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Research article

The influence of interest in tasks on the autonomic nervous system

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ABSTRACT

Although prior studies have indicated the relationships among decreased parasympathetic activity, schizophrenia, and depression, the physiological effects of psychiatric occupational therapy tasks have not been adequately explored. Therefore, it is necessary to quantitatively examine the physiological changes in the autonomic nervous system when performing such tasks to devise more individualized therapies. Accordingly, we examined the influence of task interest and its relationship with psychological characteristics. The participants included in this study were 22 healthy individuals. They completed the State-Trait Anxiety Inventory, the Center for Epidemiologic Studies Depression Scale, and the Social Phobia Scale. Participants selected the most and least interesting bookmarks from a set of 19 different color options, and indicated their degree of interest on a visual analog scale. An electrocardiogram was used during each task to record participants' cardiac sympathetic index (CSI) and cardiac vagal index (CVI) as they performed two tasks (interesting and uninteresting). The correlations between the degree of interest and CSI/CVI, and between the scores of the questionnaires and CSI/CVI were examined. There was a negative correlation between the degree of interest and CSI during the uninteresting task. Task interest may have contributed to suppressing sympathetic dominance and reducing mental and physiological loads, even if the tasks differed only color-wise. Physiological effects emerged from participants' degree of task interest. Further identification of objective and therapeutic mechanisms may lead to wider applications of activities in different areas.

1. Introduction

Interest is known to enhance motivation (Sansone and Thoman, 2005; Silvia, 2008) and is an important factor in various dimensions of performance, such as learning (Ainley et al., 2002) and development of early academic ability (Martin et al., 2013). Psychiatric research suggests that the learning capability of patients with schizophrenia is promoted by incorporating instructional techniques that enhance their intrinsic motivation when undertaking cognitive tasks (Choi and Medalia, 2010). Further, motivation is an important factor that influences psychosocial treatment outcomes in patients with schizophrenia (Medalia and Saperstein, 2011; Nakagami et al., 2008). Utilizing interest-based tasks is a traditionally employed strategy in psychiatric occupational therapy to alleviate psychiatric symptoms (Iwai and Yamane, 2007; Yamane, 2017). In a previous study, we examined the subjective effects of increasing healthy individuals' interest (Nishida et al., to be submitted); however, we did not consider the physiological effects of increasing interest.

The heart is controlled by the sympathetic and parasympathetic nervous systems, while the autonomic nervous system's activity is one of the physiological indices. In general, the sympathetic nervous system promotes cardiac activity while the parasympathetic nervous system suppresses it, and resting heart rate is preponderantly controlled through parasympathetic nervous system activity (Hori et al., 2017b). An increase in sympathetic nervous system activity and the suppression of parasympathetic nervous system activity is generally observed when negative emotions are aroused (Hori et al., 2017a).

Decreased parasympathetic activity has been reported in patients with psychiatric disorders such as schizophrenia and major depression (Agelink et al., 2002; Montaquila et al., 2015). The decreased ability to recover from a stress response due to vagal tone deficits has also been reported in patients with schizophrenia (Montaquila et al., 2015). Hence, the index of the autonomic nervous system's activity should be used for advancing tailored psychiatric rehabilitation.

Heart rate variability (HRV), which is used to measure autonomic nervous system activity, can be used to assess stress responsiveness (Bali and Jaggi, 2015). HRV has been used to evaluate mental workload; however, it has also been pointed out that brain activity should be directly evaluated to obtain more accurate readings of mental workload

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(Hori et al., 2017a). A relationship between the autonomic nervous system and mental tasks was observed in a study in which decreased vagal activity and increased sympathetic activity were found to be associated with mental fatigue (Mizuno et al., 2011; Tanaka et al., 2009). For patients with schizophrenia, a task involving social cognition can decrease both parasympathetic and sympathetic activities (Jauregui et al., 2011). HRV biofeedback can improve autonomic function along with reducing depression and anxiety symptoms (Siepmann et al., 2008). HRV biofeedback (which aims to increase HRV in a visual biofeedback setting), in addition to rehabilitation, may also be effective in reducing anxiety and improving vasomotor function among alcoholics (Penzlin et al., 2015).

Prior research has shown that exposing individuals to their favorite odors while performing a task could enhance their work efficiency and parasympathetic activity (Amano et al., 2012). Further, Tsutsui et al. (2017) found that individuals viewing a preferred video of a natural environment exhibited a decrease in heart rate, which suggested that personal preferences contributed to an enhanced relaxation effect. The influence of subjective interest on autonomic nervous system activity has not yet been sufficiently demonstrated, although some correlations have been noted. The present study quantitatively assessed the effect of subjective interest on the autonomic nervous system as a physiological index. Its results may provide evidence of the effectiveness of individualized occupational therapy, thereby promoting its use, with due consideration of the patient's condition and individuality.

2. Materials and methods

2.1. Participants

Twenty-four healthy individuals (13 men, 11 women; mean age: 22.88 $\pm$ 1.62 years, age range: 20–25 years) who confirmed that they were willing to engage in handicraft activities were recruited. Individuals who had personally interacted with the researcher who would be in front of them during the experimental tasks were excluded in consideration of the potential influence of their relationship. Participants were asked to avoid excessive work and get sufficient sleep on the day prior to the experiment. Additionally, they were asked to avoid drinking coffee and smoking on the day of the experiment, and to eat a meal at least 2 h before the experiment.

The required sample size was calculated as 17–44, using G * Power with an effect size of 0.4–0.6, a significance level of 0.05, and a power of 0.8. Written informed consent to participate in the study was obtained from all the participants. The study protocol was approved (R1639) by the Kyoto University Graduate School and Faculty of Medicine Ethics Committee.

2.2. Measures

Participants were asked to complete The State-Trait Anxiety Inventory (STAI; Hidano et al., 2000), the Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977), and the Social Phobia Scale (SPS; Kanai et al., 2004) to measure anxiety, depression, and social phobias, respectively; all three scales are self-reported questionnaires. The state anxiety score of the STAI indicates anxiety levels at the time of measurement and in daily life (Hidano et al., 2000). The CES-D is a self-reported scale for depression and asks about the frequency of symptoms during the previous week (Radloff, 1977). The SPS measures the fear of being observed in social situations (Kanai et al., 2004).

2.3. Materials

The examination environment, which is shown in Figure 1, was a semi-shielded room. The participants were recorded from the front of their right side, while the researcher was behind the camera. This set-up was intended to emulate a real-life occupational therapy room where more than one person (the patient) is present.

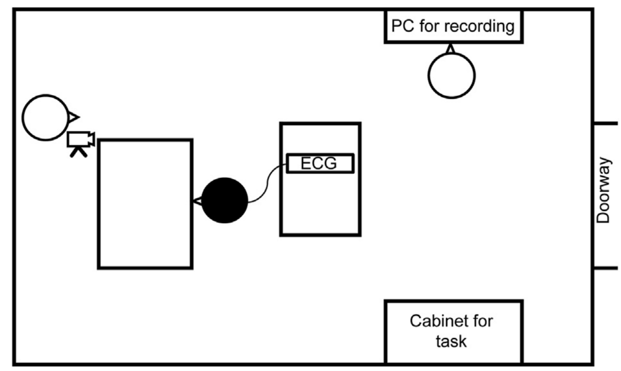

Figure 1. The Examination Environment. The participant is shown in black and the examiner is shown in white. The electrocardiogram (ECG) and actions of the participant were recorded, with the latter being recorded using a video camera from the front of the participant's right side, while a researcher stood behind the video camera.

The electrocardiogram (ECG) measuring device used was a 36-channel DC digital multipurpose electroencephalograph BIO-NVX36 (East Medic Co., Ltd.). Participants' ECG was recorded during the task.

2.4. Procedure

An ECG was attached to the participant's sternum and left flank by a chest lead. The touching points were polished with Nuprep, a skin pretreatment agent used for removing excess sebum and keratin. An electroencephalogram measurement gel (ELECTRO-GEL) was injected into the electrodes, which were fixed with surgical tape. The participants selected two plastic net craft bookmarks that they were interested in making and another two they were not interested in making from among 19 samples of bookmarks in different colors. They selected one each from the bookmarks they had chosen and determined the one they were the most interested in and the one they were the least interested in. The bookmarks were created by knitting a string repeatedly through a net using a needle, each using strings of different colors. Twelve of the bookmarks had a single color, while seven had color gradients. Their degree of task interest was marked on a visual analog scale, ranging from "*interested in and want to try*" to "*not interested in and do not want to try*."

Participants were aware that they were being watched by the researchers. They sat on a chair in front of a desk. In a resting state, they fixed their gaze on a fixed cross in the center of an A4-sized piece of paper for 3 min (baseline); this was done to prepare and standardize participants' conditions immediately before the experiment. Subsequently, participants were given their first task (Task A), in which they were instructed to craft the bookmark they were interested in. Following this, they were instructed to create the bookmark they were not interested in (Task B). Half of the participants performed Task A first, while the other half first performed Task B, then A. They were instructed to create the bookmark according to the previously selected design at their own pace, within a reasonable standard of 10 min. In case they dropped their tools on the floor, they were instructed not to retrieve them but to use the other tools on the table instead. They were also instructed to not hide their movements. The procedure details were also reported in our previous study (Nishida et al., to be submitted).

2.5. ECG analysis method

The measured ECG was captured by the waveform viewer program VitalTracer. After data conversion, 2 min of data, starting at 2 min 30 s–30 s before the end of the task, were adopted for each condition. The Lorentz plot analysis (Toichi et al., 1997) of heart rate RR interval (msec) was performed using the autonomic nerve analysis program (MaP1060). The fluctuation of the RR interval was transformed into an ellipsoid distribution in Lorentz plots, and the length of the new transverse axis T and longitudinal axis L was calculated (Toichi et al., 1997). The cardiac vagal index (CVI), which is a parasympathetic nervous system activity index, as well as the cardiac sympathetic index (CSI), which is a sympathetic nervous system activity index, were calculated. The CVI was calculated as Log (L × T), and CSI was calculated as L/T (Toichi et al., 1997).

2.6. Statistical analysis

We performed Spearman's correlation analysis between the degree of interest and CSI/CVI. Additionally, the correlations between CSI/CVI and psychiatric characteristics were analyzed. We performed correlation analysis of the CSI/CVI during rest, Task A, Task B, and the scores for STAI-state, STAI-trait, SPS, and CES-D. Statistical analyses were performed using SPSS software, version 27 (IBM, Armonk, NY). The significance level was set at $P < .05$.

3. Results

After excluding two participants with arrhythmia, a total of 22 samples remained for analysis. Their characteristics and averages for the questionnaire and CSI/CVI are shown in Table 1. The average scores of the questionnaires in this study were either below the indicated cut-off points or indicated average. We compared the CVI/CSI in each task based on gender; no significant differences were found.

3.1. CSI/CVI during tasks

There was a negative correlation between the degree of interest and CSI during uninteresting tasks ($p = .004$, $\rho = -.584$); the lower the interest, the higher the sympathetic activity (Figure 2a). The results showed that subjective interest can affect objective indicators. Even if the amount of exercise load (e.g., movements or difficulty) in the tasks is similar—as the tasks only differ in the colors used—selecting interesting activities may contribute to suppressing the state of sympathetic nerve dominance.

In this study, no significant correlation was found between CSI and interesting tasks (Figure 3a). Tsutsui et al. (2017) reported that their study participants' relaxation was enhanced while watching a video of a natural environment they preferred. Participants' preference was considered in the present study as well, with participants being required to choose the task they found the most interesting, as similar to Tsutsui et al.'s (2017) study, therefore we expected this to have an effect on performance of all participants during the "interesting task" and

Table 1. Participants' characteristics.

Characteristics	n = 22	Mean	SD
Age		22.77	1.66
Gender (Male: Female)		13:9	
STAI-state		38.64	8.59
STAI-trait		42.45	8.43
SPS		18.09	11.87
CES-D		9.64	5.27
CVI (during task)	rest	4.44	0.28
	like	4.33	0.27
	dislike	4.34	0.21
CSI (during task)	rest	2.13	0.69
	like	2.08	0.52
	dislike	2.21	0.77

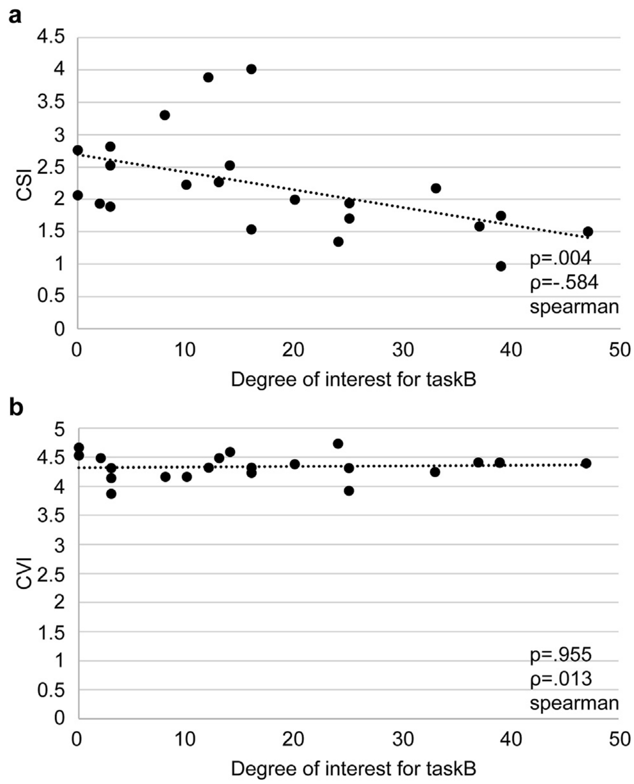

Figure 2. (a) Relationship between the cardiac sympathetic index (CSI) and the degree of interest for task B. (b) Relationship between the cardiac vagal index (CVI) and degree of interest for task B.

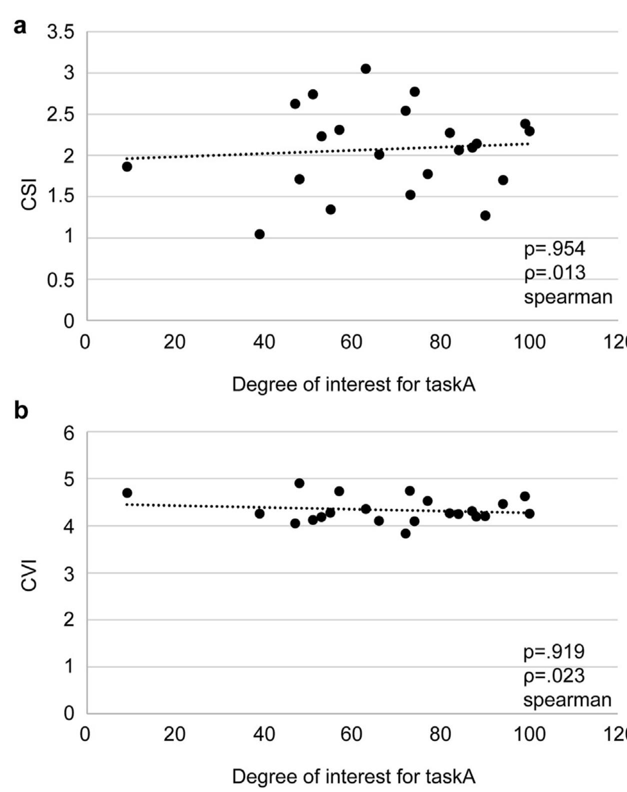

Figure 3. (a) Relationship between the cardiac sympathetic index (CSI) and degree of interest for task A. (b) Relationship between the cardiac vagal index (CVI) and degree of interest for task A.

considered that it may be difficult to make out a large difference in CSI based on degree of interest. Additionally, it is also possible that the mental load was greater for tasks that participants found uninteresting, which may have affected sympathetic activity, while the effect of interest was greater in uninteresting task. No significant correlation was found in either task (interesting or uninteresting) with CVI (Figures 2b, 3b).

3.2. CSI/CVI and psychological characteristics

There was a tendency toward a positive correlation between the CES-D score and CVI only during uninteresting tasks ($p = .073$, $\rho = .39$); the higher the degree of depression, the higher the parasympathetic activity during uninteresting tasks (Figure 4). Thus, task interest may influence the relationship between physiological state and depression. There were no significant correlations between STAI or SPS and CSI or CVI.

4. Discussion

The lower the interest, the higher the sympathetic nervous system activity when performing uninteresting tasks. Sympathetic nervous system activity is enhanced by mental load and fatigue during a task (Mizuno et al., 2011; Tanaka et al., 2009). It is possible that performing uninteresting tasks leads to greater fatigue and mental load. However, this study considered only one task and stress condition, so it is necessary to scrutinize the effects under different stress conditions. There were no gender differences in the study. By engaging in interesting tasks, mental and physiological loads may be reduced, even when the exercise load is the same. This tendency may be similar to the relaxation effect indicated by Tsutsui et al. (2017).

However, in one study (May et al., 2016), the motivation for completing a task increased depending on the task's objective: an entertainment booklet designed for fun vs an intelligence test. In contrast with the present study, the sympathetic activity of the group performing the latter—i.e., a "high-motivated performance task"—increased more than that of the group performing the former—a "low motivated performance task" (May et al., 2016). In May et al.'s (2016) study, the type of motivation (extrinsic vs intrinsic) for completing the task and its content were different from those of the present study. In our experiment, the individual's choice, motivation, and desire to "try" were respected; these motives are intrinsic. Therefore, it could be said that an intervention that respects the individual's initiative may be important in the effect for sympathetic activity in this study.

The study showed that the more severe the depression, the higher the parasympathetic nervous system activity during uninteresting tasks ($P < .08$). A prior study showed that there was a positive correlation between depression and anxiety and the parasympathetic nervous system during stressful tasks, while the impact of passive coping was considered as a possible explanation for the said correlation (Brugnera et al., 2017). In a task presented as a "passive coping condition" requiring no effort, a "conservation-withdrawal"-type response was observed (Bosch et al., 2001), which is characterized by increased parasympathetic tone (Bosch et al., 2001; Kreibig et al., 2007). Previous studies have discussed whether passive coping during stressful tasks may lead to increased parasympathetic activity (Brugnera et al., 2017). In our study, there was a tendency toward a correlation between depression and parasympathetic activity only in uninteresting tasks; therefore, lack of interest may have a relation with individuals' coping style. Additionally, for individuals who are prone to depression, task interest may lead to a coping style that influences autonomic nervous system activity when performing the task.

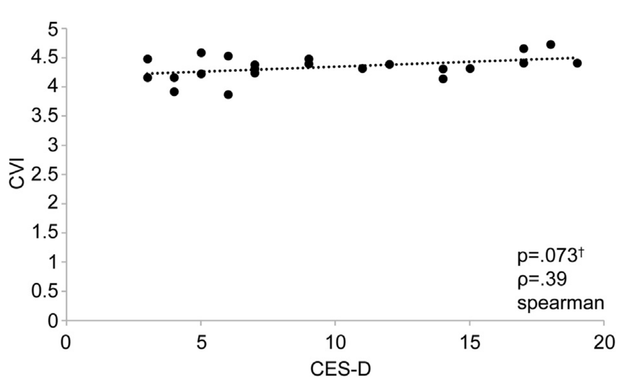

Figure 4. Relationship between the cardiac vagal index (CVI) during task B and score of CES-D.

Another study also found that during a mentally challenging task, sympathetic activity decreased as anhedonia (a characteristic feature of depression) increased (Silvia et al., 2014). It is considered that highly anhedonic people expend less effort because of the decrease in incentive value of goals and rewards (Silvia et al., 2014). A correlation between depression and autonomic nervous system activity was also observed in the present study; however, no correlation was observed when participants performed an interesting task. Thus, performing an interesting task may lead to changes in the physiological state of the depressed person. No significant correlation was found between CVI or CSI and anxiety or social phobia. However, there may be a difference in these correlation in the case of a large number of participants or patients in clinical practice, and further examination is necessary.

For uninteresting tasks, the lower the interest, the higher the sympathetic nervous system activity, indicating that engaging in an interesting task may reduce the mental and physiological load even with the same physical activity load. Although this study was not conducted in clinical rehabilitation settings (wherein individuals face their own weaknesses), if tasks having similar physical activity loads can be performed using lower mental and physiological loads, they may lead to increased ease of participation, continuation of activities, and more efficient progress. The present study showed that it is important to have an intervention that respects individual characteristics and motivates individuals to try a task. This is because of the influence of task interest on their physiological indicators, as reported in this study. Although it is necessary to consider whether to correspond to psychiatric patients in rehabilitation and occupational therapy activities, it is imperative to draw out more politely potential interest and motive and include personalized intervention strategies.

However, most patients undergoing rehabilitation take medication. Although it is difficult to directly intervene in pharmacological modulation, this influence cannot be ignored. Therefore, it is necessary to closely monitor the physiological effects of medication. Additionally, the more severe the individuals' depression, the higher the parasympathetic activity they exhibit when performing uninteresting activities. Although this causal relationship is uncertain, task interest may influence autonomic nervous system activity when depressed individuals perform a task. This correlation may also be related to coping styles and incentives; however, further research is required.

The study showed that an individual's task interest affects their physiological indicators. In the future, it is expected that physiological influence of activities and therapeutic mechanisms will be better understood, leading to treatments that include elements of individuals' interest and adjustments for physiological mechanisms. This may further lead to a common understanding with patients and professionals of other specialties, a greater understanding of physiological effects of activities, and more appropriate utilization of activities in other areas.

4.1. Limitations

This study had some limitations. First, the sample was small and it included only healthy individuals; accordingly, the impact of task interests on psychiatric occupational therapy should be studied using a larger sample of psychiatric patients. Second, this was a cross-sectional study; thus, longitudinal studies need to be conducted to reveal the long-term effects of performing tasks in daily life. Third, although the order of the tasks was counterbalanced, performing the first task could have influenced the second task. Fourth, this study only assessed simple tasks; therefore, other more complicated tasks and their associated factors need to be investigated.

In this study, we investigated the effects of task-related interest on individuals' autonomic nervous system; however, to further clarify the rehabilitative effect of performing tasks, it is necessary to implement additional measurements, such as electroencephalography. Occupational therapy includes many elements that take into consideration individual personality; thus, clarifying the influence of each element can lead to more individualized and appropriate rehabilitation. In addition, it is expected that more objective effects will be revealed in further studies, which could provide valuable insights regarding the utilization of physiological effects by activities in other fields.

5. Conclusions

This study showed that an individual's degree of task interest may reduce their sympathetic nervous system activity, even when similar tasks are performed using the same motor function. It also showed that task interest influences objective indicators and mental characteristics of depression may be associated with them. The utilization of interest-based tasks may enhance treatment from a physiological perspective. In the future, if the influence of various tasks is objectively measured, researched, and understood, it may help enhance more comprehensive understanding of the individual, and further personally tailored treatment and assistance. It can also be expected that the potential ability and outlook drawn out of the person will lead to improvement of difficulties in life and to well-being.

Declarations

Author contribution statement

Tomoki Aoyama: Analyzed and interpreted the data; Wrote the paper.

Yurika Nishida; Sumie Yamada: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Yoshiro Nakagawa: Analyzed and interpreted the data.

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Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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