In-Car Information Systems: Matching and Mismatching Personality of Driver with Personality of Car Voice

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Abstract. Personality has a huge effect on how we communicate and interact with others. This study investigates how dominant/submissive personality match and mismatch between driver and voice of the in-vehicle system affects performance and attitude. The study was conducted with a total of 40 participants at Oxford Brookes University in the UK. Data show that drivers accurately discern the personality of the car voice, and that car voice personality affects drivers' performance. The dominant car voice results in drivers following instructions better regardless of driver personality. The matched conditions showed 2 -3 times better driving performance than the mismatched conditions. Drivers with the submissive voice in the car felt significantly less at-ease and content after driving than drivers with the dominant voice. Design implications of in-vehicle systems are discussed.

Keywords: In-car System, Driving Simulator, Driving Performance, Speech system, Attitude, Personality, Dominant and Submissive, Similarity Attraction.

1 Introduction

Humans are tuned to detect characteristics in a voice and use that skill when communicating with both humans and speech-based computer systems [1]. The linguistic and para-linguistic properties of a voice can influence people's attention and affect performance, judgment, and risk-taking [2, 3]. Previous studies show that voices used by in-car systems can influence driving performance in the same manner [4, 5, 6]. Characteristics of the voice affects listeners perception of liking and credibility of what is said, regardless of if the speaker is human or computer-based system [3]. The psychological literature suggests that consistency is important. People expect consistency and prefer consistency to inconsistency. When inconsistency is encountered, people enter a state where they are motivated to adapt their perceptions in order to resolve inconsistency [7]. This process increases their cognitive load. The need for consistency is well understood in traditional media, but is less clear for human-computer interaction. In the context of in-car information systems, Nass et al.

[8] show a clear positive effect of matching the emotional characteristics of the in-car voice to the emotional state of the driver.

Communication is also more effective [9] when source and receiver share common meanings, belief, and mutual understanding. Lazarsfeld and Merton [10] showed that most successful human communication will occur between a source and a receiver who are alike, i.e., homophilous, and have a common frame of reference. People prefer people with personalities and accents similar to themselves. Communicating with entities that are markedly different requires more effort to reach common ground.

In general terms, theories of similarity-attraction and consistency-attraction [11] would suggest that personality has a huge effect on how we communicate and interact with others. Previous studies [12] show that matching personality when communicating with a computer systems matters and Dahlbäck, Swamy et al. [13] show that even matching accents matters. A system is always rated higher, and the user's perception of the systems performance better in matched cases.

The study reported here was designed to investigate if the voice of an in-car system would be subject to similarity-attraction and consistency-attraction. In particular, the personality of the voice, and how that would affect attitude and driving performance.

2 Study Design and Apparatus

To investigate the effect of matching and mismatching personality of voice with driver personality, a study with 100 participants was designed. The study was conducted at Oxford Brookes University in the UK and a replicated study was done at Stanford University in the USA. Reported here are the results from the UK study.

2.1 Study Design and Participants

The design was a 2 (Personality of driver: dominant, submissive) x 2 (Personality of car voice: dominant, submissive) between subject and gender balanced study.

There were 40 participants in the study (20 dominant and 20 submissive) Participants were screened based on the Interpersonal Adjective Scale [14] where questions were selected to assess participants along the dominant-submissive dimension. This is a standard commercial questionnaire, where the dominant-submissive dimension represents the degree to which an individual is assertive and willing to exercise control over others.

All participants were students at Oxford Brookes University and they were awarded 10GBP for their participation.

2.1 Apparatus

Driving Simulator. The studies were done using a driving simulator, and hence the results provide an indication rather than a determination of behavior in real cars and real traffic.

The main factor that motivates the use of driving simulators for initial testing is the controlled environment. Despite the dangers involved in driving, the average driver will have very few accidents in their lifetime. Due to the rarity of incidents, it would be extremely time consuming to set-up an experiment with the characteristics of real driving within the defined parameters of the study, and wait for a significant number of events to occur. The best way to examine new driving related systems and practices is to challenge people using a driving simulator. The experience is immersive; the degree of immersion varies with the fidelity of the simulator, but the effect is there even for very low fidelity simulators [15].

Fig. 1. STISIM Drive - Driving simulator.

A commercial driving simulator, STISIM Drive model 100 with a 45-degree driver field-of-view, from Systems Technology Inc. was used in the studies. Participants sat in a real car seat and “drove” using a Microsoft Sidewinder steering wheel and pedals (accelerator and brake). The simulated journey was projected on a wall in front of participants.

Fig. 2. STISIM Drive – Driving scenario with a small village, an intersection and pedestrians.

Driving scenarios in STISIM Drive consist of a road and objects placed along that road. It is important to note that a driving scenario in STISIM Drive is static, drivers can turn left or right at any intersection, but are nevertheless driving on the same road as if they had continued straight ahead. This ensures consistent driving environment from start to finish for all participants regardless of turns.

Fig. 3. STISIM Drive – Driving scenario with roadwork and road signs. Note the rear-view mirror located in the top right corner of the picture. Traffic can either be programmed to follow traffic regulations or drive without adherence to traffic regulations

The driving scenario was 52 000 feet (15.85 kilometers) long. It was especially designed to take the drivers through rural areas, villages and intersections in a varied and realistic road scenario. All properties of the simulator, vehicle dynamics, weather conditions and traffic were set to be the same for all participants in the study. The exception of course, being the voices used by the navigation system.

In-Car System. A navigation system was designed to take the driver to five locations by interacting with drivers at certain locations along the driving scenario.

The navigation system consisted of 38 utterances. 32 of the utterances were directions or suggestions, and six utterances were facts about the immediate surroundings. Directions and suggestions were designed to guide the drivers to the pre-programmed destinations. The facts were added to investigate how much attention drivers were paying to the system.

There were two versions of the navigation system. One version used a dominant male voice, and the other version used a submissive male voice. A panel of researchers using the same IAS scale used to screen participants assessed and selected the voices for the in-car systems. Even though the information was the same in both versions, the utterances varied in choice of words and voice characteristics. The main linguistic features used to distinguish between a dominant and a submissive voice, were choice of words, pitch range and speed of speaking.

The dominant voice used words such as "will", "must" and "definitely, and the submissive voice used words such as "might", "could" and "perhaps". When the dominant navigation system used assertive language "You should definitely turn right" the submissive system was more timid, "Perhaps you should turn right". For choices the dominant voice would, for instance say, "Continuing straight is shorter but may have more traffic. Turning right will definitely be faster" and the submissive voice would say, “Continuing straight is shorter but may have more traffic. Turning right will probably be faster”. The dominant voice was furthermore given a higher overall frequency, a larger range of pitch during speech, and greater speed than the submissive voice [12].

3 Procedure and Measures

3.1 Procedure

All participants were informed that the experiment would take one hour and started the experimental session by signing a consent form. After this, participants drove a five-minute test run of the simulator to familiarize themselves with the simulator and the controls. This enabled participants to experience feedback from the steering wheel, the effects of the accelerator and brake pedals, a crash, and for us to screen for participants with simulator sickness [16]. Two of the signed up participants felt nauseous or discomfort during the training course and did not conclude the study. The remaining 40 participants filled in the first questionnaire consisting of general information such as gender and age in addition to driving experience.

Participants where then randomly divided into two gender-balanced groups of 20 in the UK. The dominant and submissive participants were matched and mismatched with the personality of in-car voice.

All participants drove the driving simulator with the driving scenario scripted to take the driver to five destinations, and all participants were subjected to the factual information inserted at six locations along the road.

After the driving session, participants filled in post driving questionnaires. One of the questionnaires asked participants to assess the personality of the navigation systems, and how similar the navigation system voice was to them. A second questionnaire asked participants to recall information volunteered by the navigation system during the drive.

3.2 Measures and Dependent Variables

Personality. Participants were screened based on the Interpersonal Adjective Scale [14] where questions were selected to assess participants along the dominant-submissive dimension. This is a standard commercial questionnaire, where the dominant-submissive dimension represents the degree to which an individual is assertive and willing to exercise control over others.

Similarity. An important aspect of how voices influence attitude and perception of spoken messages is *similarity-attraction*. Similarity-attraction predicts that people will be more attracted to people matching themselves than to those who mismatch. Similarity-attraction is a robust finding in both human-human and human-computer interaction [12, 17] human-computer interactions, the theory predicts that users will be more comfortable with computer-based personas that exhibit properties that are similar to their own. Attraction leads to a desire for interaction and increased attention in human-computer interaction [18, 19]. A standard questionnaire on homophily [20] was used to identify measures of similarity. An index for similarity was constructed as a combination of attitudinal similarity and behavioral similarity. Participants were asked to rate the statements based on the questions "On the scales below, please indicate your feelings about the person speaking?" Contrasting statements were paired on opposite sides of a 10-point scale such that, 'similar to me' and 'different from me' would appear at different ends.

Driving Performance. This is a collection of measures that consists of accidents and adherence to traffic regulations. The driving simulator automatically collected the data for these measures. *Bad driving* is comprised off-road accidents, collisions, speeding and running red lights. Because it is much more difficult to drive in a simulator than to drive a real car in real traffic, the number of incidents are much higher than in real traffic, which makes this a useful measure of driving performance.

Navigation System. This is a collection of measures related to the voice used by the navigation system and how drivers reacted to it. The measure *Instructions followed* simply counts how many of the driving instructions drivers followed. *Time to destination* measures drivers' time to complete the driving scenario to the last destination. *Facts remembered* measures how many of the driving scenario facts that drivers remembered after the driving session ended. The measure *Voice competence* was based on a 30-term instrument, where participants were asked to assess the voice using a 10-point Likert scale. *Feeling calm or annoyed* after driving was measured using a 17-term DES [21] instrument where participants assessed their emotional state using a 10-point Likert scale.

4 Results

The effects of the matching and mismatching the car voice personality of a navigation system with driver personality were measured by a two (Personality of of Navigation System voice) by two (Personality of Driver) between-participants ANOVA.

4.1 Prior Driving Experience

To ensure that there was no bias based on drivers' prior driving experience, data from the two most recent years of driving was collected. The data, that included number of accidents and tickets, was averaged for each group of drivers. No significant differences were found across conditions.

4.2 Manipulation Check

The manipulation check showed that drivers perceived the voices to be dominant and submissive. All drivers rated the dominant voice as dominant (Mean=43.3, SD=5.7) and the submissive voice as submissive (Mean=30.8, SD=6.5), $F(1, 36) = 42.8$, $p < 0.001$. There were no effect of driver personality, and no interactions effects.

4.3 Similarity – Homophily

Data from the similarity assessment show an interaction effect. Dominant drivers felt similar to the person behind the dominant voice (Mean=6, SD=0.6), and dissimilar to the person behind the submissive voice (Mean=4, SD=0.3). Submissive drivers, however, felt equally similar to both the person behind the dominant voice (Mean=5, SD=0.3) and the person behind the submissive voice (Mean=5.3, SD=0.7), $F(1, 36)= 45.2$, $p < 0.001$.

4.4 Driving Performance

Bad driving. There were no main effects of driver personality or voice personality on bad driving. There was however an interaction effect such that mismatched conditions showed significantly worse driving performance than matched conditions. Dominant drivers drove significantly better with a dominant voice (Mean=6.5, SD=2.3) than with a submissive voice (Mean=20.4, SD=2.3). Similarly, submissive drivers drove significantly better with a submissive voice (Mean=7.7, SD=2.3) than with a submissive voice (Mean=15.5, SD=2.3), $F(1, 36) = 22.7$, $p < 0.001$.

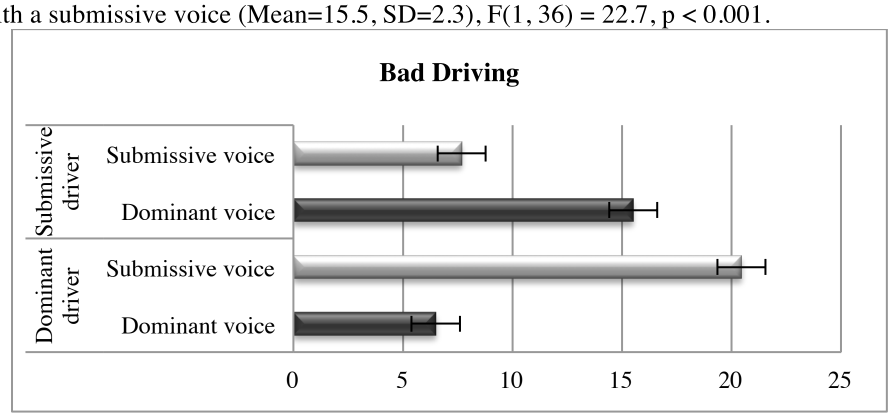

Fig. 4. Bad driving- accidents, speeding and running red lights

4.5 Navigation System

Voice Competence. Participants were asked to rate the competence of the navigation system voice. Data show no main effect of driver personality or voice personality. There is however an interaction effect so that dominant drivers rated the dominant voice more competent (Mean=70.0, SD=11) than the submissive voice (Mean=58, SD=11), and submissive drivers rated the submissive voice more competent (Mean=69.3, SD=10) than the dominant voice (Mean=62, SD=9), $F(1, 36) = 8.1$, $p < 0.007$.

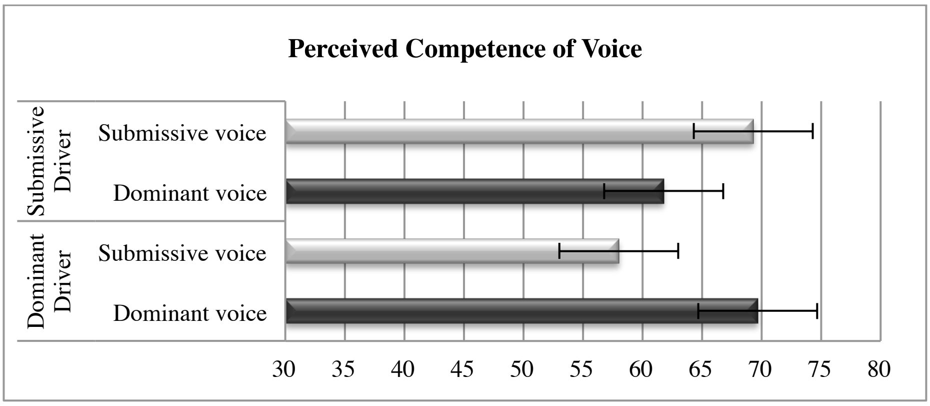

Fig. 5. Perceived competence of voice

Instructions followed. The data show that voice matching matters when following instructions. There was an interaction effect so that dominant drivers followed instructions significantly better when given by the dominant voice (Mean=18.4, SD=2) than when given by the submissive voice (Mean=15, SD=3). For submissive drivers, the data show that the voice makes no difference for following instructions. Mean=16.6. SD=3 for the dominant voice and Mean=16.7, SD=1.7 for the submissive voice, $F(1, 36)=4.2$, $p < 0.05$.

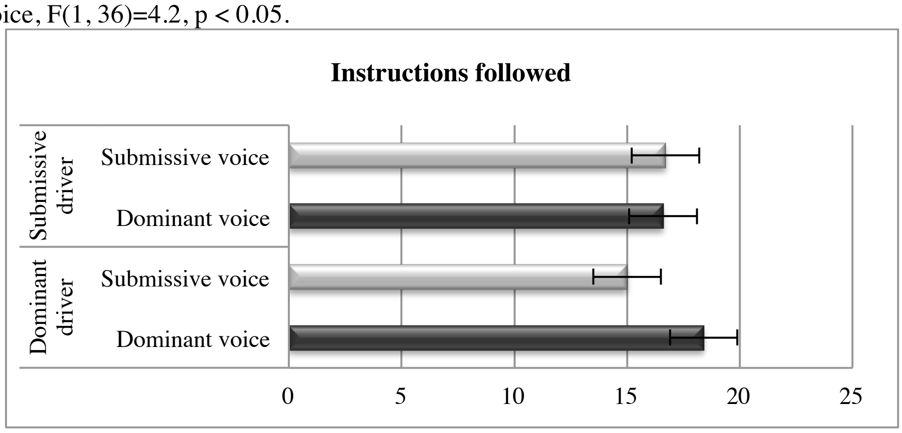

Fig. 6. Instructions followed

Facts remembered. The data show that voice matching matters, with a main effect of voice. Drivers remembered facts told by the submissive voice (Mean=2.65, SD=0.3) significantly more often than when facts are told by the dominant voice (Mean=1.1, SD=0.3), $F(1, 36)=9.4$, $p <0.005$.

Time to destination. The driving simulator automatically collected the time it took for drivers to reach their fifth destination. There were no main effects or interaction effects for time to reach the fifth and last destination.

Feeling calm or annoyed. The data show a main effect of voice personality. Drivers that drove with the submissive voice (Mean=4.8, SD=1.4) felt more annoyed and less at-ease after driving than drivers with the dominant voice (Mean=3.6, SD=1.2), $F(1, 36)=8.4$, $p < 0.006$.

6 Conclusions and Discussion

Results from the study show that drivers can discern the personality of the car voice. It is interesting to note that all drivers felt they were similar to the person behind the dominant personality, even when submissive drivers clearly rated the submissive voice more competent than the dominant voice. This influenced how drivers paid attention to instructions given by the navigation system. Data show that all drivers, regardless of personality, followed directions when given by the navigation system with the dominant voice. Submissive drivers paid attention to instructions given by the navigation system with the submissive voice, dominant drivers did not.

Data clearly show, that even if there is a slight bias towards the dominant voice in the car regardless of driver personality, matched conditions show significantly better driving performance. Matching the voice personality of a navigation system to the driver personality improves driving performance dramatically, with as much as 2 and 3 times. This huge difference in driving performance was not biased by overt speeding by any particular group of drivers, since there was no significant difference between drivers in time to reach the fifth and last destination.

Matching conditions improves driving performance, especially submissive drivers to in-vehicle systems with a submissive voice improves performance – even though data shows a bias towards the dominant voice. The data however also show that drivers felt less at ease after driving with the submissive voice, than after driving with the dominant voice. This was true for both dominant and submissive drivers.

The data from this study show complex interactions between personality, perceived similarity, attitude and performance. It emphasizes that it is important, to find the balance between matching-efforts and efficacy. Having a system that can accurately match drivers' personalities, is a remarkable technological feat, if drivers are not positively influenced by it, it is however a wasteful expense. Even worse, if a system is perceived as annoying or undesirable, regardless of its actual performance, drivers will be dissatisfied with both the system and the car. The bottom line is that even the technologically-best system may not satisfy or help all drivers: While in-vehicle information systems represent exciting technological advances, their deployment should be guided by significant caution.

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