figure 1). Furthermore, the proportion of the past perspective was larger in the Dp group than in the NDp group, while the proportion of the future perspective was smaller (Figure 2).

With respect to time dominance in the Circle Test, a previous study on advanced cancer patients receiving palliative care found that the present perspective was dominant, whereas the future perspective was dominant in cancer patients in remission (van Laarhoven et

al., 2011). With regard to time relatedness, it has been suggested that participants who exhibit higher time-relatedness scores have a greater degree of self-actualization (Getsinger, 1975). These studies suggested that time dominance may be affected by personal circumstances, and that time relatedness may reflect the subjective internal state. However, in the current study, there was no group difference in time dominance or time relatedness. Therefore, it seems unlikely that the traditional measures, i.e., time dominance and time relatedness, are affected by cancer-induced depression.

Regarding the novel indices used in this study, a significant negative correlation was evident between age and future perspective in the NDp and NDc groups, while in the Dp group, a trend was evident, similar to previous studies showing that the likelihood of future time perspective decreased with age (Brothers et al., 2014; Kooij et al., 2014; Weiss et al., 2016). These findings suggest that the novel indices are valid. Furthermore, we found significant differences in the areas and proportions of the circles between the Dp group and NDp and NDc groups. The areas of the past, present, and future were smaller in the Dp group than in the NDc group. Furthermore, the relative of the past perspective was larger in the Dp group than in the NDp group, and the proportion of the future perspective was smaller in the Dp group than in the NDp group. In the literature, a focus on the past has been associated with distress in cancer patients (van Laarhoven et al., 2011), while a predominantly present time perspective has been related to impulsive pleasure-seeking (Chavarria et al., 2015; Rothspan and Read, 1996; Sekścińska et al., 2018; Zimbardo et al., 1997). Therefore, it is possible that changes in the past and present time perspectives are associated with distress or loss of pleasure in depressed

patients. On the other hand, the likelihood of future time perspective has been shown to be lower in depressed patients relative to healthy controls (Foulks and Webb, 1970), and to decrease with increased depression severity in patients cured of cancer, and in those receiving palliative care (van Laarhoven et al., 2011). The future time perspective is especially important in terms of patient activities in the clinical setting. For example, in healthy individuals, the future time perspective has been shown to be related to wellbeing and morale (Hoppmann et al., 2017; Kozik et al., 2015), as seen in patients with brain and neck cancer, and with adherence to treatment (Baldensperger et al., 2018). Furthermore, one meta-analysis suggested that a future time perspective was positively associated with life satisfaction and health-improving behaviors, and negatively associated with anxiety and depression (Kooij et al., 2018). Therefore, the future time perspective is an important indicator of subjective patient condition; treatment of depression in patients with brain tumors may increase wellbeing and treatment adherence by increasing the likelihood of the future time perspective.

In addition, we examined whether time perspective differed according to the brain region affected by the tumor; this was not found to be the case. However, in previous studies, PFC damage reduced the likelihood of the future time perspective and impaired prospective memory (Cockburn, 1995; Fellows and Farah, 2005). Moreover, the volume and extent of activation of specific brain regions were associated with time perspective (Chen et al., 2018; Guo et al., 2017; Liu and Feng, 2019; Zhou et al., 2018). There are two possible explanations for this discrepancy. First, the effects of organic damage may be masked by the effects of psychological factors, such as depression. Second, the small number of patients with brain

tumors in each region made it difficult to analyze differences by region in our study. Thus, further analyses are required. However, our main purpose was to investigate the effect of depression caused by a brain tumor on time perspective. As the effect of tumor region was controlled for between patient groups, the effects of depression could be identified despite the fact that various brain regions were affected by tumors.

5. Limitations

Two limitations of the present study warrant attention. First, we could not compare data between patients with brain tumors and depressed controls, because no healthy control was depressed. Therefore, we could not determine whether the decline in time perspective was due to cancer-related depression or was an artifact of depression itself. Differences in depression-related changes in time perspective between patients with brain tumors and healthy controls should be examined in future studies. However, because a previous study suggested that the future time perspective was related to treatment adherence in patients with brain tumors (Baldensperger et al., 2018), our findings that the time perspectives differed between depressed tumor patients and non-depressed patients, but not between non-depressed patients and healthy controls, are important. Second, as we discussed above, no significant differences were found between the NDc and other groups of the brain tumor locations. This effect awaits confirmation in future studies.

6. Conclusion

The novel measurements used in our projective psychological assessment revealed that depressed patients with brain tumors may experience changes in time perspectives, particularly the future perspective. Previous studies of patients with brain and neck cancers have suggested that the future time perspective is related to adherence to treatment and the size of a patient's social network (Baldensperger et al., 2018). Thus, treating depression may be important in patients with brain tumors.

Author Contributions

Y.S. and A.M. conceived of the idea and designed the experiment; Y.S., S.S., K.H., K.H., and R.O. carried out the experiment; N.S. and R.Y. recruited patients and reviewed the medical record of patients. Y.S. analyzed data and wrote the manuscript in consultation with A.M. All authors discussed the results and contributed to the final manuscript.

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Open practices statement

The data are available from the corresponding author upon reasonable request. The data are not publicly available due to informed consent restrictions pertaining to the release of confidential

patient information. None of the experiments were preregistered.

Acknowledgment

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Conflict of interest statement

None of authors has any potential conflicts of interest.

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Table 1. Demographic data

	Depressed patients (Dp) (n = 40)	Non-depressed patients (NDp) (n = 35)	Non-depressed controls (NDc) (n = 40)		
Age				n.s.	†
Mean (SD)	62.4 (15.0)	60.1 (14.3)	58.4 (12.5)		
Range	21–85	31–85	30–77		
Sex (Male: Female)	20:20	18:17	18:22	n.s.	‡
SDS (N)	8	6	0		
Mean (SD)	46.5 (3.1)	33.3 (3.2)			
WHO-5 score (N)	32	29	40		
Mean (SD)	7.4 (3.5)	17.4 (3.5)	18.8 (3.0)		
Cognistat				n.s.	†
Mean (SD)	92.3 (8.9)	93.2 (10.2)	96.7 (7.2)		
Region (N)				n.s.	‡
lPFC	7	10			
mPFC	8	9			
TL	7	6			
PL	7	5			
Auditory nerve	4	1			
Cerebellum	7	4			
Type (N)				n.s.	‡
Glioma	2	1			
Astrocytoma	3	1			
Oligodendroglioma	3	2			
Glioblastoma	6	6			
Meningioma	9	6			
Schwannoma	5	2			
Chordoma	1	0			
Hemangioblastoma	0	1			
Metastasis	8	13			
Radiation necrosis	1	2			
Other	2	1			
Grade (N)				n.s.	‡
I	15	9			
II	6	2			
III	1	1			
IX	7	7			
(NA)	3	3			
(Metastasis)	8	13			

SD = standard deviation, SDS = self-rating depression scale, WHO-5 = World Health Organization-Five Well-being Index, lPFC = lateral prefrontal cortex, mPFC = medial prefrontal cortex, TL = temporal lobe, PL = parietal lobe, NA = not available, n.s. = not significant, † = ANOVA, ‡ = chi-square test

Table 2. Results of the Circle Test

	Depressed patients (Dp)	Non-depressed patients (NDp)	Non-depressed controls (NDc)		
Time dominance (N)					
First session				n.s.	‡
Past	11	5	10		
Present	19	15	16		
Future	10	15	14		
Second session				n.s.	‡
Past	17	5	12		
Present	12	11	11		
Future	11	19	17		
Time relatedness (N)					
First session				n.s.	‡
Atomicity	23	26	18		
Continuity	6	2	5		
Integration	11	7	17		
Second session				n.s.	‡
Atomicity	26	22	16		
Continuity	3	3	6		
Integration	11	10	18		
Area (cm^2)				*	†
First session					
Past	28.3 (26.3)	22.5 (16.7)	30.3 (32.5)		
Present	32.2 (35.8)	34.5 (31.5)	43.6 (33.2)		
Future	27.6 (32.1)	40.4 (39.9)	44.4 (43.9)		
Second session					
Past	32.2 (37.5)	24.0 (16.3)	34.9 (28.9)		
Present	34.4 (28.6)	35.8 (34.6)	50.2 (43.6)		
Future	27.5 (30.1)	42.3 (31.7)	56.8 (61.8)		
Proportion (%)					
Past				*	†
First session	35.4 (20.4)	26.0 (18.3)	27.3 (19.0)		
Second session	38.5 (22.0)	26.3 (15.7)	29.3 (17.6)		
Present				n.s.	†

First session	36.7 (20.0)	35.8 (18.9)	37.6 (18.1)		
Second session	33.7 (13.7)	34.2 (15.6)	35.9 (14.0)		
Future				*	†
First session	28.0 (20.0)	38.1 (24.0)	35.2 (20.4)		
Second session	27.7 (18.0)	39.6 (20.3)	34.9 (19.1)		

SD = standard deviation, * = $p < 0.05$, + = $p < 0.1$, n.s. = not significant, † = ANOVA, ‡ = chi-square test

Figure legends

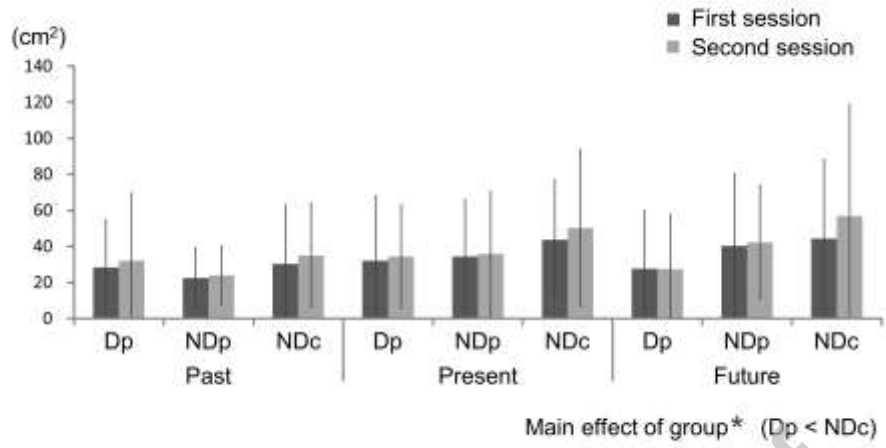

Figure 1. Areas of past, present, and future circles of depressed patients (Dp), non-depressed patients (NDp), and non-depressed controls (NDc). Error bars represent standard deviations. *P < 0.05.

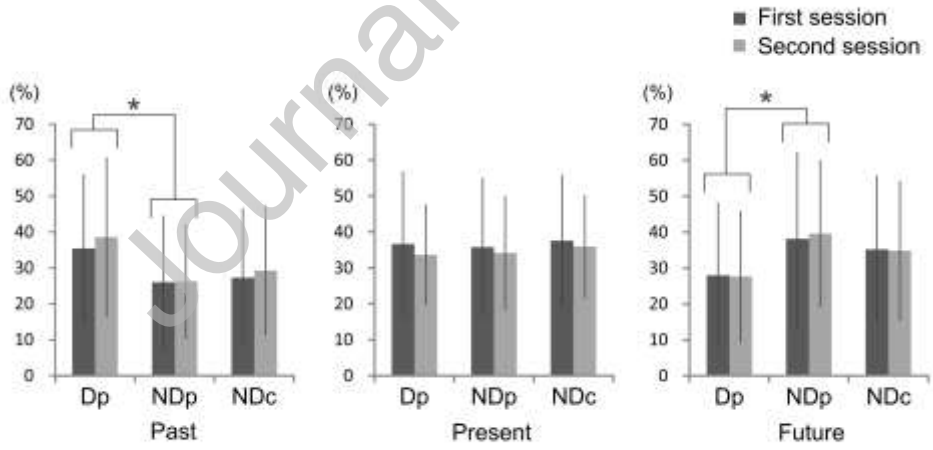

Figure 2. Proportions of past, present, and future circles in depressed patients (Dp), non-depressed patients (NDp), and non-depressed controls (NDc). Error bars represent standard deviations. *P < 0.05.