Effects of Various Horticultural Activities on the Autonomic Nervous System and Cortisol Response of Mentally Challenged Adults

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ADDITIONAL INDEX WORDS. garden plant, floral, pressing flowers, topiaries, stress hormone, horticultural therapy

SUMMARY. The objective of this study was to examine how horticultural activities, such as pressing flowers, planting, creating flower arrangements, and making topiaries, affect stress relief for patients who are mentally challenged. Two experiments were conducted in this study. In Expt. 1, the heart rate variation (HRV) of 30 mentally challenged people from the Daegu Rehabilitation Center (Daegu, South Korea) was measured. The pressed flower group and the planting group showed a significant improvement ($P < 0.01$) in the sd of the normal-normal interval HRV measurements (SDNN), which improved from 42.37 to 45.54 ms. The planting group's SDNN and low frequency (LF) significantly improved from 38.68 to 45.49 ms and from 5.87 to 6.58 ms, respectively, at $P < 0.05$. A significant improvement in total power (TP) and high frequency (HF) at $P < 0.01$ was also observed; results changed from 6.90 to 7.46 ms and from 4.76 to 5.28 ms, respectively. The flower arrangement group displayed a significant difference in LF (from 5.26 to 5.89 ms) at $P < 0.05$. Finally, the topiary group showed a significant difference in TP (from 6.72 to 7.23 ms) at $P < 0.05$. In Expt. 2, the cortisol levels of 20 mentally challenged people from the P Residential Home (Yeongcheon, South Korea) were measured. Compared with the baseline measurement, the pressed flower group displayed a significant decrease in cortisol density from 4.66 nmol·L⁻¹ on day 1 to 4.64 nmol·L⁻¹ on day 7; however, no significant difference was observed on day 4. The planting group showed a significantly decreasing difference (3.08 nmol·L⁻¹) in cortisol density (8.84 nmol·L⁻¹) on day 7 compared with day 4 of planting activities. Finally, the topiary group continued to show a significant decrease (from 9.98 to 7.0 nmol·L⁻¹) in cortisol density at each cortisol collection after the first day of topiary activities. It was concluded that indoor horticultural activities have an effect on mentally challenged people's stress relief. In particular, planting activities were effective for this relief.

Article 9 of the Korean Special Education Act stipulates that a mentally challenged person is an individual with an intelligence quotient (IQ) at or below 75 on a standardized intelligence test and who demonstrates deficits in adaptive behavior. Of the 143,162 persons who were 15–65 years old and designated as mentally challenged in 2004, 74.9% were capable of working, but did not have a job (Byun, 2006). Thus, it is thought that vocational rehabilitation may improve their quality of life. Mentally challenged persons have intellectual disabilities and deficits in adaptive skills and often demonstrate social skills deficits. For these reasons, mentally challenged persons often experience mental instability and psychological

frustration (Hong, 2005) and are thus exposed to high levels of stress.

Airhart and Douth (1992) reported that horticulture training reduced instances of maladaptive behaviors in people with physical challenges and instilled confidence in them. Doxon and Mattson (1987) found that horticulture training decreased the stress levels of mentally challenged people. Reduced stress levels, as measured by increases in alpha brain wave responses and decreases in delta brain wave responses, can be produced by gardening activities (Dannenmaier, 1995; Son et al., 1997). Horticultural activities can improve confidence and social skills, can cultivate a positive

attitude, and can refresh the mind and body (Getz et al., 1982; Palamuso, 1985; Ulrich, 1986).

Many previous studies have emphasized the effects of horticultural activities in relation to physical and psychological rehabilitation. However, those in the physical labor group have not considered the influence of horticultural activities on mentally challenged people's autonomic nervous system (ANS) and on the stress hormone cortisol (Son et al., 1997).

The ANS is largely responsible for the body's ability to maintain a stable condition called homeostasis. Stress adversely affects the ANS, which acts as a control system that functions largely below the level of consciousness (Lee, 2007). The impact of stress on the ANS, therefore, can lead to mental health deterioration.

Heart rate variation reflects the activities of the ANS. When the activities of the ANS decrease, physiological responses for external stress are weakened, homeostasis is not controlled, and, hence, the human body is more liable to disease (Porges, 1995). HRV is measured by changes in the heart-beat interval. HRV is a measurement of the balance of ANS (Kim et al., 2005). Cortisol is a steroid hormone produced by the adrenal gland (van Cauter, 1987), which is released in response to stress. Its primary functions are to increase blood sugar and influence immune system activity when the body is experiencing stress. The immune system acts as protection against disease by identifying and killing pathogens. Excessive cortisol can weaken the immune system and can lower the curative value by medication (Cassileth, 1996; Dhabhar et al., 1995; Pegg et al., 1995; Roberts et al., 1996).

This study aimed to investigate the effect of indoor horticultural activities, such as pressing flowers, planting, creating flower arrangements, and making topiaries, on the ANS and cortisol density of mentally challenged individuals.

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Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
3.7854	gal	L	0.2642
2.54	inch(es)	cm	0.3937
(°F - 32) ÷ 1.8	°F	°C	(1.8 × °C) + 32

Materials and methods

Expt. 1 (HRV)

SUBJECTS. The Daegu Rehabilitation Center for mentally challenged people is located in Daegu, South Korea. The vocational rehabilitation team is composed of 50 mentally challenged individuals. They work to assemble automobile parts in the workplace. Under the instruction of a social worker, they have worked in the Rehabilitation Center Monday through Friday for over 2 years. Of the 50 individuals, 30 (60%) participated in the experiment. Their IQ scores ranged from 35 to 75.

The participants were divided into five groups, with six participants per group. The average age of participants was 23 years (ranging from 20 to 27 years). The sample was composed of 21 men (70%) and 9 women (30%).

PLANNING AND EXECUTION OF INDOOR HORTICULTURAL ACTIVITIES. In Expt. 1, all horticultural activities were conducted in the indoor craft workshop with instructions from a horticultural therapist and an assistant. All activities were performed at the same time (from 10:20 am to 11:20 am) on different days.

All horticultural activities were performed by five groups, including a control group, and their activities were different. HRV was measured 5 min before and 5 min after a horticultural activity was performed by the same horticultural therapist in the indoor craft workshop.

1) Pressed flower group (3 Feb. 2009)

The pressed flower activity process was as follows:

In step 1, a therapist and an assistant shared the dried pressed flower materials. Materials included a frame (10 cm × 20 cm), tweezers, marguerite daisy (*Argyranthemum frutescens*), leatherleaf fern (*Rumohra adianrifolia* var. *simpliciflora*), rose (*Rosa* hybrids), and baby's breath (*Gypsophila paniculata*). In step 2, participants grasped the pressed flower using tweezers. In step 3, they put glue on the pressed flower. Participants placed the dried flower on the frame. Finally, they presented their work to the instructors and other participants.

2) Planting group (4 Feb. 2009)

The planting activity process was as follows:

In step 1, a therapist and an assistant shared materials, which included a flowerpot (10 cm × 10 cm × 20 cm) and primrose (*Primula × polyantha*). In step 2, participants put pumice and cultural soil into a flowerpot with primrose. In step 3, they watered plants in the flowerpot. Finally, they presented their work to the instructors and other participants.

3) Flower arrangement group (5 Feb. 2009)

The flower arrangement activity process was as follows:

In step 1, a therapist and an assistant shared materials with the participants, which included a basket (10 cm × 10 cm × 15 cm), freesia (*Freesia refracta*), lily (*Lilium* hybrids), hinoki cypress (*Chamaecyparis obtuse*), and carnation (*Dianthus caryophyllus*). In step 2, participants put flowers in floral foam after they cut each stem for the flower arrangement. Finally, they presented their work to the instructors and other participants.

4) Topiary group (6 Feb. 2009)

The topiary activity process was as follows:

In step 1, participants soaked sheet moss in water and then spread the moss in a circle 20 cm in diameter. In step 2, a parlor palm (*Chamaedorea elegans*) was wrapped around the moss using rope. After wrapping up, the formation was a ball-shaped topiary (10 cm × 10 cm × 15 cm). In step 3, participants decorated the parlor palm with moss. Finally, they presented their work to the instructors and other participants.

HEART RATE VARIATION. HRV is defined as the periodic changes in heart rate with time. HRV was measured by using a heart rate variability analyzer (SA-3000P; Medcore, Seoul, South Korea), an instrument designed to evaluate and track HRV as related to stress factors. The SA-3000P converts changes in heart rate to a visualized waveform based on time interval and frequency. Changes in heart rate depend on a response to stress caused by the current mental health and physiological status.

Subjects did not engage in excessive exercise, have a meal, or consume caffeine at least 2 h before the test. They sat on a chair next to the tester; electrode sensors were attached to both of their wrists and their left ankle. They were given ≈5 min to prepare for the test. HRV was measured 5 min before and 5 min after the

relevant horticultural activity. For the control group, HRV was measured on 3 Feb. 2009 using the same methods as those used in the experiment groups (Groups I–IV).

The control group was composed of six persons with the same ability to work as the experimental groups, but this group did not do a horticultural activity, such as recess for 1 h (i.e., reading a book, sleeping, and conversation). They were, however, sent to a craft workplace for 1 h. HRV for the control group was measured at the same time and in the same manner that HRV for the experiment groups was measured before and after horticultural activities. HRV for all participants in the control group was measured by a therapist and an assistant.

Expt. 2 (cortisol)

SUBJECTS. P Residential Home, located in Yeongcheon, South Korea, is home to 65 mentally challenged individuals who have stayed more than 3 years at that site. Of these individuals, 20 subjects (31%) participated in the experiment. IQ scores ranged from 35 to 75. Every day, residents work within the facility to learn about making soap products. Subjects in this study were those deemed as having an excellent ability to participate in work, as measured by a pretest conducted by a social worker on the vocational rehabilitation team. Participants were divided into four groups, with five participants each. The average age of participants was 26 years (ranging from 21 to 34 years). The sample was composed of 21 male participants and 9 female participants.

PLANNING AND EXECUTION OF HORTICULTURAL ACTIVITIES. In Expt. 2, all horticultural activities were conducted in the indoor workplace by a therapist and an assistant, who also measured the cortisol levels. All horticultural activities in Expt. 2 were the same as those in Expt. 1, except for the pressed flower activity. Each activity was performed seven times during the same time period (from 10:00 AM to 11:00 AM) using the following schedule

1) Pressed flower group (30 Nov. to 7 Dec. 2008): same as Expt. 1 (described earlier).

Group I used different materials [e.g., a frame (10 cm × 20 cm), a head accessory (3 cm diameter), a card (5 cm × 10 cm), two bookmarks (3 cm × 10 cm), one ruler (5 cm × 10 cm), and

an opener (3 cm diameter)] at each time.

2) Planting group (16 to 23 Jan. 2009): same as Expt. 1 (described earlier).

3) Flower arrangement group (9 to 15 Jan. 2009): same as Expt. 1 (described earlier).

4) Topiary group (9 to 16 Dec. 2008): same as Expt. 1 (described earlier).

CORTISOL. Subjects' saliva (at least 2 mL) was collected to analyze cortisol levels. Saliva collection was conducted four times: the day before the start of the experiment and on day 1, day 4, and day 7 of the indoor horticultural activities. Saliva was collected at 11:00 AM, directly following the relevant horticultural activity. The collected saliva was placed in a tube in which the subject's name and the date of collection were recorded. The tube was stored in a refrigerator at 4 °C. On the final collection day, all the tubes were sent to Korea Carlsam Medicine Hormone Research Center for analysis. The center used the enzyme-linked immunosorbent method to analyze cortisol (Park, 2009).

Results

RESULTS OF EXPT. 1 (HRV). One-way analyses of variance (ANOVAs) were used to analyze HRV. The homogeneity of HRV between groups before horticultural activities was verified, as shown in Table 1. There were no significant differences among the groups. Thus, it is inferred from this result that these five groups had a similar level of HRV.

For HRV, the SD of the normal-normal interval HRV measurements is an index of stress-coping skills and is considered "good" at values of 50 or more, "normal" between values of 30 and 50, a "required state" between values of 20 and 30, and a condition of "dysfunction" or "disease" at values less than 20. The following results of HRV measurements before and after the indoor horticultural activities were found in Expt. 1: No significant differences were found in HRV measurements before and after horticultural activities between the control group and the treatment groups. However, as shown in Table 2, the pressed flower group and the planting group showed a significant difference in SDNN in comparisons between the pretests and posttests at $P < 0.01$

Table 1. Difference in SD of all normal-normal intervals (SDNN), total power (TP), low frequency (LF) of heart rate variation (HRV), and high frequency (HF) of HRV before horticultural activity programs among control, pressed flower, planting, flower arrangement, and topiary program groups in the Daegu Rehabilitation Center for mentally challenged people in South Korea during experiment period (5 d).

HRV	Sum of squares	df	Mean square	F	P
SDNN ^z					
Between group	508.283	4	127.071	0.935	0.460 ^{NS}
Within group	3396.813	25	135.873		
Total	3905.097	29			
TP ^y					
Between group	1.684	4	0.421	1.088	0.384 ^{NS}
Within group	9.673	25	0.387		
Total	11.357	29			
LF ^x					
Between group	2.523	4	0.631	0.863	0.499 ^{NS}
Within group	18.266	25	0.731		
Total	20.789	29			
HF ^w					
Between group	2.784	4	0.696	1.700	0.181 ^{NS}
Within group	10.233	25	0.409		
Total	13.017	29			

^zCapability of coping with stress; high levels indicate better health.

^yLog-transformed ($\log_e$) TP [i.e., total activity of the autonomic nervous system (ANS)]. TP (TP = LF + HF) shows the activity of the ANS. It also indicates the control of ANS.

^xLog-transformed ($\log_e$) LF (an indicator of sympathetic nerve activity). Sympathetic nerve activity indices indicate a relatively LF. It is related to mental stress. The LF level is high in the condition of stress (i.e., fear and anxiety).

^wLog-transformed ($\log_e$) HF (an indicator of parasympathetic nervous system activity). This is indicated by an index of parasympathetic activity as a relatively HF. The index indicates cardiac electrical stability. The HF level is low in the condition of stress (i.e., fear and anxiety).

^{NS}Nonsignificant at $P < 0.05$ by one-way analysis of variance.

Table 2. Effect of various horticultural activity programs (HAPs) on SD of the normal-normal interval (SDNN) of heart rate variation prehorticultural activities and posthorticultural activities of mentally challenged people in South Korea during experiment period (5 d).

HAP	SDNN (ms) ^z		P
	Pre-HAP	Post-HAP	
Control	44.87	49.09	0.412 ^{NS}
Pressed flower	42.37	45.54	0.008 ^{**}
Planting	38.68	45.49	0.040 [*]
Flower arrangement	35.28	40.44	0.117 ^{NS}
Topiary	39.65	44.90	0.186 ^{NS}

^zCapability of coping with stress; high levels indicate better health; ms = millisecond.

^{NS}, ^{*}, ^{**}Nonsignificant at $P < 0.05$, significant at $P < 0.05$, and significant at $P < 0.01$, respectively, by independent t test.

(from 44.87 to 49.09 ms) and at $P < 0.05$ (from 38.68 to 45.49 ms). Total power (i.e., LF + HF) means the activity of the ANS. It also indicates the control of ANS. High levels mean more healthy condition.

Total power is another powerful index of stress-coping skills. The planting group and the topiary group exhibited a significant difference in TP in comparisons between the pretest and posttest at $P < 0.01$ (from 6.90 to 7.46) and at $P < 0.05$ (from 6.72 to 7.23), as shown in Table 3.

Low frequency is an index of the sympathetic nervous system. It is related to mental stress. The LF level is high in the condition of stress (i.e., fear and anxiety). As shown in Table 4, both the planting group and the flower arrangement group displayed a significant difference in LF in comparisons between the pretest and posttest at $P < 0.05$; LF for the planting group and the flower arrangement group increased from 5.87 to 6.56 and from 5.26 to 5.89, respectively. Finally, HF refers to an index of the parasympathetic

nervous system. The index indicates cardiac electrical stability. The HF level is low in the condition of stress (i.e., fear and anxiety). The planting group showed a significant difference in HF in comparisons between the pretest to the posttest at $P < 0.01$; its HF increased from 4.76 to 5.28 (Table 5).

RESULTS OF EXPT. 2 (CORTISOL).

One-way ANOVAs were used to analyze cortisol levels. The prehomogeneity of cortisol density between groups before indoor horticultural activities was verified, as shown in Table 6. There were no significant differences in cortisol density among the four groups; it is thus reasoned that these four groups had a similar density of cortisol. At 11:00 AM, cortisol levels ranged from 5 to 8 nmol·L⁻¹, which are considered "normal."

The primary functions of cortisol are to increase blood sugar and influence immune system activity during stress. Stress reduction is an essential part of all efforts to normalize cortisol levels. Excessive cortisol can weaken the immune system, which acts as protection against disease by identifying and killing pathogens, and can lower the curative value of medication (Cassileth, 1996; Dhabhar et al., 1995; Pegg et al., 1995; Roberts et al., 1996). High cortisol levels result after experiencing chronic stress and represent the adaption phase of the stress response. Low cortisol levels are the consequence of adrenal exhaustion or the exhaustion phase of the stress response (Bollaert, 2008). Therefore, horticultural activities are very valuable in restoring normal cortisol levels.

As shown in Fig. 1, cortisol density changes with time and horticultural activity. Compared with the baseline measurement, the pressed flower group showed a significant decrease (from 8.56 to 4.64 nmol·L⁻¹) in cortisol density on days 1 and 7 (but not day 4). Compared with day 4 of the planting activities, the planting group showed a significantly decreasing difference (3.08 nmol·L⁻¹) in cortisol density (8.84 nmol·L⁻¹) on day 7. The flower arrangement group showed a gradual decrease in cortisol density following horticultural activities, but these differences were not significant. Finally, the topiary group showed a significant decrease to 7.00 nmol·L⁻¹ on day 1 in cortisol density at each cortisol collection.

Table 3. Effect of various horticultural activity program (HAPs) on total power (TP) of heart rate variation (HRV) prehorticultural activities and posthorticultural activities of mentally challenged people in South Korea during experiment period (5 d).

HAP	TP (Ln) ^z		
	Pre-HAP	Post-HAP	P
Control	7.17	7.34	0.153 ^{ns}
Pressed flower	7.11	7.40	0.107 ^{ns}
Planting	6.90	7.46	0.007 ^{**}
Flower arrangement	6.56	7.00	0.056 ^{ns}
Topiary	6.72	7.23	0.033 [*]

^zLog-transformed (log_e) TP [i.e., total activity of the autonomic nervous system (ANS)]. TP (TP = low frequency of HRV + high frequency of HRV) shows the activity of the ANS. It also indicates the control of ANS.

^{ns}, *, **Nonsignificant at $P < 0.05$, significant at $P < 0.05$, and significant at $P < 0.01$, respectively, by independent t test.

Table 4. Effect of various horticultural activity programs (HAPs) on low frequency (LF) of heart rate variation prehorticultural activities and posthorticultural activities of mentally challenged people in South Korea during experiment period (5 d).

HAP	LF (Ln) ^z		
	Pre-HAP	Post-HAP	P
Control	5.89	6.33	0.137 ^{ns}
Pressed flower	6.32	6.73	0.072 ^{ns}
Planting	5.87	6.58	0.038 [*]
Flower arrangement	5.26	5.89	0.047 [*]
Topiary	5.57	5.97	0.159 ^{ns}

^zLog-transformed (log_e) LF (an indicator of sympathetic nerve activity). Sympathetic nerve activity indices indicate a relatively LF. It is related to mental stress. The LF level is high in the condition of stress (i.e., fear and anxiety).

^{ns}, *Nonsignificant or significant at $P < 0.05$, respectively, by independent t test.

Table 5. Effect of various horticultural activity programs (HAPs) on high frequency (HF) of heart rate variation prehorticultural activities and posthorticultural activities of mentally challenged people in South Korea during experiment period (5 d).

HAP	HF (Ln) ^z		
	Pre-HAP	Post-HAP	P
Control	5.45	5.62	0.333 ^{ns}
Pressed flower	5.05	5.24	0.165 ^{ns}
Planting	4.76	5.28	0.006 ^{**}
Flower arrangement	5.17	5.19	0.902 ^{ns}
Topiary	4.82	5.04	0.334 ^{ns}

^zLog-transformed (log_e) HF (an indicator of parasympathetic nervous system activity). This is indicated by an index of parasympathetic activity as a relatively HF. The index indicates cardiac electrical stability. The HF level is low in the condition of stress (i.e., fear and anxiety).

^{ns}, **Nonsignificant at $P < 0.05$ and significant at $P < 0.01$, respectively, by independent t test.

Table 6. Differences in salivary cortisol before horticultural activity programs among pressed flower, planting, flower arrangement, and topiary program groups in the P Residential Home for mentally challenged people, located at Yeongcheon, South Korea, during experiment period.

	Sum of squares	df	Mean square	F	P
Between group	28.170	3	9.390	1.708	0.205 ^{ns}
Within group	87.936	16	5.496		
Total	116.106	19			

^{ns}Nonsignificant at $P < 0.05$ by one-way analysis of variance.

Fig. 1. Changes in salivary cortisol content of the mentally challenged adults in South Korea treated by horticultural activity programs. Samples 1 to 4 were collected before the day of horticultural activity (HA), on the day of HA, on day 4 of HA, and on day 7 of HA, respectively. Vertical bars represent SE at $P < 0.05$.

Discussion

This study aimed to investigate the influence of indoor horticultural activities, such as pressing flower, planting, flower arranging, and making topiaries, on mentally challenged people's ANS and cortisol density, as described earlier.

The pressed flower group's SDNN improved significantly (Table 2). Furthermore, this group's cortisol density decreased significantly on day 7 of indoor horticultural activities. SDNN is a powerful index of stress-coping skills (Kim et al., 2005; Silveti et al., 2001); thus, these findings indicate that the pressed flower activities enhanced mentally challenged people's coping skills and eased their stress. It is notable that compared with the previous days, individuals showed an increased cortisol density when making bookmarks on day 4 of the pressed flower activities. This increase is likely due to the small spaces of the bookmarks. Kim and Yoo (2003) argued that pressed flower activities relieve schizophrenic female patients' depression due to stress. Given materials and contents of pressed flower activities that are suitable for the subjects' characteristics, these activities are thought to be effective for the relief of stress even though they require concentration.

The planting activity group exhibited the greatest changes in ANS in the four indoor horticultural activities (Tables 2–5). Further, this group displayed a significant gradual decrease in

cortisol density (Fig. 1). The research team of Bristol University (Bristol, UK) reported that serotonin, a chemical substance, was secreted by mice that were exposed to *Mycobacterium*, found easily in soil (Lowry et al., 2007). This scientifically demonstrates that touching soil stimulates the secretion of serotonin, which produces feelings of happiness. Park and Lee (2008) stated that sand therapy was effective in relieving the stress of infants who had depression and anxiety and exhibited cowering behavior. The research in this study further supports that touching and mixing soil in planting activities affects the activity of the ANS and relieves stress. Planting activities resulted not only in the greatest change in mentally challenged people's ANS among the four indoor horticultural activities but also in a significant gradual decrease in cortisol density. Researchers conclude from this finding that planting activities are the most effective horticultural activity for stress relief and that the extension of indoor planting activities to outdoor planting activities targeted for mentally challenged individuals will have a greater effect not only on vocational rehabilitation but also on emotional stability.

The flower arrangement group showed increased stress, as measured by LF (Medicore, 2002), and showed no great change in cortisol density (Fig. 1). It is inferred from these findings that activities such as cutting stems with shears and arranging the cut

stems in the exact location are difficult jobs for mentally challenged people.

The topiary group exhibited a significant difference in TP (Table 3). The group continued to show a significant decrease in cortisol density after the previous day of topiary activities (Fig. 1). This group not only had the most significant difference in TP but also had the largest significant decrease in cortisol density among the four indoor horticultural activities. It is because subjects displayed aggression in the processes of touching moss and tying the fixed rope with all their strength. Therefore, topiary activities are thought to be fairly valuable in aiding emotional stability and vocational rehabilitation for mentally challenged people. Future research is needed on the effect of a variety of topiary activities on mentally challenged people.

It is concluded from these results that the indoor horticultural activities of pressed flower, planting, flower arrangement, and topiary activities are considerably effective not only for activating mentally challenged people's ANS but also for decreasing cortisol density. Therefore, the adjustment of types and levels of horticultural activities suitable for the characteristics of each mentally challenged person would allow for the development of effective methods for their stress relief and vocational rehabilitation.

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