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Research on Optimization System of Radiotherapy Equipment from the Perspective of Human-Computer Interaction

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Abstract. Based on the knowledge of human-computer interaction, this paper deeply analyzes the human-computer interaction problems existing in China's existing tumor radiotherapy equipment, and notices the lack of "patient-machine" interaction in the human-computer interaction system of radiotherapy. In response to this human-computer interaction problem, the interactive experience of tumor patients was analyzed by collecting questionnaire data. According to the "input-output" process, the interactive relationship between the patient and the machine in the radiotherapy space is decomposed into visual interaction, auditory interaction, tactile interaction and comfort to form a human-computer interaction optimization system based on the data analysis. It also provides an optimized direction for the existing human-computer interaction between radiotherapy equipment and patients.

1. Introduction

In modern society, tumor patients are increasing. In many ways to treat tumors, about 70% of cancer patients choose radiation therapy as the main treatment. Radiotherapy equipment is the main factor affecting the experience of radiotherapy, and the radiotherapy experience of cancer patients is an important factor affecting the treatment efficiency.

Tumor patients are physiologically affected by their own condition and complications of radiotherapy; psychologically, most patients with cancer have problems with anxiety and depression. Under this physiological and psychological influence, most cancer patients have negative emotions such as nervousness and anxiety during radiotherapy. Negative emotion during radiotherapy will affect the patient's radiotherapy effect, so that the patients cannot be effectively treated, the treatment cycle becomes longer, and negative emotions make the quality of life decline, patients will become more depressed and anxious, forming a vicious circle. Good human-computer interaction can alleviate the negative emotions of patients in treatment and improve the efficiency of treatment. Therefore the optimization of human-computer interaction in radiotherapy equipment is particularly urgent and important.

Human-Computer Interaction (HCI) is a technique for studying people, computers, and their relationships. The generalized human-computer interaction refers to the human-machine and environment system engineering as the main research content, and coordinates the relationship among

people, machines and environment in different operations to improve work efficiency, safety, health, comfort and so on.

A human-computer interaction system, in order to achieve a good human-computer interaction between the computer and the user, usually must consider three elements. First, the person in the human-computer interaction is the user, simply refers to the person who uses a product. Interactive devices and software for man-machine dialogue. Devices are the material basis of interactive computer systems. Software is at the heart of demonstrating various interactive features.

The three elements of human-computer interaction in this paper correspond to doctors and patients, devices and interactive interfaces. The doctor and the patient are the factors that make up the human factor in radiotherapy interaction. They are an inseparable system. In the design of existing radiotherapy machines, designers tend to focus on the human-computer interaction between the doctor (user) and the machine, ignoring the important human-computer interaction component of the patient (experiencer). Patients rarely receive feedback or interaction from the machine during radiotherapy.

At the same time, in the human-computer interaction between the patient and the radiotherapy machine, the psychological and physiological state of the patient needs to be an important basis for research and optimization. Therefore, this paper collects the actual data of the patient's interactive experience in the radiotherapy machine, and analyzes the patient (experiencer) and the radiotherapy machine interaction of the whole human-computer interaction to confirm and propose the optimization system and optimization direction of the human-computer interaction of the radiotherapy.

2. Data and Analytical Methods
In this study, 100 questionnaires were distributed in cooperation with the "Department of Radiology of Hubei Cancer Hospital". 84 valid questionnaires. In these valid questionnaires, males accounted for 64.3% of the valid questionnaires, women accounted for 33.3% and the average age was 55.5 years old. The radiotherapy equipment used by the Hubei Cancer Hospital is "Elekta Synergy".

Data analysis uses multivariate analysis and univariate analysis to examine which parts of the radiotherapy machine and what aspects of the radiotherapy process have an impact on the interactive experience of the patient during radiotherapy. Descriptive statistics (frequency and mean) are used to observe the preferences of the patient's appearance choices and to summarize the laws of their effects. Before the analysis, the control variables are grouped according to the information category. In order to reduce the error, this paper excludes the data-missing questionnaire to ensure the reliability and authenticity of the analysis results.

3. Data Analysis
As can be seen from the analysis of the collected data, $P = 0.001 < \alpha$ (0.05) of T2 (The scores of the body membrane material) and $P = 0.022 < \alpha$ (0.05) of T3 (The radiotherapy room color rating). The scores of the body membrane material (T2) and the radiotherapy room color rating (T3) have a significant effect on the patient's radiotherapy experience, see Table 1.

Table 1. Test of between-subjects effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Dependent Variable: T1.Your satisfaction with the treatment process?					
Corrected Model	57.337[a]	35	1.638	11.731	.000
Intercept	385.187	1	385.187	2758.224	.000
T2	2.875	3	.958	6.863	.001
T3	1.483	3	.494	3.540	.022
T4	.680	3	.227	1.623	.198
T5	.034	3	.011	.080	.970
T2*T3	.833	3	.278	1.987	.130
T2*T4	.000	0			
T2*T5	.536	2	.268	1.918	.159
T3*T4	.808	3	.269	1.929	.139
T3*T5	.295	2	.147	1.055	.357
T4*T5	.093	1	.093	.665	.419
T2*T3*T4	.000	0			
T2*T3*T5	.000	0			
T2*T4*T5	.000	0			
T3*T4*T5	.000	0			
T2*T3*T4*T5	.000	0			
Error	6.005	43	.140		
Total	1195.000	79			
Corrected Total	63.342	78			
a. R Squared = .905 (Adjusted R Squared = .828)					

Table 2. Multiple comparisons

(I) T2[a]	(J) T2[a]	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Dependent Variable: T1.Your satisfaction with the treatment process? LSD						
Not so satisfied	Satisfied	-.27	.156	.089	-.59	.04
	Relatively satisfied	-1.14*	.166	.000	-1.48	-.81
	Very satisfied	-1.93*	.161	.000	-2.25	-1.60
Satisfied	Not so satisfied	.27	.156	.089	-.04	.59
	Relatively satisfied	-.87*	.111	.000	-1.09	-.65
	Very satisfied	-1.65	.103	.000	-1.86	-1.45
Relatively satisfied	Not so satisfied	1.14*	.166	.000	.81	1.48
	Satisfied	.87*	.111	.000	.65	1.09
	Very satisfied	-.78*	.118	.000	-1.02	-.55
Very satisfied	Not so satisfied	1.93*	.161	.000	1.60	2.25
	Satisfied	1.65*	.103	.000	1.45	1.86
	Relatively satisfied	.78*	.118	.000	.55	1.02
a. T2.Your satisfaction with body film material during radiotherapy.						
Based on observed means						
The error term is Mean Square (Error) =.140.						
*.The mean difference is significant at the 0.05 level						

It was found by comparison between two (see Table 2). The score of the body membrane material (T2) and the score of the radiotherapy experience (T1) were positively correlated. By further observing the data in the "Mean difference (I-J)" column of the table, it can be seen that as the

satisfaction of the body membrane increases, the increase in the satisfaction score of the radiotherapy experience decreases.

Further analysis of the data from the radiotherapy room color rating (T3) revealed that (Table 3), the color score and the radiotherapy experience score were positively correlated. By further observing the data in the "Mean difference (I-J)" column of the table, it can be seen that as the color score increases, the increase in the satisfaction score of the radiotherapy experience increases.

Table 3. Multiple comparisons

Dependent Variable: T1.Your satisfaction with the treatment process? LSD						
(J) T3[a]	(J) T3[a]	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Not so satisfied	Satisfied	-.39*	.158	.017	-.71	-.07
	Relatively satisfied	-1.19*	.163	.000	.-1.52	-.86
	Very satisfied	-2.11*	.161	.000	-2.44	-1.79
Satisfied	Not so satisfied	.39*	.158	.017	.07	.71
	Relatively satisfied	-.80*	.108	.000	-1.02	-.58
	Very satisfied	-1.72*	.105	.000	-1.93	-1.51
Relatively satisfied	Not so satisfied	1.19*	.163	.000	.86	1.52
	Satisfied	.80*	.108	.000	.58	1.02
	Very satisfied	-.92*	.113	.000	-1.15	-.69
Very satisfied	Not so satisfied	2.11*	.161	.000	1.79	2.44
	Satisfied	1.72*	.105	.000	1.51	1.93
	Relatively satisfied	.92*	.113	.000	.69	1.15
a. T3.Your satisfaction with the color of radiotherapy room Based on observed means. The error term is Mean Square (Error) =.140. *.The mean difference is significant at the 0.05 level						

According to the results of the above, the patient's radiotherapy experience can be quickly and significantly improved by improving the comfort of the body membrane material. However, when the comfort of the body membrane material reaches a certain level, it will not have a greater impact on the patient's radiotherapy experience. To further enhance the patient's radiotherapy experience, you need to change the color of the radiotherapy machine to optimize the radiotherapy experience.

Therefore, we further explore the factors that influence patients' color preferences on radiotherapy machines. As shown in Table 4. S3(The number of times of patient's treatment) and S4 (The working state of the patient) have a significant effect on the observed variable T15.1. The factors that influence the patient's choice of color matching are: the number of times of patient's treatment (S4) and the working state of the patient (S3).

Table 4. Test of between-subjects effects

Dependent Variable: T15.1. About four radiotherapy machine theme color, please rate. "Family" theme					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	46.566[a]	38	1.225	1.776	.096
Intercept	253.419	1	253.419	367.372	.000
S3	8.216	2	4.108	5.955	.010
S4	7.513	3	2.504	3.630	.033
S1	.017	1	.017	.024	.878
S5	.550	2	.275	.399	.677
T.16	5.368	4	1.342	1.945	.146
S3*S4	.571	2	.286	.414	.667
S3*S1	.731	2	.366	.530	.598
S3*S5	.000	0			
T.16*S3	1.812	4	.453	.657	.630
S4*S1	.000	0			
S4*S5	.000	0			
S4*T.16	2.301	3	.767	1.112	.370
S1*S5	.000	0			
T.16*S1	2.289	2	1.145	1.659	.218
S5*T.16	.000	0			
S3*S4*S1	.000	0			
S3*S4*S5	.000	0			
S3*S4*T.16	.000	0			
S3*S1*S5	.000	0			
S3*S1*T.16	.000	0			
S3*S5*T.16	.000	0			
S4*S1*S5	.000	0			
S4*S1*T.16	.000	0			
S4*S5*T.16	.000	0			
S1*S5*T.16	.000	0			
S3*S4*S1*S5	.000	0			
S3*S4*S1*T.16	.000	0			
S3*S4*S5*T.16	.000	0			
S3*S1*S5*T.16	.000	0			
S4*S1*S5*T.16	.000	0			
S3*S4*S1*S5*T.16	.000	0			
Error	12.417	18	.690		
Total	818.000	57			
Corrected Total	58.982	56			
a. R Squared = .789 (Adjusted R Squared) = .345					

Regarding the color matching of the family theme, by further observing the data in the column of the "Mean difference (I-J)" in Table 5, it can be seen that the laid-off patients have a significantly lower score on the family theme than the farmers or retired patients. Among them, the farmer's patients scored the highest on the family-themed machine color matching.

Table 5. Multiple comparisons

Dependent Variable: T15.1. About four radiotherapy machine theme color, please rate." Family" theme LSD						
(I) S4[a]	(J) S4[a]	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
In-service	Laid off	1.10	.528	.053	-.01	2.21
	Retired	-.24	.279	.405	-.82	.35
	Farming	-.63	.304	.052	-1.27	.00
Laid off	In-service	-1.10	.528	.053	-2.21	.01
	Retired	-1.33*	.509	.017	-2.40	-.26
	Farming	-1.73*	.523	.004	-2.83	-.63
Retired	In-service	.24	.279	.405	-.35	.82
	Laid off	1.33*	.509	.017	.26	2.40
	Farming	-.40	.268	.157	-.96	.17
Farming	In-service	.63	.304	.052	.00	1.27
	Laid off	1.73*	.523	.004	.63	2.83
	Retired	.40	.268	.157	-.17	.96
a. S4.Your current working condition before your hospitalization Based on observed means. The error term is Mean Square (Error) =.690.						

Comparing the number of times of patient's treatment (S4) with the scores of the color matching of the family-themed machine (T15.1), by further observing the data in the "Mean difference (I-J)" column of Table 6, it can be seen that the patients who received multiple treatments had significantly higher scores on family-themed than those who received first or second treatment. Among the patients who received multiple treatments had the highest score on family-themed color matching and had obvious preference.

Table 6. Multiple comparisons

Dependent Variable: T15.1. About four radiotherapy machine theme color, please rate. "Family" theme LSD						
(I) How many times of treatment	(J) How many times of treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
First-time treatment	Secondary treatment	-.01	.280	.968	-.60	.58
	Multiple treatment	-1.17*	.257	.000	-1.71	-.63
Secondary treatment	First-time treatment	.01	.280	.968	-.58	.60
	Multiple treatment	-1.16*	.306	.001	-1.81	-.52
Multiple treatment	First-time treatment	1.17*	.257	.000	.63	1.71
	Secondary treatment	1.16*	.306	.001	.52	1.81
Based on observed means. The error term is Mean Square (Error) =.690. *.The mean difference is significant at the 0.05 level						

Combine the above data analysis. Basic color, voice and texture for patients with first-time radiotherapy experience. After collecting the data of the patient's first radiotherapy, then, analyze and output. For patients who are farming, retired or have undergone multiple treatments, we should provide a family-themed color scheme in terms of vision. The overall color scheme is warmer and the indoor light effect is milder. The color matching of the equipment can be matched with yellow and white. In terms of voice prompts, use a gentle and steady female voice to prompt the patient during radiotherapy, or play soothing music to alleviate the anxiety and tension of the patient during the radiotherapy. In terms of tactile interaction, the material and temperature of the fixed body film can be improved. Laid-off patients need to avoid home-themed machine color matching and use other types of color matching.

As shown in Table 7. It is believed that T6.4 (Whether the main factor that considers the dissatisfaction of the radiotherapy experience is the environmental atmosphere) has a significant impact on T15.4. Therefore, the factor that influences the choice of color matching in the night sky is whether the main factor that considers the dissatisfaction of the radiotherapy experience is the environmental atmosphere (T6.4).

Table 7. Test of between-subjects effects

Dependent Variable: T15.4. About four radiotherapy machine theme color, please rate. "Night sky" theme					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	34.090[a]	15	2.273	2.554	.008
Intercept	201.173	1	201.173	226.038	.000
T6.4	16.366	4	4.092	4.597	.003
T9.2	1.386	4	.346	.389	.815
T6.4*T9.2	7.903	7	1.129	1.269	.288
Error	39.160	44	.890		
Total	527.000	60			
Corrected Total	73.250	59			
a. R Squared = .465 (Adjusted R Squared = .283)					

Through further analysis of T6.4 (Whether the main factor that considers the dissatisfaction of the radiotherapy experience is the environmental atmosphere), it was found that the main factor for the color matching of the night sky theme machine and whether it is considered to be dissatisfied with the radiotherapy experience is positively correlated with the environmental atmosphere (T6.4). However, the score "agree" is used as the demarcation point. Before "agree", with the decrease of the degree of recognition, the increase of night sky theme machine color matching rating is decreased; after "agree", with the increase of the degree of recognition, the increase of night sky theme machine color matching rating is on the rise. And the magnitude is greater.

For patients with poor hospital conditions, the night sky-themed color scheme can effectively enhance their experience. Use blue and black for color matching, while using point light sources, voice guidance is recommended to use a calm male voice. The body membrane material is used for a smooth and comfortable leather texture. But for other situations, the role of the night sky-themed in improving the experience is not obvious.

In summary, through the analysis and comparison of various data, we found the influencing factors of patient experience, and through the comparison of influencing factors and patient experience, summed up the rules and found some patients' preferences. Based on these rules and the patient's personal data, we can improve the human-computer interaction in the process of radiotherapy, improve the patient's radiotherapy experience, make the patient more comfortable, reduce the negative emotion of patients during radiotherapy, and improve the treatment efficiency.

Table 8. Multiple comparisons

Dependent Variable: T15.1. About four radiotherapy machine theme color, please rate. "Night sky" theme. LSD						
(I) T6.4[a]	(J) T6.4[a]	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Very disagree	Not so agree	-.84	.513	.108	-1.87	.19
	Agree	-.92	.509	.079	-1.94	.11
	Relatively agree	-1.08	.609	0.82	-2.31	.14
	Very agree	-3.25*	.667	.000	-4.59	-1.91
Not so agree	Very disagree	.84	.513	.108	-.19	1.87
	Agree	-.08	.278	.787	-.64	.49
	Relatively agree	-.24	.434	.580	-1.12	.63
	Very agree	-2.41*	.513	.000	-3.44	-1.38
Agree	Very disagree	.92	.509	.079	-.11	1.94
	Not so agree	.08	.278	.787	-.49	.64
	Relatively agree	-.17	.431	.701	-1.03	.70
	Very agree	-2.33*	.509	.000	-3.36	-1.31
Relatively agree	Very disagree	1.08	.609	.082	-.14	2.31
	Not so agree	.24	.434	.580	-.63	1.12
	Agree	.17	.431	.701	-.70	1.03
	Very agree	-2.17*	.609	.001	-3.39	-.94
Very agree	Very disagree	3.25*	.667	.000	1.91	4.59
	Not so agree	2.41*	.513	.000	1.38	3.44
	Agree	2.33*	.509	.000	1.31	3.36
	Relatively agree	2.17*	.609	.001	.94	3.39
a. T6.4 What makes you feel uncomfortable throughout the hospitalization process? The environment Based on observed means The error term is Mean Square (Error) =.890. *.The mean difference is significant at the 0.05 level						

4. Conclusion

Due to the particularity of human-computer interaction in radiotherapy equipment, doctors, patients and equipment together form a human-computer interaction system. In radiotherapy equipment, doctors act as "input" operators in human-machine relationships, while patients are "output" experiencer. Therefore, the patient is usually in a state of static experience during the course of radiotherapy. In this special human-computer interaction relationship, we can input the patient's personalized information into the radiotherapy equipment, according to the law of data research and summary, the patient can be rationally differentiated in the process of radiotherapy, and the output personalized radiotherapy equipment color, light effects, voice prompts and body membrane to enhance the patient experience in the process of radiotherapy.

Under such human-computer interaction process, the doctor first needs to collect and organize the patient's basic personal information, the condition, the satisfaction of the existing radiotherapy equipment, and the like; after that, the operator inputs the patient-related data to the radiotherapy machine, according to the results of the above studies, from the visual, auditory and the tactile aspects, different radiotherapy settings are output for different patients to enhance the patient's radiotherapy experience.

In the future direction of interaction improvement of radiotherapy equipment, we establish an analysis database based on the patient's information: personal information, condition, treatment process, work status, satisfaction degree of existing radiotherapy experience, etc. Based on this database analysis and output the radiotherapy interaction experience that patients need. As the number

of patients treated increases, the physiological state and mental state change and the satisfaction with the radiotherapy experience gradually increase. We can build a patient radiotherapy experience file, periodically update and collect patient data, re-enter the patient's data, and output the optimized results. The patient's personal data and output data will be developed in depth and the output will be more accurate. At the same time, it helps the database to expand the amount of data, making the "output" analysis results more reliable. Let patients, doctors and radiotherapy machines continuously optimize the human-computer interaction between them, and to improve the patient's treatment experience and enhance the therapeutic effect.

Finally, the data collection in this paper provides a reference for a wider range of research and data collection. However, the scope of this survey is limited, so the experience data of patients from different countries and different nationalities needs further data collection and verification.

Acknowledgments

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