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# Advbot: Towards Understanding Human Preference in a Human-Robot Interaction Scenario

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*Abstract*— **Recent studies show that the growth of social robotics market will dominate the robotics sector by 2025. Social robots are set to enter and co-exist in daily living, making human-robot interaction studies a crucial research direction in these robotics applications. One such application is the deployment of robotics in information dissemination to augment the shrinking workforce in developed economies, such as advertisement campaigns. This work seeks to understand whether live robot advertiser can better engage audience and improve audience perception of a marketed product as compared to pre-filmed video advertising clips. In this preliminary study, a humanoid robot, the NAO, was programmed to act according to a marketing campaign script, engaging the audience through voice, simulated eye-contacts, gestures and interaction with the Keepon, a robot to be advertised. We carried out three sets of experiments in the CBD of Singapore on teenage pedestrians. The results of this study suggest that physical robot presence will enhance information dissemination and hence improve advertising result, providing value-add to the advertised product.**

## I. INTRODUCTION

In recent years, robotics has undergone rapid developments, providing people with enhanced support and convenience. This is manifested by the robot augmenting human workers in various fields - mainly in manufacturing and industrial operation. Furthermore, human-robot interaction is gaining traction and gradually becoming more prevalent across domains, e.g. in healthcare, education and surgery. The increase demands in employing such commercial applications imperceptibly becomes the impetus of growth in robotic-affiliated market economies. While there are new market opportunities arising from these applications, the competition among businesses remains stiff owing to globalization [1]. This compels companies to seek new ways to present their products to best the others in competition. On the other hand, with the advancement in robot hardware and artificial intelligence, the growth of social robot market has boomed in the last few years and is expected to dominate the robotics market by 2025 [2].

With globalization, advertising plays an important role in today's competitive marketing world [1]. However, there is a decrease in the effectiveness of traditional advertising communication [3]. As a result, the needs for creative methods to produce more effective advertisements becomes crucial to increase brand awareness and information recall. In this competitive business world, advertising is used for introducing businesses, brand establishment and securing foothold for the company, product or service against the competition [1]. Adding on, with the rapid development of technology, advertising is no longer limited to the traditional media such as newspaper, magazines, television, it is also brought forward to new media such as websites and text messages. Hence, to maintain competitiveness and success in the intense business world, effective management of advertising should be applied to address the needs of consumers - since market is controlled by the demand from consumers [4].

Robotic devices are not only applied to solving problems in traditional manufacturing or industrial settings, but also involved in physical interaction with humans [5]. Face-to-face interactions between human and robot (fHRI) will enable better task sharing and control, that will enhance human performance capabilities [5]. Hence, social and interactive skills will be necessity traits for robot to operate in these applications, especially in context where robots are required to interact and collaborate with other robots or humans [6]. As such, fHRI knowledge is crucial to support these interactions. Previous studies have demonstrated the merits of physical presence of robots for providing information [7], [8], [9]. Moreover, humanoid robots' human-like bodies will enable them to perform natural gaze motion [10] and deictic gestures [11], which facilitate their communication with human.

In [3], the authors develop a social robot to explore the possible daily application in advertising. It has shown the potential to promote technical assistance, increase the efficiency, affect consumer's decisions as well as increase customers' involvement and satisfaction. While the presence of the robot helps to attract customers, the effects of robot advertisements remain unknown. Therefore, this paper will investigate the effectiveness and potential benefits of robot live advertisement using a humanoid robot to merchandise a robotic toy.

The rest of the paper is organised as follows. We introduce our hypotheses in Section II followed by the experimental design and methodology in Section III. We present the experimental results and discussions in Section IV before concluding this paper in Section V for future work.

## II. HYPOTHESIS

Based on the recent results presented in [3], the following hypotheses are developed for investigation in this study:

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*1) Hypothesis 1:* : A robot can help to increase the effectiveness of an advertised product by enhancing the perceived value of the product.

*2) Hypothesis 2:* : Live interaction of a robot with the audience will result in improved effectiveness in the advertising campaign as compared to interaction through TV media.

## III. METHODOLOGY

### A. Participants

180 teenagers, aged 13 to 18, were randomly recruited for participation in the experiment conducted on Orchard Road, the CBD strip and a symbolic place that represents the youth culture in Singapore [12]. The participants were randomly divided equally into three different groups of experiments, specifically control experiment, experiment A and experiment B. Each subject only participated in one experiment.

### B. Robot Features

An Aldebaran Nao (Fig. 1a)[1] humanoid robot was used as the robot advertiser in both Experiments A and B. The advertising script for the robot was spoken using the NAO's on-board Text-to-Speech (TTS) system. Various voice profiles were incorporated, to distinguish male and female roles in advertising when necessary. This implementation was similar to the approach in our previous work [13]. NAO's gestures and gaze control through head movement during advertisement were implemented using Choregraphe as shown in Fig. 1c, a behaviour editor to compose motion sequences. All three experiments were scripted to maintain similar baseline conditions.

My Keepon$^{TM}$, a robotic toy gadget shown in Fig. 1b, was used as the producted to be advertised by NAO. Keepon is designed to mimic social interaction with children through 2 different modes - Dance mode and Touch mode. By selecting the buttons on its platform, it is able to switch between the modes.

### C. Experiment Design

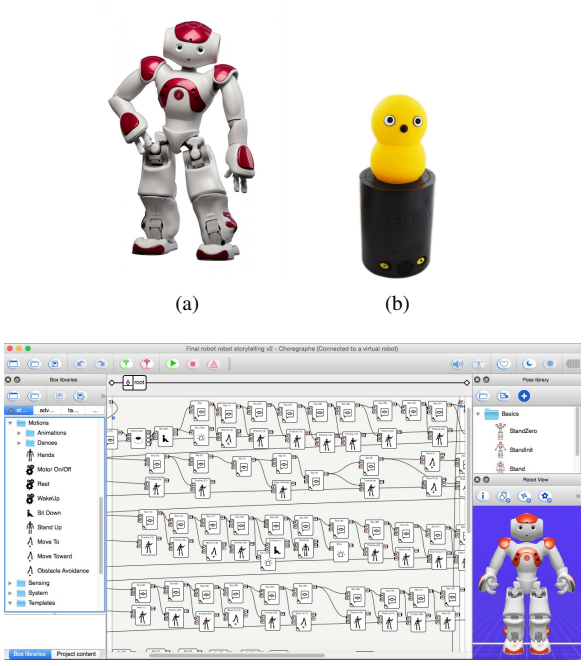
All experiments were conducted on 60 teenager subjects while the scripts adopted in all three experiments were the same. In the Control Experiment, the Keepon was advertised by a person. In both Experiments A and B, the Keepon was advertised by the NAO robot. Experiment A was conducted live in front of the subjects while Experiment B was filmed in a video to be shown to the participants. The level of action and speech of the advertiser was kept as close as possible. Various features, such as tactile head and hand, were implemented in Experiment A such that participants was able to experience physical interactions with the NAO robot. In Experiment B, the video utilised sounds, such as background music and additional sound effects, filters, slow motion as well as freeze frame[2].

All of the participants received the same post-experiment survey immediately after the experiment. The survey focuses on the data collection of the following two proxy indicators to evaluate the effectiveness of advertisement.

- The price that the audience is willing to pay for the Keepon in Singapore Dollars.
- Perceived liking of the product (Yes or No question)

[1]https://www.aldebaran.com/en/humanoid-robot/nao-robot

[2]Video available at www.youtube.com/watch?v=8t-ovvrzf7A



(a) (b)

(c)

Fig. 1. (a) Aldebaran Nao robot; (b) My Keepon$^{TM}$; (c) Choregraphe, the GUI programming environment used to implement the experiment on Nao

## IV. RESULTS AND DISCUSSIONS

Hypothesis 1 was analysed based on the comparison between control experiment and experiment A. Experiment setup and techniques were kept as controlled variables apart from the mode of interaction, specifically advertising was done by a person in the control experiment while advertising was done by NAO robot in experiment A.

Hypothesis 2 was determined by the correlation of perceived liking and mode of advertisement. Furthermore, preliminary conclusion was drawn from the comparison between Experiments A and B. Experiment setup and techniques were kept as controlled variables apart from the medium of interaction, specifically advertising using NAO robot was done live in Experiment A while advertising using NAO robot was done in a video in Experiment B.

TABLE I

AGGREGATED SURVEY RESULTS OF ALL EXPERIMENTS. 60 PEDESTRIANS FROM THE AGE GROUP OF 13-18 WITH EQUAL NUMBER OF MALES AND FEMALES FOR EACH EXPERIMENT WERE RANDOMLY SELECTED AT THE CBD OF SINGAPORE.

| Experiment | Control | Live | Video |
|---|---|---|---|
| % New to product | 100.0% | 93.3% | 95.0% |
| % Like the product | 43.3% | 85.0% | 75.0% |
| S$ willing to pay [MeanSTD] | 18.9(27.2) | 40.32(25.9) | 30.5(15.8) |

Given the randomly sampled population of teenagers with the sample size of 60 for each experiment and population standard deviation $\alpha$ is unknown, thus the S standard deviation of the sample would be used in our hypotheses. Owing to the size of N for each experiment, it is large enough for Central Limit Theorem to ensure that sample means vary normally, even though the distribution of the valuation price might be skewed to the right or having anomalous outliers.

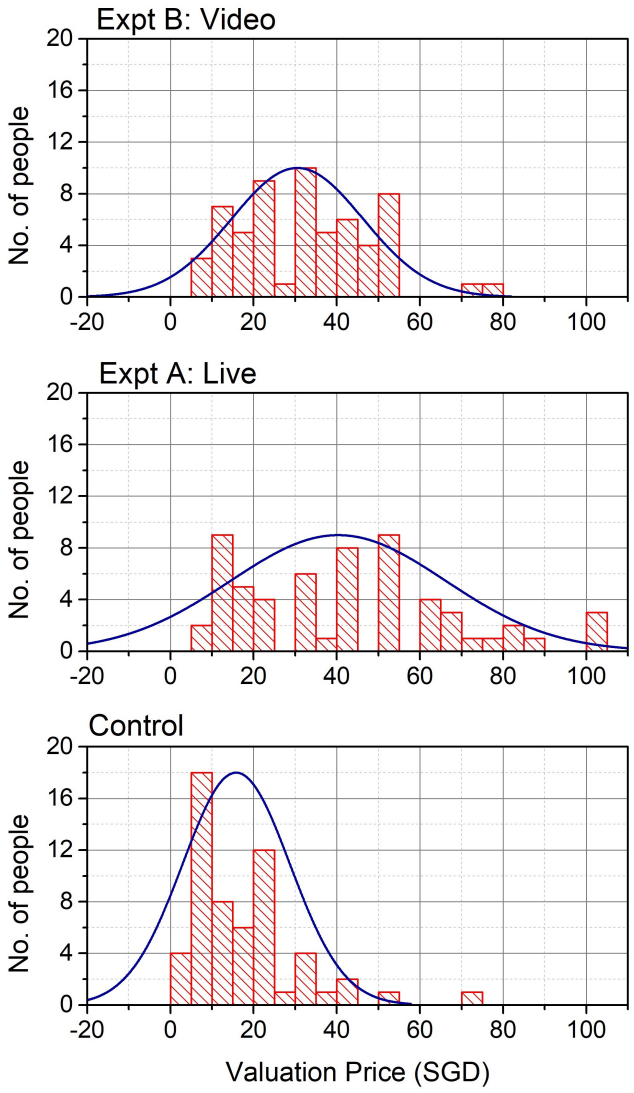



Fig. 2. Histogram of My Keepon™ valuation price for the three experiments. The solid blue line represents the fitted normal distribution for the data set. The sample size, N, mean and sample standard deviation are given as [N, mean, SD]: 1. Control – [59, 18.93, 27.18], 2. Expt. A Live – [59, 40.32, 25.87], 3. Expt. B Video – [60, 30.52, 15.80]. In the control experiment, the data point value at 200 SGD was masked for better representation of the graph and fitted curve; nonetheless it was considered for all the calculations in T-test and Chi-Square test.

To validate that the two hypotheses are valid and relevant, we would be using two indicators: 1. Valuation Price & 2. Perceived Liking. These indicators are statistically supported by:

- Two independent sample T-Test on the valuation price, between Control and Experiment A (Live) & Experiments A and B (Live v.s. video)
- Chi-Square test for determining the correlation between perceived liking and mode of advertisement

For hypothesis 1, it will be tested by the two indicators, with comparison between the control and Experiment A (Live), because the only varying factor in the experiment will be a human narrator and actor (Control) and NAO robot (experiment A). As for hypothesis 2, it will be compared between Experiments A (Live) & B (Video) – which NAO robot will be the narrator and actor for the video advertisement. In all our statistical tests, we adopt the significance level $\alpha$ = 0.05.

### A. Hypothesis 1

We define $\mu_C$ as the mean of the valuation price of Keepon in Control Experiment and $\mu_L$ as that in Experiment A. The hypothesis to be tested can be defined as follows:

$$H_0 : \mu_C - \mu_L = 0 \quad (1)$$

$$H_\alpha : \mu_C - \mu_L < 0 \quad (2)$$

Based on the p-value of the probability from the t-test as shown in TABLE II, the data presented sufficient evidence to reject the null hypothesis - since $p = 2.53E-05$ is significantly smaller than the significance level of 0.05. Furthermore, from the data, there is sufficient evidence to claim that Experiment A (Live with NAO) would have a higher mean valuation price compared to the human-based Control setup. This claim is also manifested by the higher mean valuation price of the robot at SGD 40.32 for Experiment A (Live) compared to SGD 18.93 for Control setup.

TABLE II

THE COMPARISON TABLE FOR ANALYSES FOR HYPOTHESIS 1. FROM THE RESULTS, IT IS SHOWN THAT THE PROBABILITY IS MUCH SMALLER THAN THE CONFIDENCE LEVEL, THUS WE CAN SAFELY REJECT THE NULL HYPOTHESIS IN BOTH CASES.

| Valuation Price ($\alpha = 0.05$) | T-Test Statistics | Probability |
|---|---|---|
| Control vs Expt. A (Live) | -4.38 | 2.53E-05 |
| Expt. A(Live) vs Expt. B (Video) | -2.49 | 7.83E-03 |

For the analysis of perceived liking, we performed Chi-square test to investigate if there existed a relationship between the mode of advertising dissemination and the perceived liking of the product. The $\chi^2$ test is defined as:

$H_0$: No relationship between perceived liking and mode of advertisement

$H_\alpha$: There is a relationship between perceived liking and mode of advertisement

From the $\chi^2$ test, the critical region (2DF and $\alpha = 0.05$) to reject the null hypothesis $H_0$ (for chi-square test) is defined at test value, $T$, $T < 0.103$ or $T > 5.991$. The perceived liking test value, $T = 10.68$, is much larger than the upper-tail critical value. Furthermore, $p = 0.004803$ is much smaller

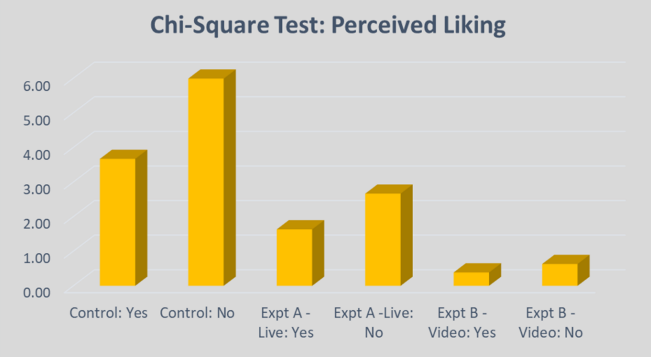



Fig. 3. Chi–Square values of the perceive liking for each experimental set-up. The values for the individual Chi-Square components are as follows [3.67, 5.99, 1.63, 2.66, 0.39, 0.63]

than $\alpha = 0.05$. We can conclude that there is a correlation between the three categorical variables (advertisement modes), perceived liking and mode of advertisement.

In Fig. 3, it can be observed that the large contribution to the chi-square value, T, for both Control and Experiment A(Live) manifested the evidence of relationship. This is since the number of perceived liking – 'yes/no' has much difference from the expected value if null hypothesis is true. Referring to Fig. 4, we observe that the total liking for Experiment A(Live), from the sample population, has a much higher percentage liking for the product at $75\%$ compare to control experiment that has $42.4\%$.

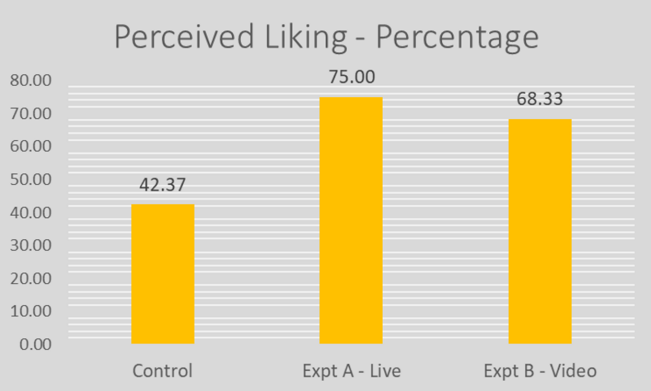



Fig. 4. Perceived liking in percentage for the 3 experiments. The ratio of the data is given by: Control = 25/59, Experiment A: Live = 45/60, Experiment B: Video = 41/60.

Therefore, from both indicator results, we can conclude that the effectiveness of advertisement, pertaining to robotics, are improved, via value adding to the product, with presence of the robot in the advertisement. Thereby, the claim Hypothesis 1 is supported by the experimental results.

### B. Hypothesis 2

We define $\mu_V$ as the mean of the valuation price of Keepon in Experiment B. The hypothesis to be tested can be defined as follows:

$$H_0 : \mu_V - \mu_L = 0 \tag{3}$$

$$H_\alpha : \mu_V - \mu_L < 0 \tag{4}$$

In TABLE II, we can observe that the p-value of the two independent sample T-test for Experiment A(Live)and Experiment B(Video), $p = 7.83E - 03$, is significantly smaller than the significance level $\alpha = 0.05$. Thus, there is sufficient evidence to reject the null hypothesis in this case and claim that Experiment A(Live) has a higher mean valuation price compared to Experiment B(Video). The mean valuation price has also been shown to be clearly higher in Experiment A at SGD 40.32 compare to Experiment B at SGD 30.52.

Since the validity of the relationship between the perceived liking and the mode of advertisement has been shown above, it would make sense for the simple comparison of 'perceived liking percentage' between the two experiments. From Fig. 4, it can be observed that the Live demonstration (at $75\%$), albeit less stark difference from control setup, has $7\%$ difference in the 'perceived liking percentage' as compared to Video demonstration (at $68.33\%$). Thus, we can conclude that Live demonstration yields better advertising results than other modes. It is suggested that such observation is due to the higher level of human-robot interaction in the advertisement demonstration for the Live demonstration.

In conclusion, Hypothesis 2 can be justified that the mode of advertisement involving robot, live and video advertisement, affects the effectiveness of the advertisement. And both indicators show that live robot advertisement performs better.

The experimental results support the observations from the literatures that human-robot interaction has a role in affecting effectiveness of communication and perception, specifically in advertising. And depending on the mode of advertisement, the degree of human-robot interaction differs, thus, affecting the effectiveness of the advertisement.

## V. CONCLUSION

In this paper, we presented a human-robot interaction study to probe into the effectiveness of using robot as a means of information dissemination through the application of an advertising campaign. Two hypotheses were tested based on three sets of experiments carried out using different modes of advertising media with similar script. The experiments were carried out in the busy CBD district of Singapore with 180 teenage passers-by. The results suggest that based on the indicators such as valuation price and perceived liking of the product, face-to-face HRI is effective in promoting a robot toy to teenagers. While there are limitations such as the variation in product marketed as well as experimenting on a different target audience to probe the effectiveness of the advertisement, these are also aspects for future work to be investigated in.

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