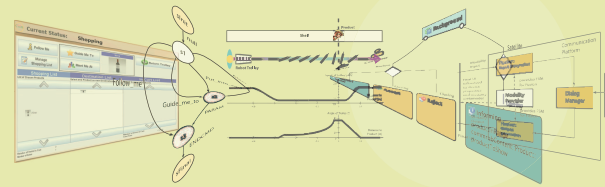# Multimodal Communication Involving 2D-Space Movement

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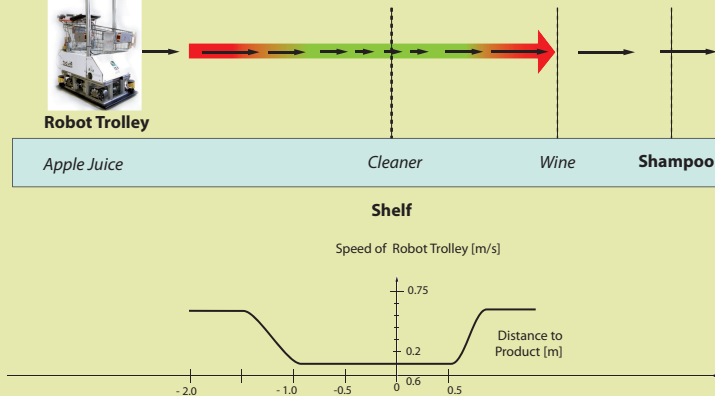Karlsruhe, Germany
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PROBLEM

Movement of a robot not sufficiently used for communication.

SOLUTION

◆ New approach to multimodal communication including 2D-space movements.

◆ Movement as Communication (MaC) reinforces other modalities like GUI or speech output.

◆ Enhances the existing communication channels between a semi-autonomous robot and its human user by involving its embodiment (but without 'hand' or 'foot' gestures).

Robot Trolley

Apple Juice | Cleaner | Wine | **Shampoo**

Shelf

Speed of Robot Trolley [m/s]

0.75

0.2

0.6

Distance to Product [m]

-2.0   -1.0   -0.5   0   0.5

Movement as Communication in the Laboratory

We have implemented Movement as Communication on a semi-autonomous robot. The robot triggers the output modality MaC when the robot is approaching another product of the shopping list. Then the robot slows down and offers this product not yet taken via MaC, GUI and speech. The human operator may either ignore the offer or stop the trolley. If the human operator ignores the offer, the robot increases its speed again. Otherwise the trolley stops near the product of interest.

Dependent Variable: products

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	26,182 [a]	3	8,727	11,059	,000
Intercept	112,634	1	112,634	142,728	,000
behavior	4,715	1	4,715	5,975	,022
run	8,715	1	8,715	11,043	,003
behavior * run	11,834	1	11,834	14,996	,001
Error	20,518	26	,789		
Total	155,000	30			
Corrected Total	46,700	29			

a. R Squared = ,561 (Adjusted R Squared = ,510)

ROBOT PROTOTYPE

The semi-autonomous robot has a multimodal user interface:
Input: GUI, speech, hand gestures
Output: GUI, speech, MaC

Experiment

The prototypical robot and its functionality is studied in a simulated shopping environment. For investigating the effects of MaC, we designed and performed an experiment around a shopping scenario, with and without MaC. The experiment shows that MaC reinforces GUI and speech.

The table above shows an analysis of variances with the robot's behaviour and the experiment run as independent fixed factors. Both, the robot's behaviour and the run, have statistically significant effects on the action of the subject.

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