The influence of the contrast setting of an OR monitor on the force applied during minimal invasive surgery.

Elise Buiter, 1316117, e.c.buiter@tudelft.nl, Eline van der Kruk, 1355430, e.vanderkruk@student.tudelft.nl and Aimee Sakes, 4044827, a.sakes@student.tudelft.nl.

Abstract – The gasping force used by surgeons during laparoscopic surgery is estimated mainly on the information given by the monitor. Hypothesized is that contrast influences the way the object looks and therefore the estimated amount of force used. The focus of this study was the influence of the contrast settings of the screen on the applied grasping force of 42 test subjects. The forty-two test subjects were divided into two groups, one with low contrast (40%) and one with high contrast (80%) settings of the screen. An independent t-test was performed to analyze the results and Laverne's test showed equal variances could be assumed. No significant difference between the two contrast groups was found.

Index terms – Minimally invasive surgery, monitor settings, grasping force, visual feedback, contrast.

1. Introduction

During minimally invasive surgery (MIS) the surgeon gets visual feedback via the OR monitor and haptic feedback via the surgical instruments. Since the haptic feedback received from most instruments is minimal and cannot provide sufficient information about tissue health and properties, surgeons rely largely on visual feedback when handling delicate tissue. Surgeons judge the material properties of the tissue, such as oxygen saturation and surface properties, by its features, color, deformation, texture and shading that are displayed on the screen [a]. Based on these features first decisions are made on the amount of force that is required to perform the desired task. During the task the surgeon collects visual feedback about the exerted force using the tissue features displayed on the screen.

Since exertion of too much force can lead to damage of the manipulated tissue and too little force can cause slip and dropping of the tissue, it is imperative that the surgeon can accurately judge the exerted force from the visual feedback displayed on the screen. Multiple settings of the monitor can change the properties of an image, which may result in an impaired visual feedback to the surgeon. Unfortunately hospitals do not have standards for the settings of the monitor, resulting in different settings per OR.

The aim of this study is to find out if the settings of the monitor can influence the visual feedback surgeons receive about the exerted force on the tissue. Settings that can be changed in a typical OR monitor can be divided in three groups: brightness, contrast and color.

The color of the image is mainly used to determine the condition or health of the tissue, like oxygen saturation and possible necrosis of the tissue. However, for force feedback, surgeons do not depend on the color setting. It is therefore thought to be an important independent variable that does not influence visual force perception.

The brightness of the monitor is not only influenced by the screen settings, but also by the light source that is used during the surgery. Brightness depends on the type of surgery, quality, age and type of instruments, making this feature highly variable. It is therefore not useful to explore for a correlation between brightness of the screen and the force of a surgeon.

The final feature that can be adjusted with the OR monitor is the contrast setting. The contrast setting determines the difference between a lighter and a darker area. Low contrast minimizes the difference between the lighter tissue parts, like tendons and bone, and darker tissue parts, like blood vessels and muscle fibers, making it more difficult to distinguish different tissue types from one another. High contrast will maximize this difference and is hypothesized to result in the tissue appearing less compliant, due to the more noticeable edge of the tissue and the higher difference between light and dark tissue types[b].

This led to the following null-hypothesis: "There is a positive relation between the grasping force, applied by a participant using a grasper and the amount of contrast set by the monitor".

2. Materials and Method

2.1. Test set up

To test this hypothesis the set up as is illustrated in Fig. 1, was used. A webcam (Logitec 300 cam), light

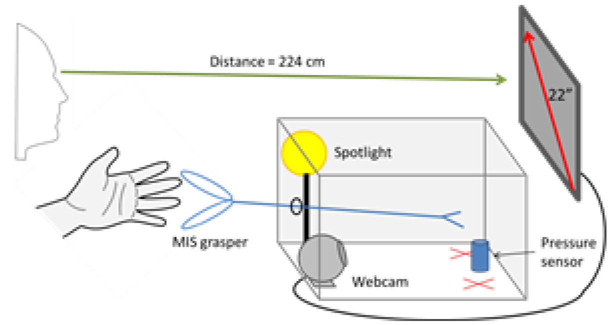

Figure 2 - The experimental setup consisting of a non-transparent box with a lid, a simple laparoscopic grasper, a 22 inch monitor with horizontal resolution 800 lines, a web cam, a force sensor, a spotlight and tape to mark the position of the force sensor.

Figure 1 – A screenshot of the image that the participant sees on the screen. The rectangular shape is the pressure sensor.

source and load cell (Feteris components Mini load cell S beam 45 N) were placed inside a non-transparent box with a hole ($12mm\ \emptyset$) situated at the center of the front panel. Through this hole a laparoscopic grasper (Endopath, $10mm\ \emptyset$) was inserted. The webcam was subsequently connected to a laptop that in turn was connected to a 22 inch Dell monitor via a VGA-cable, functionally displaying the webcam images (Fig. 2). The mini load cell was wrapped in colored plastic, to disguise the identity of the object. An amplifier (Analog signal conditioner CPJ2S, from Feteris Scaime) was used to boost the mini load cell's output and via an USB DAQ device (National instruments USB-6008:12-bit, 10 kS/s low-cost multifunctional DAQ) the load cell was connected to the laptop for recording purposes.

Logitech webcam software was used to display the images of the webcam on the Dell monitor. LabVIEW (2011, National Instruments) was used to record the load cell measurements, with a sample rate of 20 ms. The load cell data was saved as an excel file and subsequently exported to Microsoft Excel for further analysis.

2.2. Test subjects

The test subjects included in the test were from the age group 18-60 years, were both male and female and were left and right handed. Test subjects were excluded if they had prior experience with laparoscopic graspers or were suffering from muscle disorders.

The test subjects were unknowingly randomly divided into two groups: low contrast (40%) and high contrast (80%) to exclude the influence of the possible learning curve. The monitor was adjusted to this setting before the test, the sensor was in place and the lid of the box was closed. The subject was brought into the room and was told that the research was about the use of laparoscopic graspers. Then the setup, the use of the grasper and monitor were explained.

2.3. Experimental task

The subject was asked to pick up the object as gently as possible, grasping only the sides of the object and to move it to a specific location marked inside the box where it had to be released. Before the actual measurement the subject was allowed to practice with the grasper and the grasping of the object. After five trial runs the subject was asked to repeat the test five times. The force used during the task to grasp the object was measured and recorded using LabView2011. If during the test the object was picked up in a wrong way, with too much force (effectively clipping the sensor output) or dropped, the measurement was seen as incorrect and discarded from the measurement. The test had to be repeated until five good measurements were collected.

From the force measurement of each subject the five peak forces, that matched the five good measurements, were selected. These values were used to determine the mean and standard deviation per test subject. Subsequently, the total mean and standard deviation per contrast group was determined.

2.4. Statistics

In this research one continuous outcome variable was used; the exerted force. The one predictor was categorical, with two categories, namely high contrast (80%) and low contrast (40%). In these categories different participants were used, therefore the data was analyzed by using an independent t-test. To perform the t-test, the variances in the two groups should be equal. To check if equal variances in the groups could be assumed, Levene's test was used. If Levene's test is significant, p>0.05, we can assume that the variances are roughly equal.

Table 1 – The group statistics of both contrast groups.

Group Statistics

	Contrast	N	Mean	Std. Deviation	Std. Error Mean
Force	40	22	21.3	9.9	2.1
	80	22	21.4	7.7	1.6

2.4. Power analysis

To calculate the amount of participants needed to determine if there is a significant difference between the two contrast groups, a power analysis was performed. Equation 1 depicts the power analysis with the corresponding parameters. The required power was set to 80% (giving $z_b = 1.28$), the required significance level at 0.05 (giving $z_a = 1.96$) and the clinically relevant difference (d) was determined at 40%. Since no data could be found about the expected standard deviation, a subsequent pilot study was performed to determine the amount of participants needed.

$$\#\, participants = 2 \cdot [\frac{(z_a + z_b) \cdot \sigma}{d}]^2 \quad (1)$$

The pilot study was performed using the same set up as aforementioned and included 6 participants; 3 participants with low contrast setting (40%) and 3 with high contrast setting (80%). Analysis of the sensor measurement in Microsoft excel showed an average standard deviation of 1.5N. The average mean of both groups was calculated at 2.7N, resulting in a relevant clinical difference (40%) of about 1.1N between the groups. Using these values in Equation 1 determined the amount of participants needed in this study at 40. The pilot study also confirmed the presence of a learning curve, confirming previous assumptions and validating the need of the five trials.

3. Results

In Table 1 the group statistics of the research are shown. In total 44 test subjects performed the experiment; 22 with the low contrast setting (40%) and 22 with the high contrast setting (80%). In Table 2 the results of the independent t-test are shown. From the results of Levene's test we may conclude that equal variances may be assumed.

The averages of the two groups show that participants did not have a higher peak force while using the grasper with a low contrast on the monitor ($M = 21.3, SE = 9.9$) than with a high contrast ($M = 21.4, SE = 7.7$). The difference was not significant ($t(42) = 0.970, p > 0.05$).

4. Discussion

The results indicate that there is no relevant clinical difference (p>0.05) between the two contrast groups. This leads to the conclusion that the contrast setting in this set up did not have an effect on the exerted force.

It can however be questioned whether the high variance between the test subject with respect to exerted force was not of large influence of the experiment. This large variance could be due to a too low web cam quality and the non-uniform light distribution inside the box. Both decreased the quality of the image and made it more difficult to see the deformation of the load cell.

Table 2 – Results of the independent t-test.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Force	Equal variances assumed	.84	.37	-.038	42	.970	-.10	2.68	-5.5	5.3
	Equal variances not assumed			-.038	39.6	.970	-.10	2.68	-5.5	5.3

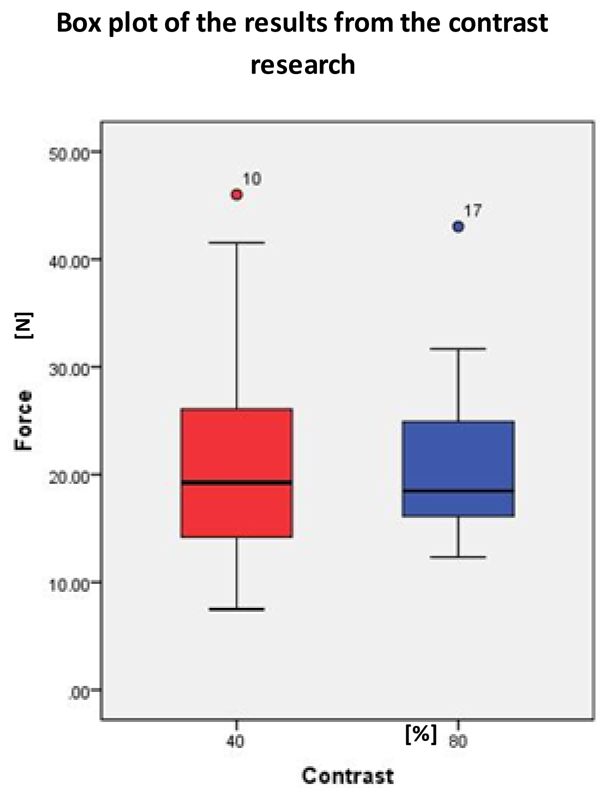

Figure 3 – Box plot of the results from the research. Given are the

The simplicity of the task ensured that the inexperienced subjects could perform the task with relative ease. However, due to the relative low difference in height of the load cell in comparison to the grasper, it was difficult for the test subjects to detect the deformation of the load cell and thus to predict the exerted force. Test subjects mentioned that they were unable to receive any haptic feedback, due to high friction inside the grasper, which resulted in high reliance on the monitor screen.

5. Conclusions

In this study it was shown that under these circumstances there is no difference between the peak forces exerted using a laparoscopic grasper used in a high contrast setting or a low contrast setting of a monitor giving visual feedback. Thus the hypothesis is invalidated.

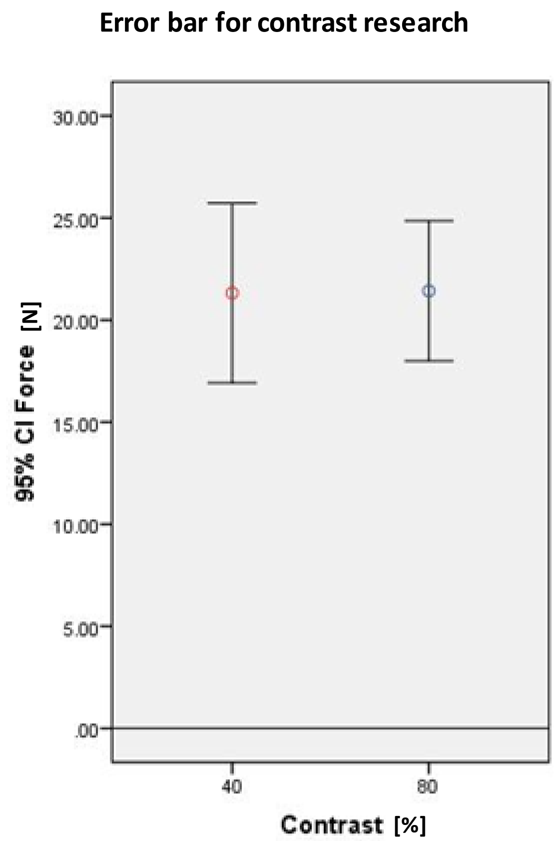

Figure 4 - Error bar of the research. Given are the mean and standard deviation of the two contrast groups. As can been seen from the bar error, the means are almost the same.

References

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