Sound over Matter: The Effects of Functional Noise, Robot Size and Approach Velocity in Human-Robot Encounters

Michiel Joosse
Human Media Interaction
University of Twente
Enschede, The Netherlands
m.p.joosse@utwente.nl

Manja Lohse
Human Media Interaction
University of Twente
Enschede, The Netherlands
m.lohse@utwente.nl

Vanessa Evers
Human Media Interaction
University of Twente
Enschede, The Netherlands
v.evers@utwente.nl

ABSTRACT
In our previous work we introduced functional noise as a modality for robots to communicate intent [6]. In this follow-up experiment, we replicated the first study with a robot which was taller in order to find out if the same results would apply to a tall vs. a short robot. Our results show a similar trend: a robot using functional noise is perceived more positively compared with a robot that does not.

Categories and Subject Descriptors
H.m [**Information systems**]: Miscellaneous

General Terms
Experimentation

Keywords
Social robot, functional noise, robot height, approach experiment, artificial noise

1. INTRODUCTION AND BACKGROUND
The first impression counts [1], and has already formed when approaching someone. Research has shown that when approaching each other, people exchange social signals using non-verbal communication [7]. Also their appearance is a signal that provides information to the other person [5]. While robot designers can control some of these latter signals by ways of morphological design, robots fall short in employing subtle (non-verbal) signals, such as short glances or gestures, due to technical limitations. Thus, we - as interaction designers - have to find ways to compensate for this lack to ensure that users understand and can predict the robot's behaviors.

Therefore we propose to add functional noise to robots to convey their intentions. Functional noise is added artificial noise to inform people. For instance to an electric car some engine noise may be artificially added so that people can hear it coming. We carried out a first study [6] in which we investigated the effect of fictional noise that communicates how fast the robot is going. This experiment provided us with results of how functional noise and approach velocity influence people's perception of robots.

In the current study we aim to address the biggest limitation in the first study: the height of the robot was only 78 cm [6]. This may explain the lack of effect of approach patterns on users' attitudes and behavior. Previous work on height in HRI found no significant result (120 cm vs. 140 cm) [8]. Or, when differences were found, both height and appearance were manipulated [3]. In order to address this limitation, we conducted an experiment in which we replicated the previous experiment [6] with a taller robot, having a height of 163 cm instead of 78 cm.

2. METHOD
We conducted a 2x2 between-groups experiment, manipulating two independent variables: robot (acceleration and deceleration) velocity and functional noise, see also Figure 1. Our hypothesis is that "*a robot using functional noise to convey its intention to the user will be more positively perceived than a robot which does not use intentional functional noise"*. A 163cm Giraff robot was used. On the screen of the robot, we displayed a pair of eyes, made up from static colored dots. The robot was programmed to accelerate and decelerate either slowly over time (0.1 m/s^2) and to drive "smoothly" or to accelerate and decelerate as fast as possible (1.35 m/s^2) and to drive in an "abrupt" way. The maximum speed of the robot was set to 0.69 m/s, and the robot would approach the participant by driving 4.9 meters in a straight line.

We created two different functional noises; a noise with "*constant noise* level" and a noise that increased in volume at the beginning of the approach and decreased in volume at the end, the latter called "*intentional noise"*. The manipulations resulted in four different experimental conditions.

A 32-item post-experiment questionnaire was used as dependent variable, measuring among others helpfulness (see [6]) and the Godspeed scales [2]. All five Godspeed scales had medium to high internal reliability. The Godspeed scales anthropomorphism (α=.740), animacy (α=.656), likeability (α=.898), perceived intelligence (α=.804) and perceived safety (α=.778).

The sample consisted of 40 participants (25 males, 15 females) with a mean age of 21.25 years (sd=2.30). Participants were equally distributed over the experiment conditions. The participants, mainly students, were recruited from the premises of the University of Twente. After being provided with a short explanation about the experiment, participants filled out a consent form. The robot approached the participants once, after which they filled out the post-experiment questionnaire.

HRI'14, March 3–6 2014, Bielefeld, Germany
ACM 978-1-4503-2658-2/14/03.
http://dx.doi.org/10.1145/2559636.2559822

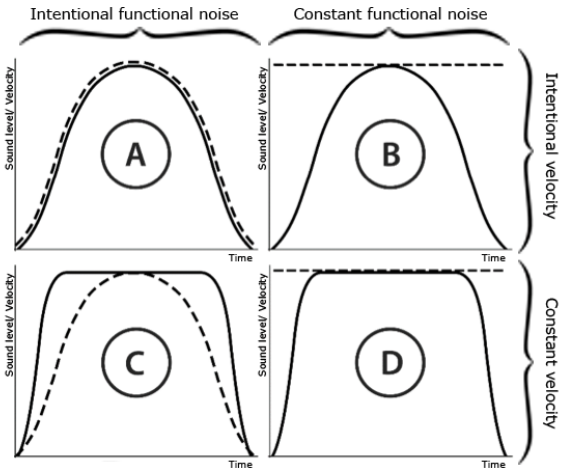

Figure 1. A 2x2 between-groups experiment was conducted, manipulating functional noise and velocity.

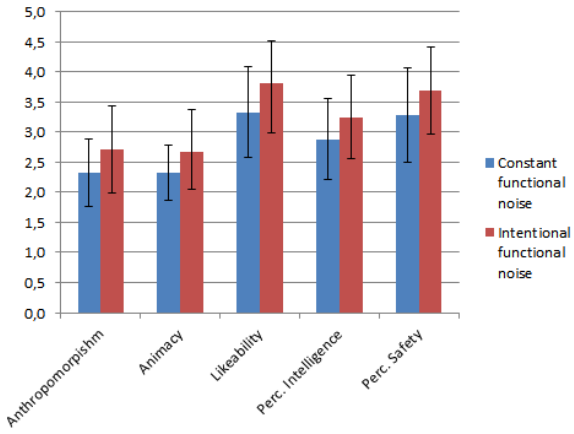

Figure 2. Mean ratings for the combined sample Godspeed scales.

3. RESULTS AND DISCUSSION

Participants liked the robot more in the functional noise conditions, instead of a constant noise conditions, $F(1,39)=3.844$, $p<0.05$. A main effect was found for functional noise on perceived helpfulness: participants rated the functional noise conditions (M=3.35, sd=1.089), as being significantly more helpful than the constant noise conditions (M=2.70, sd=1.081), $U=135.5$, $p<.05$.

When we combined this dataset with the one in [6], we found a significant main effect of functional noise on helpfulness. Participants found an intentional noise pattern (M=3.35, sd=1.122) significantly more helpful a constant functional noise pattern (M=2.73, sd=.987), $U=546.00$, $Z=-2.546$, $p<0.05$. Furthermore, we found significant (2-tailed) main effects for functional noise on all Godspeed scales: anthropomorphism ($F(1,73)=7.685$, $p<0.01$), animacy ($F(1,75)=7.474$, $p<0.01$), likeability ($F(1,75)=9.336$, $p<0.01$), perceived intelligence ($U=520.00$, $Z=0.10$, $p<0.01$) and perceived safety ($U=607.50$, $Z=0.059$, $p<0.05$). For the above scales the intentional noise conditions were rated more positively than the constant noise conditions as can be seen in Figure 2.

No significant effects were found between size of the robots. Both short and tall robots were simple-looking robotic devices without moveable arms. It could be that a robot with a more anthropomorphic, or sophisticated shape, yields different results.

We are aware that we have introduced limitations towards the validity of our work. Previous work in HRI has found that full-frontal robot approaches are not necessarily the most comfortable. The experiment procedure perhaps made participants unnaturally well aware of the approaching robot; participants were focused on the robot from start to finish.

In conclusion, we found that a robot approaching with intentional noise (increasing in volume when the robot accelerated and decreasing in volume when the robot decelerated) was perceived more helpful, and was regarded more positively. Our study shows that functional noise could be a powerful tool to convey a robot's intentions when approaching a user.

4. ACKNOWLEDGMENTS

This work has partly been supported by the European Commission under contract number FP7-ICT-600877 (SPENCER).

5. REFERENCES

[1] Ambady, N.E., and Skowronski, J.J. 2008. *First impressions.* Guilford Publications.

[2] Bartneck, C., Kulić, D., Croft, E. and Zoghbi S. 2009. Measurement instruments for the anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety of robots. *International Journal of Social Robotics* 1, 1 (Jan. 2009), 71-81. DOI= http://dx.doi.org/10.1007/s12369-008-0001-3

[3] Butler, J.T. and Agah, A. 2001. Psychological effects of behavior patterns of a mobile personal robot. *Autonomous Robots*, 10, 2, 185-202.

[4] Fong, T., Nourbakhsh I., and Dautenhahn, K. 2002. *A survey of socially interactive robots: Concepts, design and applications.* Technical report CMU-RI-TR-02-29.

[5] Hegel, F., Gieselmann, S., Peters, A., Holthaus, P., and Wrede, B. 2011. Towards a typology of meaningful signals and cues in social robotics. In *Proc. of the RO-MAN'11* (Atlanta, Georgia, July 31-August 3, 2011). RO-MAN 2011. IEEE, 72-78.DOI = http://dx.doi.org/10.1109/ROMAN.2011.6005246

[6] Lohse, M., Van Berkel, N., Van Dijk, E.M.A.G., Joosse, M. P., Karreman, D.E., and Evers, V. 2013. The influence of approach speed and functional noise on the perception of a robot. In *Proc. IROS'13* (Tokyo, Japan, Nov. 3-8, 2013). IROS2013. IEEE, 1670-1675.

[7] Picard, R.W. 2000. *Affective computing*. MIT press.

[8] Walters, M.L. 2008. *The design space for robot appearance and behaviour for social robot companions*. PhD thesis, School of Computer Science, Faculty of Engineering and Information Sciences, University of Hertfordshire.